Transcript of the

Joint FAA/Industry Symposium

on

Level B Airplane Simulator Aeromodel Validation Requirements

To the Memory of Daryl Schueler

Part 1 of 7

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Washington Dulles Airport Hilton
March 13 - 14, 1996

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Preface

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Preface

This is the transcript of the Joint FAA/Industry Symposium on Level B Airplane Simulator Aeromodel Validation Requirements held on March 13-14, 1996, at the Washington Dulles Airport Hilton. The purpose of the meeting was to discuss the aeromodeling considerations associated with updating FAA qualification requirements for Level B flight simulators. It is available to the public on 3.5" high density drive diskettes in Adobe Acrobat Portable Document Format (PDF) format from Dr. Thomas Longridge, Advanced Qualification Program Manager, AFS-230, Tel. 703-661-0275. The document is platform, application, and font independent and may be viewed and printed using Adobe Acrobat Reader, V. 3.0 for PC, UNIX or Macintosh. The Reader can be downloaded from the Internet at http://www.acrobat.com. Upon request, the Reader can be made available on a second diskette.

Flight simulator technology has advanced significantly during the past decade, one result of which is that device capability has increased while cost has declined. However, for commuter airlines, cost continues to be an obstacle to flight simulator access, particularly for recurrent training. We believe that it may be possible to revise Level B simulator qualification procedures and requirements to enhance affordability, without degrading the standards or quality of performance for such equipment. The first step in this endeavor is a comprehensive review, beginning with aeromodeling and flight data considerations. A description of the overall project can be found in Longridge, T., Ray, P., Boothe, E., & Bürki-Cohen, J. (1996): Initiative towards more affordable flight simulators for U.S. commuter airline training, *Royal Aeronautical Society Conference on Training - Lowering the Cost, Maintaining the Fidelity* (pp. 2.1-2.17), London, UK, located in the file 07*Append.pdf*. It also contains the final version of the tables referred to in the transcript.

Attendance at the meeting was by invitation only and included selected experts from industry, academia, and government in the disciplines of aerodynamic modeling, aircraft flight test instrumentation, simulator qualification, aircraft certification, and air carrier pilot training. The meeting was chaired by Dr. Thomas Longridge, with the participation and cooperation of Mr. Paul Ray, Manager of the FAA's National Simulator Program. The technical discussions were led by Mr. Edward Boothe. Mr. Donald Eldredge, the Battelle project manager, was responsible for the meeting logistics. The discussions were recorded live by Mr. and Ms. Dave and Allison Hoyman of RealTime Reporters. Dr. Nancy Soja incorporated the participants' comments. Ms. Mary Townsend applied the final editing touches to the transcript. The overall project is managed for Dr. Eleana Edens of the FAA's Human Factors Division AAR-100 by Dr. Judith Bürki-Cohen of the Department of Transportation Research and Special Projects Administration's Volpe Center.

We extend our highest appreciation and gratitude to all. Finally, we would like to dedicate this effort to Mr. Daryl Schueler. We cherish his invaluable contributions to the discussions and deeply regret his untimely death.

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Participants

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Participants

Stewart Baillie	National Research Council, Canada
Gerald Baker	FAA, Aircraft Certification Office
Edward Boothe	Consultant, Flight Simulation and Training
Judith Bürki-Cohen	Department of Transportation, Volpe Center
Thomas Davis	CAE Electronics, Ltd.
Donald Eldredge	Battelle
David Ellis	Wichita State University
Robert Heffley	Robert Heffley Engineering
David Kohlman	Engineering Systems Inc.
David Leister	Simulation Consultant
Thomas Longridge	FAA, Advanced Qualification Program
Kendall Neville	Boeing Commercial Airplane Group
Paul Ray	FAA, National Simulator Program
Daryl Schueler	FAA, Aircraft Certification Office
Hilton Smith	FAA, National Simulator Program
Charles Stocking	Hughes Training, Inc.
Thomas Toula	FAA, Aircarrier Training Branch
Stuart Willmott	SimuFlite Training International

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Abbreviations

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Abbreviations

35	type of airplane
210	type of airplane
300	type of airplane
421	type of airplane
601	type of airplane
727	type of airplane
737	type of airplane
747	type of airplane
777	type of airplane
1900	type of airplane
1900D	type of airplane
AAA	Advanced Aircraft Analysis
AC	Advisory Circular
accel(s)	acceleration(s), accelerate
AFM	Airplane Flight Manual
AHRS	Attitude Heading Reference System
alpha (α)	angle of attack
alpha-dot	time derivative of angle of attack, rate of change of alpha
AQP	Advanced Qualification Program
ATD	Advanced Training Device
ATG	Approval Test Guide
ATR-42	type of airplane
ATR-72	type of airplane
a_y	lateral acceleration
B-737	type of airplane
beta (β)	sideslip angle
C-130	type of airplane
CAA	Civil Aviation Authority (UK)
cert	certification

CFD	Control Force Dynamics
CG	Center of Gravity
C_L	Coefficient of Lift
CRM	Crew Resource Management
DATCOM	USAF Stability and Control DATCOM (Data Compendium)
DC-3	type of airplane
dev	deviation
decel(s)	deceleration(s), decelerate
FAA	Federal Aviation Administration
FADEC	Full Authority Digital Engine Control
FAR	Federal Aviation Regulation
FDR	Flight Data Recorder
FOIA	Freedom Of Information Act
FRL	Fuselage Reference Line
FTD	Flight Training Device
g	acceleration caused by gravity, 9.8 m/sec^2
G-3	type of airplane
G-4	type of airplane
GD	General Dynamics
GPS	Global Positioning System
h	altitude (height)
h-dot	time derivative of altitude (height), ascent or descent rate
IATA	International Air Transport Association
IQGT	International Qualification Test Guide
ITT	Inter Turbine Temperature
JAA	Joint Aviation Authorities (Europe)
JAR-SIM	Joint Aviation Regulation-Simulators
KSR	Kohlman Systems Research
$L_{\delta a}$	rolling moment due to aileron deflection
L_p	rolling moment due to roll rate
LOE	Line Oriented Evaluation

LOFT	Line Oriented Flight Training
min	minimum
MoT	Ministry of Transport (Transport Canada)
MU-2	type of airplane
N_1	rotational speed of fan on turbo fan engine
NASA	National Aeronautics & Space Administration
NASA-Ames	National Aeronautics & Space Administration Ames Research Center
NC-130	type of airplane
NTS	Negative Torque Sensing
NTSB	National Transportation Safety Board
OEI	One Engine Inoperative
ops	operations
P-3	type of airplane
parens	parentheses
PC	Personal Computer
QTG	Qualification Test Guide
rpm	revolutions per minute
RTO	Rejected Takeoff
SFAR	Special Federal Aviation Regulation
sim(s)	simulators(s)
spec	specification
STC	Supplemental Type Certificate
TC	Type Certificate
TIR	Type Inspection Report
u, v, w	velocity components along x, y, z
UK	United Kingdom
V	Velocity (speed)
V_1	takeoff decision speed (formerly critical engine failure speed)
V_2	takeoff safety speed
V_{LOF}	lift-off speed
V_{MC}	minimum control speed with critical engine inoperative

V_{MCA}	minimum control speed air
V_{MCG}	minimum control speed ground
V_{MCL}	minimum control speed landing
V_{MU}	minimum unstick speed
V_R	rotation speed
V_S	stall speed

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Transcript of Day 1

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Transcript of Day 1

MR. LONGRIDGE: I'm Tom Longridge, I would like to welcome you all here. We are delighted to have this group. We know this is a very select group and many of you have taken time away from perhaps better paying opportunities to be with us here today. We think it's a very important exercise and I know I speak for all of us on the FAA side, we are delighted that you are all here.

All of you have, I believe, a copy of the agenda in front of you, as well as some materials that have previously been mailed to all of you that are going to serve as a basis for discussion today and tomorrow. I'm going to take a few moments to kind of give a little bit of background from my perspective, Paul Ray will do the same.

We are also fortunate to have with us this morning, Tom Toula. Tom [Toula] is the individual at FAA headquarters who is responsible for training policy for air carriers. He will give you a few remarks that reflect his perspective on the need.

As far as background is concerned, many of you are probably aware the FAA recently issued a commuter rule. Tom Toula will talk a little bit about that.

One of the most important aspects of that rule was the goal to establish one standard of safety for major and commuter airlines. One of the things that we need to do in order to make that happen is to make training equipment, and from our perspective flight simulators, as available to that community as it already is for the major carriers, and that is presently not the case today.

Another player in this endeavor is the Advanced Qualification Program. The Advanced Qualification Program is an alternative to the traditional regulatory requirements for pilot certification and qualification. It differs from the traditional programs in that it refocuses proficiency evaluation away from maneuver-oriented proficiency checks towards scenario-based line operational evaluation in which we test both technical skills and crew resource management skills together for jeopardy purposes, so that a pass/fail endeavor in an AQP is a scenario-based evaluation that tests both types of skills.

Another aspect of AQP that's relevant to training equipment is the fact we employ progressive evaluation in AQP, we replace the final proficiency check and oral with a progressive evaluation that's distributed throughout the curriculum. By virtue of doing that, we enable an air carrier to sign off proficiency at lower level skills and not have to repeat the evaluation of those skills at a later point in the curriculum. That particular approach definitely enables the use of and encourages the use of lower level training equipment throughout the entire curriculum, starting with ground school. It enables maximum use of flight training devices to sign off proficiency and procedurally oriented skills as well as for those maneuvers for which the FAA has enabled carriers to get credit for flight training devices.

But what it does not do is eliminate the requirement for a flight simulator. Because of the fact we have a scenario-based evaluation we want that scenario-based evaluation to be a true test of both technical and CRM skills. Although we can reduce the footprint requirement for a high end device with an AQP program nevertheless, we still require a flight simulator forthe final evaluation of proficiency. That's a very important point that people that are familiar with AQP sometimes miss, because of the fact that we emphasize crew resource management many folks think that all we care about is a CRM evaluation in the end. That's absolutely not the case. It must be a true evaluation of both technical and CRM skills. Okay.

One of the motivating factors for this meeting is simply the availability of training equipment for commuter airlines. I spent yesterday morning with a commuter airline who has experienced so much turn-over due to the fact that major airlines have been hiring all of his regional pilots, that he suddenly has a totally unprogrammed training requirement for which he is absolutely unable to obtain simulator time anywhere in the world. And he is going to have to conduct this training in the aircraft simply because of the unavailability of such training equipment.

His situation, I think, is quite typical today, this is a problem. And this is an issue that we seek to resolve here in the FAA.

Another consideration is simply, for commuter airlines, the cost of this equipment. We are dealing with much smaller airlines that perhaps don't have the budgets to purchase their own training equipment. Some of them are limited even in their capacity to rent simulator time to lease, dry lease it from training centers or wet lease it, as the case may be.

Cost is a significant factor for commuter airlines and if we want to create a situation that's going to encourage commuters to go to flight simulators and train, we are going to have to make it cost effective for them to do that.

Now the Regional Airline Association has come to the FAA with their own proposed solution to this dilemma. Their solution is well, we will take a flight training device perhaps a Level 5 FTD, we will go ahead and augment its capability, we will make it a Level 5^{++}, or maybe make it a Level 6^{++}. We would like to do at least our recurrent training in this enhanced Level 5 or 6 FTD that's their proposal to us.

We have an alternative proposal, that is to revisit the qualification requirements for a Level B flight simulator. Because our feeling is that whatever you would have to do to a Level 5 or Level 6 in order to augment its capabilities, such that the FAA would permit you to use it for the purposes that they are proposing, whatever you would have to do to accomplish that goal would in effect create a flight simulator, so why not focus on building a flight simulator to begin with.

There are a variety of advantages to that approach, from our perspective, not the least of which is we already have regulatory language which will permit an air carrier, be it commuter or major airline, to use a Level B simulator for 100 percent of their recurrent training needs. There is no requirement to go to the aircraft if you use a Level B simulator for recurrent training.

I should add that our focus in this endeavor with respect to trying to reduce cost is on recurrent training. We think that's the big cost, that's the big area, nobody is really complaining as much about the requirement to use a Level C or D simulator for initial pilot training. So our focus is strictly on recurrent training and a Level B solution. What we want to attempt to achieve is the goals that the commuter airlines have for less expensive devices with a Level B flight simulator.

And another very important point is we would like to do this without in any way degrading the standards for that device. We are not interested in allowing credit for a less capable device. We want to explore whether or not we can come up with a more affordable device without diminishing the performance qualification standards for that equipment.

So we have initiated a comprehensive program to address this issue. And this meeting today is really the first component within that overall approach. We are going to be looking at the data requirements for aeromodeling, we are looking at the data requirements outside of aeromodeling for flight simulators. We are looking at the motion cueing requirements for the device and we are going to be of course looking at the visual cueing requirements for the device. We are going to attempt to approach this in a systematic fashion and we feel that the most appropriate place to start is with respect to the quality of the device and the aeromodeling.

So that's what we are going to be focusing on entirely today. Aeromodeling. And as I indicated in the letter that went out, there are two considerations, one of them is of course revisiting the FAA's requirements for qualifying a Level B simulator. Looking at the extent to which the data requirements for doing so might be obtainable on a more affordable basis. But of course that in and of itself doesn't necessarily mean that the simulator is going to fly like the aircraft. We need to also provide guidelines which are not FAA requirements but nevertheless would be guidance to the industry on how they might more affordably go about acquiring the data needed to program the simulator so indeed the handling characteristics are such that they replicate the aircraft.

We will be looking at both those issues, and the tables[1] that were mailed to you are intended to support some discussion along those lines.

So our focus, what, if anything, it may be possible indeed that nothing can be done, but what, if anything, can be done to reduce cost with respect to how the aircraft data is gathered, what data sources are required, what points in the flight envelope will be matched for validation. Notice I say "what points within the flight envelope," not necessarily what maneuvers. This is an issue for discussion. Do we want to base this approach on matching a specific maneuver or do we want to pick optimum points throughout the flight envelope that we will be requiring for model validation purposes, and what tolerances, what level of accuracy will be permitted.

Okay. We want this to be kind of an informal free-for-all discussion. These are ground rules that hopefully will contribute to that. First of all, we know we have a very select group here. All participants are here as equals.

[1]The final tables resulting from the Symposium can be found in Part 7 - Appendix: Longridge, T., Ray, P., Boothe, E., & Bürki-Cohen, J. (1996). Initiative towards more affordable flight simulators for U.S. commuter airline training. *Royal Aeronautical Society Conference on Training - Lowering the Cost, Maintaining the Fidelity* (pp. 2.1-2.17), London, UK *(Appendix.pdf)*.

Because of the fact that we do want to record all of your comments, we would like to require that one person speak at a time. We do have a recorder here who will need to identify who is speaking. And after a while, she will, I'm quite sure, memorize who it is, but we would ask at least during the first several hours when you make a comment you preface it with your last name.

We will try to stay focused on the session goals and agenda. That will be my role, so we don't wander off too far.

Another very important point, clearly consensus is desirable. Consensus is going to provide the FAA with a high level of confidence, particularly given the group that we have here when we achieve consensus we have achieved a valid solution. On the other hand, we haven't asked you to come here to rubber stamp our ideas about how to proceed here. And that extends to the tables issues. We want to hear alternative viewpoints. So please don't hesitate to disagree with one another in the course of the session or to disagree with the FAA.

Time permitting, we hope to allow hearing virtually everyone's point of view. Okay?

Now I would like to give Paul Ray the opportunity to make a few remarks.

MR. RAY: Thanks, Tom [Longridge].

The main thrust of my comments are really towards thank you for everyone who has shown up here today. As Tom [Longridge] indicated, there are a lot of things you could be productively doing back at wherever you reside. Extensive time and discussion was spent over who was actually invited to this meeting today.

There is a lot of interest around the aviation community regarding this meeting. Not only within the States, but also abroad. Acknowledgments have been received from the JAA JAR-SIM group. Last week the JAR-SIM group met in London and they are well aware of our meeting that's being conducted these two days and look forward to the output from this process.

But thanks again to each and every one of you, we didn't have a single decline. Thanks again for your time in coming here. If there was ever a group of experts, on simulation, you are certainly that group. This group has the opportunity to establish a new foundation for the simulation and training community.

That's why you have been invited here today. The question we are asking I believe is the right question at the right time for the right reason. Tom [Longridge] has done an excellent job of summarizing that on the screen for us here today. Whatever we come out with tomorrow is an honest answer to an honest question. There is no preconceived [idea], at least on our part, [about] what the answer should be. Your input, your ideas on how and if we can get from point A to point B.

Thanks again, we look forward to all the interaction that's going to go on. I look forward to the comments here, the ideas bounced on the floor or picked up, put on the table and worked out. Thanks again for your time.

MR. TOULA: I feel like I'm in a room full of experts, but I definitely am not one of the experts in the caliber you folks are today. I think I can play more of a role of the user of what you talk about today.

Tom [Longridge] did an excellent job of briefing the need that we have, the urgency, I want to stress the urgency because I have had individuals as well as companies come to me and say they are very worried about what is going to happen when the full effect of the commuter rule, I'm not sure if everybody knows what that commuter rule does, it basically brings a lot of [Part] 135 folks who were training under 135 and require them to operate their aircraft at a [Part] 121. Train under 121.

The commuter rule, the training rule combined, mean a lot of people now, a lot of air carriers are going to have to train for CRM. I think one of the best ways of training for CRM is in a full-blown simulator with a practice of all things that can be thrown at them and they can practice the CRM, practice their skills and hone their skills in CRM. I think we don't want to lower what we have as standards right now, that we have guides. Some have proposed that the CRM training be conducted for LOFT scenarios so to speak, CRM conducted in Level 6 and Level 7 devices.

One of the problems we are facing of course with these folks is they don't have deep pockets that some of the operators that traditionally we think about, the Deltas, they don't have the money, the facilities, to have a full corral, so to speak, of simulation devices. They can't afford the 18 to 15 million dollar simulators, and my numbers may be off on that, but they certainly need some economic breaks here so they can get the quality training they need in a device that will support that training.

The needs of course are time. I can't stress any more, we need to move quickly. The commuter rule became effective, becomes effective in two or three days. And compliance requirements is a year from, I think it's March 19 or March 20, I'm not sure, of 1997. So we are looking at one year where these folks are going to have to start training under--to 121 standards.

We also have another rule-making project in the books that are going to actually require that air carriers train using simulation devices, flight training devices. If we go down that road we have to make the simulation devices usable and economical enough for these folks to use. We have a sense of urgency in time, I think otherwise what we are going to do is end up forcing a lot of carriers to do a lot of their training in the aircraft and airplanes and we don't want to go down that road.

So whatever we can do today, whatever you folks can do today, I wouldn't know an aerodynamic package from a Christmas package, to be honest with you, whatever you folks can do today to speed that process up I certainly appreciate.

I know the folks that now have to comply with 121 training requirements appreciate it also.

MR. LONGRIDGE: Thanks Tom [Toula]. Okay.

Before Ed Boothe presents the technical agenda, although everybody knows everybody else, it would be useful to me and to the recorder to go around and introduce yourselves to each other.

Tom Longridge from the FAA.

MR. BOOTHE: Ed Boothe. I used to be with the FAA.

MR. RAY: Paul Ray, still with the FAA.

MR. TOULA: Tom Toula, still with the FAA.

MR. KOHLMAN: Dave Kohlman, with Engineering Systems.

MR. BAILLIE: Stewart Baillie, National Research Council, Canada.

MR. HEFFLEY: Robert Heffley, Heffley Engineering.

MR. BAKER: Gerald Baker, FAA Wichita.

MR. SCHUELER: Daryl Schueler, FAA Wichita.

MR. DAVIS: Tom Davis from CAE Electronics.

MR. LEISTER: Dave Leister, I'm an ex Flight Safety International employee.

MS. BÜRKI-COHEN: Judith Bürki-Cohen from the Department of Transportation, Volpe Center, in this case working for the FAA.

MR. WILLMOTT: Stuart Willmott from SimuFlite Training International, Dallas.

MR. STOCKING: Chuck Stocking from Hughes Training.

MR. ELLIS: Dave Ellis, National Institute for Aviation Research.

MR. SMITH: Hilton Smith, FAA.

MR. NEVILLE: Kendall Neville, Boeing Commercial Airplane Group.

MR. ELDREDGE: Don Eldredge from Battelle.

MR. LONGRIDGE: Very good, thank you.

Now we will proceed with an introduction to the technical agenda from Mr. Ed Boothe.

MR. BOOTHE: Thank you, Tom [Longridge].

The only reason I'm coming around here is to turn off this light, because I don't have any use for it.

When I was putting together some thoughts for how to introduce these tables it had occurred to me that it might be well to just pass them out to you. So I did that. You have a sheet of thoughts I had as I went over how we would introduce the tables and what we might be thinking about as we work on them. So that's not a formal document, it's just some thoughts.

But to address the technical issues you have two tables, and to put them in perspective, I gave you the computer disk with straw man 1 and straw man 2. That's exactly what we intend these tables to be. They are documents to stimulate discussion.

There are two of them, the first one addresses simulator validation data. These are the tests, the FAA Advisory Circular for simulator qualification, the other is what I have called simulator programming data, and that's really, really that's taken from the IATA data document.

As I was charged to build a draft table, I kept thinking what can I say to build a table that isn't bad and how shall I approach this, and it really came down to, it's really already done, it's just not very usable for us. So what you have on table 2 is really my version of the IATA data document, but just so we keep ourselves straight, we thought it might be worthwhile for each of us to have a copy of those pages. So I'm going to pass these around. I took as an example the turbo prop airplane because I think that's the most applicable for the problems that Tom [Longridge] and Tom [Toula] have discussed with you this morning. There are some differences, of course, from the jet airplane case.

Let me pass these around. If you would each, I think there is 16 copies so there may not be quite enough for everybody. We will get a couple more copies if we need them.

We think it's probably best to start with validation data. So the part that's being passed around now will be the second table of discussion. And the validation data table was sent to you, it's also in the second half of this document. I don't know quite how Don Eldredge managed this, you have to turn it upside down and backwards.

MR. ELDREDGE: Don't ask.

MR. BOOTHE: Then you have to be from the Orient, because it goes from back to front.

MR. ELDREDGE: I'm left-handed.

MR. BOOTHE: The first table I drafted Stewart Baillie looked over, and also he had been working independently to put in some thoughts, so I incorporated some of Stewart's thoughts, and I thank you for that help, Stewart, in bringing that table up to a better level than it was.

Now in that table you will see a column called Level 6 and I think we need to explain why Level 6 is there. Level 6 is a flight training device. It began its life really as an advanced training device under the old Advisory Circular we did back in about '87. And it never, those of you from the simulator manufacturing side of things will agree, it never went anywhere. But I think the concept was valid, I think there was some misunderstandings as to why it never went anywhere.

One of the important considerations in the ATD was we could use a less--I don't want to say less rigorous, a more simpler like data collection process. So if you look at the Advisory Circular today you will see that all of the tolerances for comparing a Level 6, which is what the ATD became, are the same as a Level B simulator. We kept the tolerances the same. But the thought that got lost was there could be some relaxation at that level of data quality, I guess I can say, but of collection techniques you need a full-blown Boeing installed flight data acquisition system that gave you enough work to last the rest of your life and three or four other guys, too. That was the concept.

So I put Level 6 there with the thought if a data validation is good enough for Level 6, and if we extend the thoughts of Level 6 to a Level B in terms of how we can use it, then why isn't it enough for Level B? It's a reminder as we go along we use this ourselves in a meeting, preparing for this, and I chose to just leave it in there for that reason.

Now certainly not--I'm certainly not advocating that we dismiss rigor or that we just arbitrarily dismiss data quality, but I'm also saying we should keep in mind these relative levels and not require a more stringent data acquisition when we have got to do the same thing with the device. That doesn't apply across all tasks, for training and checking, and in fact when we get finished and say what we need to collect the total package, it may not even be applicable. It's part of the thinking that I wanted to stimulate amongst you.

Speaking of that, that's the whole purpose for these two tables, to stimulate discussion. I sat and built tables based on information I had, some of the ideas in the validation table concerning data acquisition, flight test suggestions, data sources, are things that I pulled out of a lot of places that they may be erroneous. So that's why we are here discussing that with you. But that's an important reason why we wanted to include Gerry Baker, and Daryl [Schueler] is kind of wearing two hats now, he has been in both sides of the business.

You notice as you go through the tables, there are times when I would say certification data and type inspection report, it seems over the years we totally dismissed certification, airplane certification data. When I say “certification” I'm referring to airplanes and when I say “qualification” I'm referring to simulators for the most part. So if I don't explain that, that's what I mean. But over the years we sort of dismissed airplane certification data.

And type inspection report, there was a time when maybe there wasn't very much information in those documents, but I don't know what's currently in them. My airplane certification work is quite old at this point, so we needed a fresh look of what's there and how we might use it.

One of the problems that occurred to lead to the dismissal of TIR data we don't train in extremes, so that data is no good. Well, to my way of thinking that's nonsense, because what we want in a simulator is a continuous model that's validated at some important points in the flight envelope, and I really am not all that concerned that I'm going to be using this device for training perhaps a mid CG at a medium weight, which is not really where I think we should be trained, but that's another subject.

If on this continuous model I can file a couple of validations that end up in the TIR, I think that's an important contribution. So that's why I have included those kinds of thoughts.

Another thought I had in mind as we did a validation table is to minimize the need for an inertial measurement requiring a flight data acquisition system. I couldn't get rid of it. And try as I may, I couldn't get rid of it, but I got it down to a limited number of cases.

Further, I wanted to just minimize the need for instrumentation at all. I can't get rid of that, either. Certainly there is some need for instrumentation, there is need for instrument calibrations, there is lots of needs that remain. But I think we have overlooked some of the simpler techniques that one might employ, and while I've taken a stab at some of those, again it might be totally erroneous, you might look at them and say Ed [Boothe], you have on the wrong hat, you can't do that. Please do that, I don't want you to take, as I said on my outline, there are no sacred cows on this, it's purely a document to stimulate discussion and get your input.

That leads to the next point of hand held instrumentation, certainly. I want to stress, and it's been stressed to me by people such as Stewart [Baillie], Stewart has been involved in a couple of recent important data acquisitions for commuter type airplanes so he had some recent thoughts on it. We don't want to dismiss rigor. We must insist on a rigorous flight test data acquisition. But rigor can mean a qualified crew and a qualified test pilot, a sharp pencil and a knee board and some hand held instrumentation. Not for everything you need but for some of the things you need, and I have tried to suggest some of those things.

Now, the thing I think that Hilton [Smith] and Paul [Ray] have to help us with is as we make these suggestions, and I'm going to come to you with hand recorded data maybe for some tests in a simple airplane, is that going to be acceptable for simulator acceptance and qualification by the FAA? So we need that input as we go.

So it's important to get this exchange going because those of us who may like to collect data and can go out and have a good time collecting data, but if these guys aren't going to accept it, all we did was have a good time and spend money. I think that's a very important aspect as we discuss these validation techniques. Of course all that leads up to minimizing the data cost.

One of the things that I think we are all interested in is at the end of the day can we describe an increment of the difference in cost? Let's take today's methods and then compare that to what we come up with here, and can we defend a significant cost. Because if we wanted-- maybe data is the wrong place to look for saving money on simulators. I think that's one of the most important outcomes of the whole discussion is what's the cost increment when we get done, and if I can only reduce the cost of validation data five percent and the overall cost of the simulator is that significant, is that important, is it worth the effort?

Those kind[s] of thoughts are just as important to us as how to collect data. So I'd like you to keep that in mind, if you will, as we go. And then matters arising, well matters always arise, I learned to use that from my friend Paddy Carver at the CAA. He put it on his agenda and I learned to put it on mine. Things you don't anticipate always come up. Whatever comes up germane to this discussion I think is important for us to consider here. Okay?

The modeling data, which it's a second order of discussion, I think, although these things are not completely separate and independent, we might want to do some crossing over as we go, as we need to, but again the table is to stimulate discussion. Don [Eldredge] has again put that in a book which I have put down and can't find. And he has left us plenty of room for notes.

So the tables that you were sent have been structurally modified to put in the book and leave some notes room. Don [Eldredge] said he arbitrarily picked sideslip and he broke every table 5 sideslip and started that at the top of the page. I guess that's as good a place as any. But anyway, there is a lot of room for notes. And again, you might have to twist the book or something, but it is there. I haven't actually looked at this, I assume it is.

MR. ELDREDGE: No changes in the tables.

MR. BOOTHE: I take it he trusted the computer to put out the same stuff. My experience with computers is it's not necessarily so. That thing has another trick for me every time I use it.

Of course the real issue in those tables is aerodynamic coefficients, sources of them, accuracy of them from those particular sources, and again I have taken a really wild stab at what I think the accuracy of any given variable value might be from some source I might have named. And you probably, or may, totally disagree with me, but that's okay. I said this is straw man 2, we have to put something on paper or else we wouldn't have anything to discuss. So please don't think there is any sacred cows in there. I probably don't know as much about data sources as all of you do, so I just put something there for us to discuss. I think the rest of that is sort of self-evident relationship to validation requirements, matters arising, as we discussed, and recommended changes.

But at the end we would like some reviews and recommendations, and a cost increment which I did not write down on here, we would like to try to address that, and of course where do we go from here? That's true for most of the tables.

So with that I think I will take my seat and we can get started on the validation set and go from there. Thank you.

MR. LONGRIDGE: You are going to lead that discussion on the validation set?

MR. BOOTHE: I guess. Can I do it from there?

MR. LONGRIDGE: You can sit down.

MR. ELDREDGE: Tom [Longridge], can I just say something?

All of the things that you are going to say here are going to be recorded. And next week when I get the copies of the transcripts, they will be sent out to all of you individually. And you need to go through them and make sure everything that you have said has been recorded accurately. And then get those back, it will go out in a letter, whether from Tom [Longridge] or myself, asking you to review the transcripts, to make any corrections or change things that we might have got wrong when we recorded it, then get those back to us. We will send out a letter with all of that. You will have a chance to review all the transcripts.

MR. BOOTHE: If everybody can find proposed validation test data sources in their book of tables.

Stu [Willmott]?

MR. WILLMOTT: Excuse me. I wonder if it would be pertinent to determine exactly what type of aircraft we are talking about. There are five families of aircraft. And I guess the first family is concerned with [Part] 121. And then there are four other categories, the last one being helicopters. For Part 135 operators, regional operators, are we talking about all four categories other than 121? In other words, helicopter, single-engine, multi-engine, general purpose, and SFAR aircraft.

MR. LONGRIDGE: I think we are talking about multi-engine turbo prop primarily.

MR. WILLMOTT: Second class, in other words aircraft between ten and 30 passengers and greater than 12,500 pounds, that's the class of aircraft we are talking about.

MR. TOULA: Not necessarily greater.

MR. RAY: I think that's generally the group that's provoked the discussion, but if we could come to grips with--sorry, Paul Ray.

THE REPORTER: I've got you.

MR. RAY: If we can come to grips with the issues, the validation data and the programming data, if that's the right word to use, would be applicable to all aircraft, excluding helicopters.

MR. WILLMOTT: One of the things I did to familiarize myself with the aircraft that we might be talking about is get a list of the aircraft and the numbers that are operated by the Regional Aircraft Association in their annual report, and there are 3448 aircraft altogether. Ninety-seven different types of aircraft, some are single, some amphibians, some helicopters, are we addressing all of those?

MR. LONGRIDGE: No, standard air carrier commuter. We are not talking about single engine. You have to remember we are also starting this discussion on validation requirements that are going to apply across the board. We are not trying to come up with a solution that will work for one aircraft, we are trying to come up with a set of FAA validation requirements at this point in the discussion that apply to all those aircraft.

MR. LEISTER: I don't think it makes any difference what kind of aircraft, Stu [Willmott]. I think they are going to be carrying passengers, commuter--they are going to be commuter type service in the future. I'm dealing with a 210 now and I'm having more difficulty with it than any of the simulators.

MR. WILLMOTT: As far as the aerodynamics are concerned with this type of airplane, the aerodynamics of the control surfaces are probably more important than the basic aerodynamics.

MR. BOOTHE: I don't think I would limit the discussion to any particular airplane, but the fact that we chose turbo prop from the IATA data, which addresses other airplanes as well, I think it's a strong clue, but that seems to be the major problem area for regional carriers who are having to upgrade to large airplane operating rules. So I think the focus I took was turbo prop smaller airplanes. But we have to consider Beech 1900--or is it now a Raytheon--

MR. WILLMOTT: 1900--

MR. BOOTHE: --on up.

When you consider, I read something the other day that in that particular size, that airplane has 90 percent of the market. I think it's 95 percent or something. But then we have got to look on up through people flying Jetstreams, 31s, 41s, we have to look at even into the ATRs. But I don't think we need to be too terribly concerned, although I would not want the results to not be applicable. But when we begin talking Regional Jets and Fokker 100s, and 737-200s, and airplanes like that, I think those are covered in a different area.

But if one were to choose to build a Level B simulator, after we are finished, for any of those airplanes, including a 777 or whatever, these same standards will have to apply. I don't think we want to set out and say we are going to have two sets of standards, one for people who can't afford it and one for those who can. Because that puts the FAA back in this often spoken two levels of safety mode, and I don't think that anybody wants to even think two levels of safety.

Whatever we do from a perspective of a Level B simulator will be applicable across all airplanes, air carrier service, even some that aren't used in air carrier service. If someone wanted a simulator for 210, then the same standards would apply. But I think we have focused on where is the problem area today, and that seems to be in the smaller turbo propeller airplanes that the regional airlines are currently using for which they are having difficulty finding affordable training devices. I don't think our purpose here is to really diminish any standards. Our purpose is to find out how to do them better and cheaper. Or equivalently but cheaper, if you will.

Did I answer your question or just get on a soap box?

MR. WILLMOTT: My summary is it doesn't really affect the single engine aircraft, we start off with the twin turbo prop as the basis and then those same rules would apply to the other aircraft? Tom [Longridge] is saying it's basically the second category of aircraft that we are starting off with.

MR. BOOTHE: You mentioned one thing that I think is important to these tables. I would assume that we are generally dealing today with reversible control systems. So that makes a difference as to how we might discuss some of these, but we want to be careful that anything we might include on Level B could also be used for irreversible systems. Now generally that's a real easy route, rather than the other way around. So that's a thought to keep in mind. We must keep reversible systems in mind, and I think when some of the standards were originally done, people only thought big airplanes with irreversible control systems and sort of overlooked--

MR. WILLMOTT: That's more important for the second thing, which is the aeromodeling, it's quite different from one class to the other. Stewart [Baillie] has just done a recent aircraft and of course he has done some of the turbo prop.

MR. BAILLIE: With that introduction, Stewart Baillie. I actually without prompts brought a couple of view graphs to describe and to show what level of effort is required to gather the ATG data set right now for Level B and where the effort is spent.

MR. DAVIS: If I can ask a quick question. I'm curious why we are using [AC120-]40B in the draft as a baseline, I assume soon [AC120-]40C is going to be law.

MR. RAY: We are focusing on B and below. Any changes which can be agreed upon will [be] included in a change to 40C addressing Level B and below. Level C and D will remain consistent with international standards.

MR. BOOTHE: That's an important point.

Do I have to say my name every time?

THE REPORTER: No, I know who you are.

MR. BOOTHE: Now I forgot what I was going to say. What we do here hopefully will not affect C and D unless for some very good reason. But that may result in the Advisory Circular needing some revision to talk about data acquisition, and what's acceptable at A and B level but not acceptable at C and D level. I don't know at the moment how to handle that, but I think I would put that aside until we look at this with Level B in mind and see what we can get out of this. But I think it's real important for the simulator evaluation and qualification people to stay quite attuned and remind us if there is something we are approaching that they find unacceptable, because I would hate to get to the end of two days and then a week later find out well, no, we can't accept that.

So I don't want to particularly beat on you guys, but I do want you to let us know as we go. I think that's real important.

I'm sorry Stewart [Baillie]. Go ahead.

MR. BAILLIE: It's okay. I just wanted to say my sort of background in this. When I first was aware of the problem, the question was how can we validate existing models? And so I spent the time just looking at existing model validation.

The trade-off there was the depth of the model validation versus flight test and data handling cost. Intrinsically that doesn't mean we are trading off model accuracy because I had taken as a given there was already a model we were trying to validate. Really we are dealing with level of training transfer, I don't know how that fits in this whole process.

With that in mind, I looked at a recent example, the aircraft is still on the hangar floor, of what it takes to do the Level D international test guide. Our data gathering was 67 channels plus some 20 odd discrete events. We had the aircraft in the hangar for six weeks. Of that period it takes nine days to do the flying. And so 21 percent of the time is actually gathering the data and most of the time is the installation.

So regardless of what we choose in maneuvers, the importance is minimizing how much effort you have to deal with the aircraft in installation and removal of sensors, the variety, I'm sure this is not new to anybody, these are from a previous program, the variety of data can be anywhere from flight data recorders, sensors already on the aircraft, installed potentiometers, brake pressures, control forces, that's the full Level D package.

I asked our instrumentation people what their ideas were on what takes time. Inertial is easy, you strap it to seat rails in the center of the aircraft, anything that is a computer, nosewheel steering computer, any flight data acquisition units, anything already on the aircraft is easy to tap onto.

What's more difficult is when you get in mechanical things, potentiometers, control positions, AHRS, attitude heading reference system, usually that's a little more difficult because the signals are kind of hard to characterize.

What's most difficult is oleos, trim tabs, anything you have to develop the installation. Those are the easy, most difficult and end up defining where the savings can be. If we keep it simple, you save time. But you are only going to save, like I say, 80 percent of the aircraft time. On the hangar floor.

That's all I wanted to say.

MR. LONGRIDGE: Thank you.

MR. WILLMOTT: Is it possible to get a copy of those?

MR. BAILLIE: I can get a copy.

MR. ELDREDGE: Let me see if I can get some copies made.

MR. BOOTHE: Thank you, Stewart [Baillie]. I think that's an important piece of information on his experience as to where he spent the time, and I'm sure there is others here who might, David Kohlman and Bob Heffley who might confirm or argue.

MR. KOHLMAN: I don't have any specific figure. All our experience, I think Daryl Schueler will concur, says those numbers are right on. The greatest part of your time and expense is installing, calibrating, and then removing. It takes much less time in terms of aircraft time to do the flying.

MR. LEISTER: I would like to add one thing to that. I think a large part of the expense of flight test comes from having to instrument the control surfaces, the elevators, whatever. When you come right down to it, when you build a simulator, you are building a box where a pilot is working with the control positions that he is used to working with in aircraft. And he does not know what an elevator or aileron or angle of attack is or anything like that.

I think one of the biggest cost savings could be released by not requiring surface positions, externally measured surface positions, things like that. I know most of you would argue with me about that. But I think I can build as good a simulator as anyone with just the internally measured positions, the control forces and positions, nosewheel positions, the rudder, pedal positions and forces, what the pilot actually feels and perceives in the actual airplane cockpit, rather than the externally measured things.

And I'm not advocating building the model without rigorous aerodynamics. You have to do that, you have to build a good aeromodel, but you do not need the externally measured parameters, I don't think.

MR. DAVIS: Well, I disagree in some respect. I think if the premise is we already have a model, I tend to agree with you to a certain degree.

MR. LEISTER: Even if you don't have a model.

MR. DAVIS: If you don't have a model, I challenge anyone to come up--

MR. LEISTER: You can derive the hinge moments that will drive the surfaces, the positions in the cockpit to be what the pilot feels or however far the positions move in the cockpit in the airplane. You can derive that from the flight test data without knowing what the elevator, the rudder or aileron is.

I worked at flight safety years ago when we didn't have the luxury of flight test, getting flight test data other than going out and getting video data and hand held force gauge, very crude measurements in the cockpit. We learned to derive a pretty solid model from just what the pilot is looking at, what he is feeling, what he is seeing, rather than the typical aerodynamically measured thing.

MR. BOOTHE: Bob Heffley has a comment.

MR. HEFFLEY: Yes. I think you must know what the correlation between cockpit control and surface is.

MR. LEISTER: You have to be able to measure the cockpit control.

MR. HEFFLEY: But the cockpit control can be quite nonlinear.

MR. LEISTER: Absolutely.

MR. BOOTHE: What I would like to do is incorporate those thoughts, I don't want to cut anybody off, Chuck [Stocking].

MR. STOCKING: That's all right.

MR. BOOTHE: Go ahead.

MR. STOCKING: I was going to say I recently have done a couple of programs where we did an entire aircraft from scratch, and to develop the control laws we went out and we measured the airplane, and that was the substantive--we defined the control laws exactly by measuring the aircraft, even cable stretch. I put on the gust locks and went through the airplane exactly, saw where the stretch was until we had a reasonably accurate model to use in the simulator, what we miss, those little fine details went into the coefficients. So--

MR. LEISTER: That's what I'm saying.

MR. STOCKING: What I'm doing is replacing not having access to the airplane data by having access to the airplane to develop those models. It worked quite well.

MR. BOOTHE: So what you are doing is measuring the cockpit control displacements?

MR. STOCKING: Right. Calibrating the airplane before we go, basically. Defining the control laws.

MR. BOOTHE: You probably will find some thoughts like that through this table. I didn't advocate that we not measure control surface deflections, because that's the sort of thing that comes out of the kind of discussion we are having. I know I have got to get some forces to feed back to the control loader from someplace, it doesn't necessarily mean I have to measure at the surface. So I think those thoughts will flow out as we get into that part.

But while we are beginning this table, if you--hopefully you have had some time to go through it. One of the things I did do was when I said minimize instrumentation, one of the things I did was try to shift some thoughts to some steady state measurements and try to avoid having to have an active measurement of angle of attack and sideslip. Now that may not be successful, but you will see those thoughts through this paper.

And one thing that you will find as we go through is I have added a whole lot of trim runs that are not normally required in the validation, thinking that if I had enough good trims at various configurations and speeds, and level flight, perhaps I could correlate angle of attack and not have to measure it in active maneuvers. Now I may be all wet, but that's something that I've done in this table. I didn't address not measuring surface position and I did say if the airplane has flight data recorder sensors, then there is a sensor and we need not replace it. The flight data recorder itself is a pretty low resolution device, but Stewart [Baillie] tells me that's not true of the sensors. So perhaps there is a source and I would incorporate thanks to Stewart, those thoughts here, too.

So maybe as we go through we can stumble on, excuse me, stumble onto those very ideas and put them into the right place as we go through the table. I would like to just go through it, unless you would like to do it in a different order. I mean, as long as we cover the whole thing.

MR. KOHLMAN: May I say one more thing that I think applies to all of these conditions that we are going to be looking at here one at a time?

I think that echoes what Dave Leister is saying. We are trying to reduce cost, and so the question is not necessarily do the data exist, but do we want to require the effort and expense to match more parameters than we really need? And I think a rule here ought to be that it doesn't make sense to force a validation match of a parameter that in the simulator does not physically exist and the pilot cannot perceive it, such as control surface position. It doesn't physically exist in the simulator. Now I think as an aerodynamicist you have to compute it at some point in the loop, but the pilot doesn't know it's there. So whether we have it or not, why require the extra expense of matching that and other parameters that are only in the computer but don't exist for the pilot.

The goal is to make the pilot perceive the simulator as closely as possible to the airplane. And so we should only require matches of parameters that he can see, read, feel, and as another guideline, only to the resolution that the pilot can perceive and read on his instruments. To require more resolution is requiring something that is going to be transparent to the pilot.

MR. SMITH: That's correct. And in a lot of respects. But I think the philosophy has been that the ATG just present a limited number of cases in which we match it with flight test data, and the attempt has been if we rigorously check these few cases, then it would match the airplane throughout the envelope. And the purpose of doing that, probably the philosophy incorporated, has been that you have to make sure say for correct aileron effectiveness, that the sideslip is correct. In this particular case you are checking you may have a lot of sideslips, and aileron effect is right, because other cases in the envelope where you may only have sideslip and get roll due to it, or cases where you are rolling with aileron with zero sideslip, maybe keeping very coordinated with the rudder, those points would also match because it's possible in a few test cases that you have the aileron effectiveness off one way and the roll due to sideslip off in the opposite direction, granted there are other checks, checks in sideslips to verify the static, basic aileron effectiveness, but there are many other terms in there that I think the philosophy has been we feel more comfortable if the model replicates the airplane.

MR. KOHLMAN: I think that's a good point. If we don't have enough matching points within the envelope, you can force fit the model to match the isolated discrete points and it won't be correct with the other ones.

MR. BOOTHE: I don't think that Dave [Kohlman] was suggesting we not have those measurements, I think he is suggesting that we derive them from a different source rather than literally measuring them.

Is that correct? You have got to have them to develop the model.

MR. KOHLMAN: That's correct.

MR. BOOTHE: But you can get them, according to Dave [Kohlman] and Dave [Leister] and I think Chuck [Stocking], too, by means other than direct measurements.

That's really all you are saying, is that not true?

MR. SMITH: Well, you get the effect of them by doing what Dave [Leister] says, measure the cockpit control positions throughout all your testing and you can do that. And this kind of leads into something that, you know, I'd like to say a little bit, our overall objective is to, you know, produce a device that the bottom line regardless of what we say, FAA Level C or D or whatever, it winds up having to be acceptable to the trainee as a device in lieu of the airplane. And no matter if we, and I think Dave will attest to this, if we build a device and give an FAA qualification and the operator starts using it and all the pilots go through and complain "this thing ain't like the airplane," your training goes down like mad. Most operators will do something about that.

Probably a case of that is probably the biggest training operator, independent of the operator of the airplanes, is constantly updating simulators. In the last five years I have noticed they have gone out and done new test programs in order to get a better set of data in order to get it to match the airplane better. That's the bottom line.

What we have done typically over the years is require a lot of objective testing. Here again, you have to go to the subjective evaluation, if you get a lot of objective data and sit down with the pilot and even the inspectors and show them that all the objective data matches, when he comes to a point that's questionable, he doesn't feel--he may even want to revert to asking someone who is more experienced, more current in the airplane, or maybe going and checking it in the airplane. It's not like the airplane, because subjectivity is a very difficult thing to do.

But what it does is, having all that objective data match, it kind of, I don't want to say intimidates, but it alerts him to the fact that he should be real careful when he evaluates this thing, if you have a question, check with someone else, get another opinion or two. Expert opinion from someone from the airplane. And I guess it's difficult to say, you know, what is required to do that.

And we talk about modeling data and validation data, and essentially it's all the same in a way, you get one set of flight test data, even if you have coefficients, predicted data, you are going to use the flight test data to extract from it however the classical or other means to validate your predicted data and come up with basically flight test correlated coefficients, and then you turn around and put them in the model, you turn around and match them to the same flight test time history data or static data you have. It's basically the same data, but how well you match that flight test data is, like I say again, the first step to get a simulator that's acceptable. And it's difficult to say. I guess the people who are in the business of doing this pretty much have to determine, you know, how they are going to get that data. It's difficult, I guess from my perspective as a regulator, to say you have to get this data this way. Of course we have done that, but they have the ultimate responsibility to match a set of data, then that pretty much dictates what kind of methods they are going to use or what kind of data they are going to get to do that.

Maybe--Dave brought up a good point, that we can possibly require, you know, not require matching of control surface, and maybe put more emphasis on matching cockpit control positions and forces.

MR. BOOTHE: Thanks. I don't think anybody here is suggesting a less rigorous process. I think the suggestion is, is that we look at a less labor intensive, a less costly way of getting to the same end. And in the end you still will have the data that you are concerned about, it's just that some of it may not be direct measurement.

Is that a true statement?

MR. KOHLMAN: I think so.

MR. BOOTHE: You still have to have those variable values to generate the model and then you have to have the validation data. But the point I could add, we want a simulator always to stimulate a pilot for a given task as the airplane would stimulate a pilot. So that's a thought that I keep in mind as I think about these things, if I can't produce the correct pilot stimulation, then something is not right with the simulation.

And all of us Stu's [Willmott] and my age remember those contemptible simulators we had to fly. We certainly don't want to revisit that. So we are not here to degrade the quality of simulation in any respect. We are here to try and find a cost increment by doing things better.

MR. RAY: I would like to amplify what Ed [Boothe] said and what Hilton [Smith] was touching on, can the FAA reasonably accept validation data that is less comprehensive than what is currently required for a Level A or Level B simulator. The answer among the people we see in this room is undoubtedly yes. How does that float with those not in this room? That's the issue we have to wrestle with.

The thing we cannot do in good conscience to anyone is to back up to those days with the data requirements and measurements that we applied to those contemptible simulators of a number of years ago. Such a device was the topic of a conversation Gerry Baker and I had last night. If you put the flaps down, the pitch was wrong, totally wrong. We can't throw the baby out with the wash and revert to those type[s of] devices.

How do you quantify that process that you go through to include the rigor required so that we can achieve the desired product with only internal cockpit measurements? As far as validation you have to have something in place I think to ensure that foundation is still there so you don't back up 20 years in time. We can't afford to do that. That's our concern. Can we alter the validation? The answer is clearly yes. How do we do that? That's the issue on the table.

MR. WILLMOTT: I don't have a copy of [AC120-]40B in front of me, but I thought it used to say control surface or pilot control, as far as that is concerned.

MR. LEISTER: Yes.

MR. WILLMOTT: And I would whole-heartily agree with Dave [Kohlman] and Dave [Leister], that you could replace the surfaces by the pilot controls and you can replace angle of attack, because that comes about from the pitch attitude and the flight path angle, but for the class of aircraft we are thinking about here, sideslip I'm not sure about. When you have got slip streams from the propellered aircraft, even in symmetric flight, if I can call it that, generally you have sideslip. And although there is nothing that the pilot can see normally to measure it when he is on approach and doesn't have a crosswind, he can see if he has a sideslip or not. I'm not sure what we could put in place of that. That's important for verifying a simulator.

MR. LEISTER: I would question how accurately can you measure sideslip angle? Especially in a slip stream, you can't do it. It's a nebulous term really.

MR. BOOTHE: Let me hear Chuck [Stocking] and then I want to comment on that. We will press on.

MR. STOCKING: Go ahead. I was going to--

MR. BOOTHE: Let me say in this table I have pretty much eliminated measurements of angle of attack and sideslip. Did I do it correctly? Did I do it well or did I screw it up? Excuse my language, but that's what we have to dig out.

Also, if you look at page 6 of the validation test data, I just--I'm not going to start here, but I want to refer you here to, temporarily, to right at test No. 2.a.(1), these are the same test numbers used in the Advisory Circular, column position versus force. If you look under the proposed test technique, I have sort of addressed the very thing we are talking about here. And looked at using flight data recorder sensor or something similar to what I think Chuck [Stocking] suggested earlier, select control positions measured on the ground, using a surface measurement protractor, there are devices for doing that sort of thing. So that we have some numbers to go with the elevator position versus the cockpit controller position.

Now what I didn't do was work in cable stretch and those sort of things. I'm sure our ingenuity can figure that out, but I have incorporated some of these thoughts and I don't want to get our cart in front of the horse and just dwell on this one thing. I would really recommend we go through the table test by test and then as we go through them, maybe one will relate to another. And we can come back.

But I am happy to say that my thoughts aren't too far off of yours on this subject because I have tried to look at some ways of eliminating some of the difficult measurements.

MR. STOCKING: There are factors within the industry, Stu [Willmott] has a list here of 97 aircraft, there are factors that are outside of aerodynamics, if you will, that will affect what we do. One of them is the change in the capacity of the computer. I now have a home computer that has ten times the capacity of the simulators I built ten years ago.

The other thing is the cost to build a simulator. The approach that we are taking in an experimental program within our company is we want a program that will simulate all 97 aircraft without change, without changing a line of code. Now that may seem ridiculous, but it's really not. We are falling back on making theoretical models that have all these factors embedded in them, we need control surface position, we need angle of attack and all those positions. But when you go to validate what you have done, all you need is what you have seen in the cockpit; right? And collecting the data to put in there, we now have great engineering tools, like Roskam's model, you put in the geometry of the airplane, it gives you a coefficient. Then you validate it.

You are looking at it from the cockpit, which is just the answer, you don't know all the component parts. We have developed a theoretical model that has all the component parts and then we see if the answer is correct. So these factors are going to influence what we do. That's all I want to say. Look at the big picture, because there are forces driving us to develop these models that will be used on airplane after airplane, they will be refined, corrected as we go along. Real high fidelity models, much higher than we are using now. That's what it takes to lower the cost and improve the simulator.

MR. LONGRIDGE: But you still have to validate the models. The question is, what of all the things you could validate are you going to validate.

MR. STOCKING: Within the cockpit, you are going to look at what's in the cockpit in greater detail than you are now. I need real good accurate control positions, I need real good accurate forces, you will concentrate there instead of all the pieces all over the airplane. There is things you will--well, it's a complex problem.

MR. BOOTHE: It is. And I don't know how to address it except one piece at a time. But what you are saying is the guy who was asked, how do you fly that great big airplane, it's such a massive thing, you just fly the cockpit, the rest of it follows. And that's sort of what we are going to do here, is fly a cockpit. If that's the solution, then that's what we need to think about. So, I mean, I never flew from the tail. Ken [Neville]?

MR. NEVILLE: Ken Neville. I guess I have a little concern about simplifying the models to the point where the aerodynamic characteristics would not be a function of these pieces that the pilot can't see. It's true he doesn't know where the elevator is, but the aerodynamic characteristics physically are a function of the elevator. They are a function of angle of attack, they are a function of pitch rate, so when the pilot applies a force to the column, these things are happening in various combinations. And if you try and bypass that and just make the pitching moment be a function of column position, that might work for a specific maneuver. As Hilton [Smith] pointed out you can match one test that's required in an ATG, but it may not match anywhere else if you don't have these pieces modeled correctly.

MR. BOOTHE: It's not my understanding we are not going to have those things.

MR. LEISTER: You misunderstood. The model is as rigorous as it ever has been. You just drive the various things like hinge moment, coefficient, whatever, that will drive the cockpit position and force to be correct. The model is as rigorous as ever. You have to drive all that stuff.

MR. DAVIS: You still model surface. Nobody has insight as to what it is when you have a wheel position you get right. What happens in a malfunction state? Again we measure wheel, we measure roll rate, things match, we don't know where the other surfaces are. In this case if one of the surfaces locks out, how do we know they are where they should be and the effect is correct?

You wouldn't know the aileron, you are in the right spot--

MR. LEISTER: You wouldn't get that in a flight test--

THE REPORTER: Gentlemen.

MR. DAVIS: --you wouldn't be able to establish that you are getting the right spot, in that instance you can still debate whether each surface is correct.

MR. LEISTER: There would be no difference, you are still modeling all these entities. Your aileron, spoiler, whatever, are not going to be based on flight test data, you don't have flight test data, there is no reason you can't still rigorously model that. Whatever.

MR. BOOTHE: I think there is some misunderstanding here already.

Stu [Willmott]?

MR. WILLMOTT: I was going to say I don't think anybody has suggested doing anything as far as the modeling is concerned. What we are doing is addressing the subject, which is validation testing right now. And this is a way of reducing the number of parameters that you have to compare and everything else. To some extent what we have done is say okay, we can do that cheaper, but we still have got to get all of those things for the purposes of doing the modeling. To some extent we may not see much cost [difference], but we certainly have fewer problems when you don't have to compare so many variables when you are validating the simulator.

MR. BOOTHE: Or you don't have to, I think where the cost saving is, you don't have to instrument and collect those variables in the flight test if you have an alternative means of identifying them and assigning them the proper value and using them in the model. Is that not what we are saying?

MR. KOHLMAN: I think there are two scenarios here. One you start with an airplane that you have never modeled before. You have to go out there and instrument the control surfaces. I certainly agree you can't build the model without that. But having done that, then the cost of validation is a function of how many of these parameters do I have to sit down and match? Even though you have the data, I'm saying we can save by not having to match a lot of things that the pilot can't see or experience directly. Now I think they are going to match pretty closely anyway, but we are trying to save time and effort.

The other scenario is we already have a model for a Level 5 or Level 6 training device and the customer wants to upgrade to Level B. Then we go out and do just the validation flight test and we would like to get away without having to instrument the control surface and do the matching. Perhaps we will have to fine tune hinge moments and control surface effectiveness, but we don't have to instrument and measure them to upgrade to Level B.

MR. BOOTHE: I guess I agree. I refer you back to page 6. I almost said that, not quite, so I think if I could just summarize that point, that there is no intent to not have those values, those parameters included in the model. In fact if I understand modeling at all, you have got to have them, otherwise there is going to be some real missing links. If we don't know where the surface is and we don't have a reasonable estimate of the hinge moment, then you don't know what to tell the controller, so I won't know what the cockpit forces are.

So you cannot not have it, it's just a question, as Dave [Kohlman] said, of a direct measurement and a direct comparison for validation. Why can't we use another source and another measurement that's more directed?

MR. KOHLMAN: That's correct.

MR. BOOTHE: Stewart [Baillie]?

MR. BAILLIE: Stewart Baillie. In keeping with that idea, the original process we have for approval test guides ensure that we are modeling all of the variables by matching most of them, as you were saying, Hilton [Smith]. With a reduced matching set, how does the FAA have the authority to say I need to check to make sure that the model has those parameters in it? You have said we will do this, we will do this, but the fact of the matter is, unless you guys have a regulation that you can use unfortunately as a club, in the long term you will get simulators out there that don't have those terms. And so the question is, are you going to add a regulation that says in addition to matching these maneuvers, you have to demonstrate that? Yes, angle of attack is a function in your model, and your elevator control surface position is a function in the model, how are you going to address that? Because otherwise you will get the Microsoft simulator that's been tweaked to match the ten or 20--

MR. BOOTHE: That's already addressed, I think, in the Advisory Circular. And that does require some measurement of surface position in some cases and angle of attack and sideslip. But for Level B, and trying to look at how can we maintain the fidelity, if you will, and lower the cost, we try to eliminate some of those measurements, we can't get off that subject to get through here to find out where those things are. And so I think that this table reflects some of those thoughts, but again I want to be quick to say they may not be in the correct places and they may not be the correct thoughts, so it's our job to straighten that out now.

But I think that thought or that philosophy has been partially addressed here at least. As I said earlier, I have tried to eliminate sideslip and angle of attack measurements, I might have done it erroneously, but nevertheless that has been my approach. I have tried to take, you got the Ed Boothe cheap data collection. When I say cheap, I don't mean American cheap and poor quality, I mean British cheap and low cost. So I have already tried to put some of those thoughts in, and so I'd like to suggest we go through here and find out how they will affect us and whether or not we can do these things.

Again, I did some trade-offs like that to trade off angle of attack, as I said, I added a bunch of trim lines, because I think in level flight I can get a correlation that will convince me angle of attack is okay to model if it matches those conditions. I have added some things and taken away some things. But the total package is still here addressing each and every test in the Advisory Circular now.

If there are some of those tests we should argue about and perhaps suggest eliminating, I think we can grope into that too, I think that's what we should be about.

MR. SMITH: Could I ask Dave [Kohlman], when you were talking about some of those parameters you wouldn't have to match, were you referring to not having to match and show presentations in the ATG? You would have to match those parameters, wouldn't you, in developing your model?

MR. KOHLMAN: Well, let me give an example. Just Monday I did a flight test for a Lear 35 for a training device. And I collected about 15 different data points with fish scale type force, video camera, and noninvasive physical measurements in the cockpit: control position, wheel position, pedal position. I didn't know what the rudder position was, or the aileron position or the elevator position. And I knew the stabilizer position just from reading what the pilot could read.

We are going to take that data back and match all those points with the training device. And if they all match within the required tolerances, the FAA will approve that as a training device. And I'm presuming as an aerodynamicist, that those control positions are reasonably accurate, even though I didn't measure them, if everything else is consistent and the model is based upon the full airplane set of parameters.

MR. SMITH: But in your model or your data analysis you will take those cockpit control positions, go through the gearing curve to determine where the rudder and ailerons are, so that's the control surface positions put in your model in order to do your modeling rigorously.

MR. KOHLMAN: The modeling has been done, we don't have to do any more modeling unless these don't match.

MR. SMITH: But the model itself will have to know where the aileron and rudder is.

MR. KOHLMAN: Exactly. At anywhere in the process the simulator is computing and will print out what the control surfaces are doing. I'm not recording them nor am I required to match them, which is going to cost a lot of money, much, much more than the pretty low cost flight test--

MR. SMITH: I agree with that on a control surface position. But like angle of attack and sideslip, it seems like you have to know a little, because there are a lot of functions, systems that require angle of attack or sideslip, maybe stall warning, stall horns, things like this are programmed specifically as a function directly of angle of attack.

MR. BOOTHE: They are in the model though, they have to be in the model.

MR. SMITH: You have to know what angle of attack is, in relation to the other parameters, in order to make the stick shake.

MR. LEISTER: You can derive that from the data.

MR. KOHLMAN: Indirectly I do get that. I did a bunch of trim points where I can read pitch attitude on the artificial horizon, then match it.

MR. BOOTHE: Exactly. That's what I incorporated here.

MR. RAY: One comment. Stewart [Baillie], you made the comment earlier, about the Microsoft. That's the "me toos" of the world, they will come to the FAA, say "trust me, I got that off the airplane on this day, trust me, I went to Microsoft and bought my $39.95 program, slapped it in here, and it works." That's the motherhood statement process I think on the fidelity of the model you already have, that layers in on top of this. If we can come up with, we can go through this, but there is a side issue we need to address at the end, which is that motherhood statement, whatever you want to call it, that goes in front of all this, the ethics that reside in this room on how you do that, from point A to point B, we are not trying to exclude the "me toos" of the world coming in, we are trying to encourage that.

But if they are going to get in this arena you better have a process that can give the confidence to the regulators that that device you are building in fact performs the function it's designed to do. If we don't have that process or motherhood, then this is a wasted effort. And I want to make sure we quantify that assumption that's underlined, I'm convinced we can do this.

But the other piece of it is, I hate to refer to it as motherhood, but that's basically what it is inside of this room. To me it is. I will shut up.

MR. SMITH: Let me add one thing to what you said. You are right. Even though they get our acceptance, the FAA's acceptance, that's not the final test. The final test, when this thing goes into service, if it don't fly like the airplane you are going to find out.

Isn't that right, Ed [Boothe]?

MR. BOOTHE: That's right. But I remind us all that I began this discussion with no sacrifice of rigor and no sacrifice of quality. And so when we get to the end we need to have satisfied those requirements.

What we are trying to do is look at how to maintain that rigor and that quality with less cost. And if it is proper and rigorous and of high quality, to shift some measurements from one place to another, to do things simpler, to do some hand held flight test techniques, then I think that's what we ought to address. So I would ask us to keep these thoughts in mind the last hour, and as we go through this table, because we are not here to, as I said, revert to contemptible simulation. I suffered through enough of that, I don't want anybody else, I've been a victim, if you will, and I don't like being a victim and neither does anybody else. So we are not going to sacrifice our simulation quality.

We know what the standard is, to stimulate the pilot correctly. I think it's just that simple. But it doesn't mean that we have to keep doing things the way we always did them to accomplish that end. And so if we can keep those thoughts and go on through and look at these techniques and discuss them and then at the end, look at the overall package, I think that would serve our purpose a little better. So let's just start at the beginning of the table. Page 1 on.

MR. TOULA: The upside down one or rightside up one?

MR. BOOTHE: I guess you open the book at the middle, turn it upside down and work from the right. I thought the Japanese were pretty smart about that, I have always picked up a magazine and thumbed through it with my left hand from back to front, it seems to work nicely. I have to read the end of an article before I read the beginning. The Japanese do magazines that way. It's a nice idea, but I didn't know we would pick it up here.

The first thing there is a minimum radius turn, I don't think there is any need there for anything but what's in an AFM or ops manual, nothing else required. I think that's probably what we are doing now. So unless there is some further discussion, I think that's fairly accurate stuff in an AFM. Gerry [Baker]?

MR. BAKER: Most of them came out of an operations manual.

MR. RAY: If I could throw a comment in on the Level 6 FTD. I would agree it doesn't necessarily have an impact on a Level 6 device unless you raise the ante and have visual systems attached to a device. The potential impact would be increased if a visual system is added on the Level 6. Lacking the visual, does it react reasonably on the ground as opposed to the old skidding ice routine?

MR. BOOTHE: But that's no different than what you would expect now.

MR. RAY: No, that's true, it just becomes a player, that's all.

MR. BOOTHE: Next is rate of turn versus nosewheel steering angle. I have taken again a simple position there of how we might look at that without extensive instrumentation. And perhaps you can give me some feedback. I've just put some sort of protractor on the tiller and suggested video to record a steady state measurement. I think the video is fine in a steady state condition. That's a steady state measurement, anyway. I think one could come up with a quite accurate measurement for different nosewheel steering positions.

Now if you want to relate the tiller to the wheel, to the nosewheel itself, then I think that's really sufficient to use what's known about the gearing in the airplane. Truly there is some backlash and bending and torsion, but is that significant for that test, I ask you?

MR. BAKER: You are obviously assuming you have a power steered airplane. You have a lot of airplanes in the category you are talking about that are mechanically steered airplanes, some--force is a major impact, you have some that have very strong forces to move the airplane. I'm not so sure you shouldn't consider some type, if you have an airplane with force pedals, you should consider some type of force input.

You take a Beech 1900, Beech has an optional power steering, but 99 percent of the airplanes don't have it. And your steering--it's not a simple thing. Steering in a two engine operation is nothing like steering in a one engine operation, some airplanes you can't hardly steer on one engine unless they are powered. There are a lot of variables. I think you have the simplest case here, is what I'm saying.

MR. BOOTHE: Are you suggesting, Gerry [Baker], we should add a force measurement from both the tiller and a rudder pedal?

MR. BAKER: I think you have to consider the airplane you are working on. Some of the Fairchild airplanes, the old ones, had tillers, the new ones don't have tillers. A lot of airplanes are that way. So I think you have to start with what airplane, what configuration are you looking at here. And the test techniques and measurements would have to vary, depending on the type of steering system.

I think there is probably a simple way to do it, but I think you need to consider all of those matters.

MR. LONGRIDGE: So we would change it to say if not power steering, then we need force input measures appropriate to the aircraft steering system.

MR. BAKER: It's one of those things where it would sure be nice to have, say a mechanically steered airplane with no mechanical steering rudder pedal position, rudder pedal force.

MR. DAVIS: I think there is a lot of merit in that, but the question in my mind is, is that going to increase the requirements?

MR. BOOTHE: Not necessarily. I think Gerry [Baker] is saying--

MR. DAVIS: It is if you have to start matching force now.

MR. BOOTHE: That's true, but if that's what the airplane has and we need this information, then we have to address that airplane.

MR. BAKER: If it takes 100 pounds of rudder pedal force to turn the airplane and you put ten pounds in the simulator, the simulator is never going to get past the customer.

MR. DAVIS: Absolutely. I think it's checked qualitatively now and I think we ought to leave it that way.

MR. WILLMOTT: I think the original purpose of this test was to check steady state turn rate versus steady state nosewheel, that to my knowledge is always what it has been there. But over recent years we have tended to make it into a nosewheel response test, not by rudder pedal, by tiller input. I wonder if we want to clearly define what we are checking here.

MR. BOOTHE: Later on when we do control force and position measurements, then there is a requirement there to measure rudder pedal forces. So if we look at the total package we are going to have to somehow be prepared to do that anyway. And if you have got to put a force transducer on the rudder pedal for the other test, then you have it for this test. So I don't think we are adding anything, necessarily.

MR. BAILLIE: Taking part of what I heard Stuart [Willmott] just say, I will probably ask this question on each maneuver, so I will just say it once, the one question I have is how does this maneuver apply to what current training is supposed to be doing? Is it essential that the pilot knows how to taxi the aircraft through recurrent training?

A lot of maneuvers, you look at them, they are validating a simulator, but if the task of that simulator is not around that maneuver we are wasting our time and wasting our money.

MR. SMITH: Except that even though that's not a training maneuver, if in the process of training he taxies the airplane around and it's significantly different from the airplane, that's going to throw him off.

MR. BOOTHE: Maybe it would be a good time, before we have a cup of coffee, for Tom [Longridge], if you don't mind, to give us a generic scenario of a line-oriented evaluation under the AQP and let's see what a person has to do to relate these training events that Stewart [Baillie] is talking about. Because it's my understanding an LOE can have a great amount of variation and it has random events which may or may not occur in the next--could you give us a summary of what one is?

MR. TOULA: Not just LOFT, Ed [Boothe], it's a proficiency check.

MR. LONGRIDGE: I think the point is that I mentioned earlier, was that an AQP, we conduct scenario-based evaluation so the individual is going to go essentially through and be evaluated for pass/fail purposes. I think in that context fidelity is an important consideration. The individual can always say of course I couldn't perform in this thing, it does not fly like the aircraft at all. In a scenario we are talking about from pushback to docking, it's a complete scenario. I think from my perspective we want to see the fidelity in the flight simulator all the way through.

Now your point with respect to recurrent training I think is an argument that would apply to an FTD where the fidelity may not be important for the task at hand, it's not a requirement for the FTD. When we come to a scenario based pushback to docking assessment system, that's where we are going to see it.

MR. BAILLIE: If that's the case, then you want the exact fidelity of a Level D simulator and you are only going to get it by using a Level D simulator. We have to--I would propose you have to stand back and say this simulator is not going to be as good because of the role that it's going to be used for.

MR. LONGRIDGE: I think you could get into a philosophical argument in that regard. We are taking the position that the current existing regulations that apply would continue to apply in the context that we are looking at in the future. Namely you are permitted to use a Level B with its existing level of fidelity for 100 percent recurrent training. You can use a Level B for scenario to scenario based level training. What we are looking for is an equivalent capability in the future with hopefully a more affordable device that emotes the same standards of quality.

MR. KOHLMAN: Could I make a comment?

I think Stewart [Baillie] took the words out of my mouth, as to what are we going to use this Level B simulator for? If we are not going to use it for Level D type jobs, which is gate to gate, and everything has to be just like the airplane, if it's primarily to help the regional airlines meet the new requirements and it's primarily for recurrency training, then we ought to really focus on quality and fidelity in the areas that are important for recurrency training. And those are the things that the pilot doesn't get practice doing every day when he is flying the airplane.

He gets to practice taxiing every time he is in the airplane. I'm not saying it should be way off, it's going to have to be good when it's accepted, but it doesn't have to be matched.

The things that should be matched are the critical training problems such as V_1 cuts, and the multiple systems fail situations you can't practice in the airplane. That is, where you are going to do the recurrent training. Don't spend a lot of time and money matching things that he gets practice doing every day and are not critical.

MR. LONGRIDGE: But I think the FAA already made that distinction with respect to allowing you to use a Level B versus C or D.

MR. BAILLIE: If that's the case, why do you even worry about the taxi model? Every case costs money, mostly in effort.

MR. TOULA: You have to worry about that, outside of AQP taxiing is a requirement, if you are doing proficiency checks in a training program, you have to do one of those basically every six months unless they are all in training. So the requirement for taxi is there.

MR. LONGRIDGE: It's there in AQP, too.

MR. WILLMOTT: It's all part and parcel of takeoff.

MR. BAILLIE: Let's match it in the takeoff.

MR. WILLMOTT: Well, this turn rate is a low speed type of takeoff in a crosswind.

MR. LEISTER: You better have two or three of these tests in there for different speeds.

MR. RAY: It could be your tolerances are different. Let's not get hung up on what we are actually testing here. As Gerry [Baker] says, if you have a hundred pound force required on a given aircraft for rudder pedal steering or nosewheel steering, is ten pounds in the simulator reasonable? Clearly not. What is a reasonable tolerance, is it within five pounds.

MR. BOOTHE: I can tell you my legs and feet are not going to notice the difference between 90 and 100.

MR. RAY: I agree.

MR. WILLMOTT: I think some of these things we have already in Appendix 2 or Appendix 3, subjective evaluation, where certain special aspects of an airplane like the bungie forces on the Beeches, Cessnas and a whole lot of others, are important, would be assessed by the pilot doing all these subjective evaluations. This particular test dates back from the days when simulators didn't even have the right turn rate for a given nose wheel input. The purpose of the test was to ensure if you put a given amount of pedal or tiller in, you got the right turn rate. We weren't even in the right ballpark in the early days. This has grown from that to a point now where we tend to use it as a dynamic test for the nosewheel steering system. And I don't think it was really meant to be there. I think that perhaps can be a subjective evaluation on the part of the pilot.

And as we said, we don't want to make these requirements more complicated than they exist right now for Level B.

MR. BOOTHE: There has been creep. I think that creep has probably been on both sides of the fence, but what you are suggesting is let's really go back to the original intent here.

MR. WILLMOTT: Nosewheel tiller versus turn rate.

MR. BOOTHE: Or the rudder pedal position.

MR. WILLMOTT: Or the rudder pedal position.

MR. BOOTHE: Forces will get picked up at another point. So we have to do that anyway. But for this particular test, I don't know that we need to really mention that, do we? We do need to address rudder pedals, if that's ever the steering mechanism, and we maybe need a comment to say as applicable to the particular airplane. But do we need to add something here that we are going to do somewhere else?

MR. RAY: The point about the subjective, in many cases that's overlooked unfortunately, we don't have the benefit, with most of the initial evaluations, of the expertise that we have with Gerry [Baker] or Gene [Bollin, FAA, Aircraft Certification Office], or somebody [else] from the certification office. We just don't have that level of expertise on our typical evaluation.

In many cases we are down to that pilot with that airline who may have a bias going in, a training department that needs to use it 30 minutes after we stop the evaluation. If there is a reasonable objective measurement that is not intrusive, without driving the instrumentation cost out of sight, and we can do it with gauge only rudder pedal, then it's reasonable to do, I think.

Is it an added test? Maybe. But is it reasonable, does it contribute without driving cost on the data acquisition end. I think it's reasonable.

MR. LONGRIDGE: That was an excellent discussion. But we are five minutes late for our coffee break. I suggest we take 15 minutes and reconvene at a quarter of.

(Break taken.)

MR. LONGRIDGE: We are going to continue. Let me say it was pointed out to me that some people had comments, raised their hand, weren't called on. If you have something to say, raise your hand high so whoever is leading the discussion will be sure to call upon you.

MR. BOOTHE: Thanks, Tom [Longridge], if I did that I apologize. I didn't mean to not recognize anybody who had something to say.

A couple of points came up during the break that I think are worth thinking about. We are looking at the validation tables, so let's assume we have a model and the simulator works, we are looking at validation, we hope to get to the modeling table, I'm not sure we will, but let's just go on the approach we have a model and we are validating it.

The other thing I think is worthwhile here is just taking a quick page-through of this table, so that we know what's coming and we don't try to bring things forward that maybe we will be looking at later. So it does follow the Advisory Circular, but there is no reason why everybody here should really be familiar with the Advisory Circular. So let me just step through it.

There is two main sections, those are typical airplane stuff, performance and handling qualities. We are starting in the performance part, we are in the taxi block. From there we go to the takeoff block and a lot of the same argument might apply. I'm not going through those tests one by one, but just to see what's ahead of us, there are a number of tests in the takeoff block ranging from ground acceleration to rejected takeoff.

Then we have a climb block, which you know is typical of normal climb, climb with an engine inoperative and so on. And then at the end of the performance section we will get to stopping or decelerations.

Then there is a little block on engines, which is really nothing but an acceleration and a deceleration under the flight conditions given in the Advisory Circular, which I don't recall offhand, but I think they are like takeoff and approach. So as we go through those, you will see things in the takeoff section that might address some of the issues in the taxi section, so we have to look at the total package.

Then we move into the handling qualities portion of the table, and the very first thing it says, control checks. So there is where we would find some measurements that we would likely apply to the taxi case, but we happen to be doing them in the static control checks where we measure force versus position of the cockpit control systems and correlate that to some surface positions. How we do that we will discuss as we get there.

Then we have the longitudinal handling qualities, for those it addresses things like effects of various configuration changes, like flaps and gears, it addresses trim cases, maneuvering stability, static stability and the dynamic modes of classical longitudinal dynamic modes.

And similarly for the lateral directional case, we have the typical lateral directional measurements for airplane handling qualities, and if you were to look at a handling quality spec you would find these same kinds of maneuvers listed.

And then finally there is landings and ground effect.

So as we begin with one or two tests in taxi, let's keep in mind that there is much more to come, and before we get too involved in one particular test, let's look ahead a bit and then we can come back. I don't want to diminish any discussion on any particular block of the table, but I'd like to do it in total context, I guess is what I'm trying to get at.

So with that, I think we probably are ready to proceed to takeoff. Although I have added to the taxi area, on the rate of turn versus nosewheel steering, an acknowledgment that it may not be a tiller, that rudder pedal position may be necessary for rudder pedal steered airplanes, and then in parens measurements applicable to the airplane steering system, so we have that latitude that we are not trying to impose--we are not trying to impose a measurement on somebody for something that doesn't exist.

Of course the simple solution to this is, let's go back to the Douglas B-26, where it didn't have any nosewheel steering. Are there any more comments on the taxi area? Stewart [Baillie]?

MR. BAILLIE: There was one, the comment about while you are suggesting the video be the data source, you really just mentioned the yaw rate versus input and video would be one possible source of that data.

MR. BOOTHE: Very good point, yes. A source, that doesn't mean you couldn't get it from some other sources, in fact whatever--I think whatever you can support and justify for measuring that heading rate change is fine. I don't think that we should dictate it, how something gets done, it should simply be here is the thing that probably ought to be measured. But I don't think that there is any attempt to dictate exactly what gets measured or how.

If you can tap into the heading indicator and calibrate that and come up with a rate of turn, personally I don't see the reason why that shouldn't be done.

MR. DAVIS: Can you use a stopwatch to time the 360? Is that adequate?

MR. BOOTHE: Are you asking me or them?

MR. DAVIS: Everyone, I guess.

MR. LEISTER: It is, if you know the speed. It's as good as anything. Absolutely.

MR. BOOTHE: You have to know--but you have to know the speed, anyway. That's a tough one. From my way of thinking, you know, a steady state 360 degree turn here, using a stopwatch, I don't have a problem with that.

MR. BAILLIE: You mentioned speed, but you haven't described it here. Do you have to match speed in the test?

MR. STOCKING: There is no other way to determine turn rate without speed.

MR. BAILLIE: Then how are we measuring speed?

MR. BOOTHE: I neglected it by error. I'm sorry. I don't know.

MR. BAILLIE: That's a difficult one to measure. Unless you have a differential GPS these days.

MR. WILLMOTT: I'm told that you can get those devices and just connect them up to a PC relatively simply.

MR. BAILLIE: Everything is relatively simply--

MR. WILLMOTT: We are about to do a test involving that.

MR. BAILLIE: We thought about duct taping a GPS antenna on top of the aircraft and doing the test that way. That's the only way, though, that I'm aware of that you can get adequate ground speed for this.

MR. BOOTHE: That's a good point.

MR. BAILLIE: Or an inertial solution.

MR. KOHLMAN: Or wheel turn rate, tire turn rate.

MR. STOCKING: Whether you have speed at the CG or at the nosewheel.

MR. WILLMOTT: Didn't you previously use a radar gun, too?

MR. KOHLMAN: We did. But I don't think at that speed.

MR. SCHUELER: Not at turn speed.

MR. BOOTHE: Do you want to add some suggestions here for speed measurements? GPS is a good one.

MR. BAILLIE: The important thing is you also have to match ground speed. How you get ground speed is up to you.

MR. SMITH: If you can maintain the constant, you know, turn rate, the problem is when you are doing a test you want to maintain a constant speed. You've almost got to monitor it as you are doing the test. So you have to have some measurement of it, somewhere. Maybe you do this by off the nosewheel or outside or whatever, I don't know. Because you can always compute that in terms of--

MR. BOOTHE: That's a good point, Hilton [Smith]. If you don't have--if you have a steady rate of heading change, an invariable heading rate, then you have got a constant speed.

MR. SMITH: And you compute it.

MR. BOOTHE: Once you have gone around in enough circles to get stabilized and you have a constant rate of heading change, then maybe computed speed would be all right. Is that crazy?

MR. STOCKING: Time and distance is a valid measurement of speed.

MR. SMITH: But you are right, you have to make a bit--you have to get the right power setting to maintain that.

MR. BOOTHE: Now the control tower may think you are crazy, but that brings up a war story I will save for later.

Any more comments on that? Shall we simply add ground speed measurements and leave it be? Or do you want to include some specific suggestions? I will just add if heading change at constant rate, then you can compute ground speed. How is that?

MR. STOCKING: Constant speed.

MR. SMITH: Constant heading rate.

MR. STOCKING: Constant speed turn.

MR. BOOTHE: But if the heading rate change is constant, then the speed has to be constant.

MR. STOCKING: You can increase or slow down then modulate the angle to keep your turn rate the same. If you say constant speed turn, then you lock in the term.

MR. BOOTHE: Maybe you can do that, I don't think I could. Chuck [Stocking]?

MR. STOCKING: Leave it to chance, somebody will do it.

MR. WILLMOTT: What we have in [AC120-]40C for that is a minimum of two speeds greater than turning radius speed with a spread of at least five knots. That was picked up in 40C. The fact that it's not in [AC120-]40B--

MR. BOOTHE: I don't think we need to apply that to Level B, do we?

MR. WILLMOTT: No, it's just that you just need to put whatever the equivalent is. Turn at constant speed, whatever you said, is fine.

MR. BOOTHE: I have some additional notes for constant speed and constant heading rate change. They are dependent, so--

MR. WILLMOTT: That's fine.

MR. BOOTHE: --it should work out.

MR. STOCKING: Constant rate at a constant speed meaning you don't want them to move the tiller.

MR. BAILLIE: Sorry to add something else, but that suggests of course absolutely no wind in the test environment.

MR. STOCKING: To run it that way would be nice.

MR. BAILLIE: Otherwise you won't get constant rate.

MR. BOOTHE: Stuart [Willmott], everybody knows that flight test people work at dawn. Isn't that right?

MR. WILLMOTT: And on the side of a runway which has a nice angle--

MR. BOOTHE: Let's not take the common sense approach. Okay, can we move on to takeoff?

The first test in takeoff is ground acceleration, and to my recollection this is something that would have to be done for airplane certification, is it not?

MR. BAKER: It is, but how do you get access to the data?

MR. BOOTHE: Well, good point. Is a TIR in public domain?

MR. BAKER: No, not necessarily. It depends on the manufacturer. He can make you come through an FOIA, and if you request things and if he claims it's company proprietary data, you can't get it.

MR. STOCKING: I have been turned down flat.

MR. BAKER: Unless you have some ability to work with the particular company that built the airplane, it would not necessarily be available.

MR. WILLMOTT: What could the Regional Aircraft Association do about that?

MR. BAKER: I would think they could help.

MR. WILLMOTT: The people that buy the airplane have got the hammer, presumably, to get that information.

MR. BAKER: To me it would benefit the manufacturers. You are talking foreign manufacturers and a lot of different organizations.

MR. LONGRIDGE: Most of the foreign--most of the commuters are employing aircraft that are manufactured overseas. That's a problem. They could do a lot better job than they are, they need to coordinate their efforts.

MR. BAKER: Your original statement is correct, the data is available. Whether it's accessible is the question. It would be highly desirable, and I think to the manufacturers' benefit, to provide this data. How you convince them to do that--

MR. BAILLIE: From the other point of view, if you already have a ground speed system for doing the turn rate, this is a trivial test.

MR. BOOTHE: Yes, it's not our intent here to say this is the only way you can do it. We are trying to find a way that might be the least costly and using readily available data. But that's not to say you couldn't collect that data, particularly if you are instrumented for other purposes and want to do it that way.

MR. BAILLIE: I was just saying we have made that instrumentation requirement already.

MR. BOOTHE: Yes.

MR. DAVIS: Not necessarily. With a steady turn and time you can calculate ground speed, so if that was your option on the yaw rates.

MR. SCHUELER: The instrumentation for low speed, high speed, are maybe completely different depending on how that's done.

MR. KOHLMAN: We also have a number of points with a strap-down inertial system, i.e., accelerometers. For the takeoff run we have the data directly measured.

MR. BOOTHE: That brings up a good point. You notice in the right-hand column there are three points with a double asterisk. What that double asterisk turns out meaning, if you look at the bottom of the chart, hopefully it's still there, is that we needed some inertial data acquisition system anyway for those points.

But again, I was trying to minimize those tests on which that double asterisk might show up. I think in this whole context if you have to have it there and you choose to collect more than those minimum number of tests, that's strictly up to the person doing the test. But if the data is available from some other source, then we can just skip that measurement and that would be the least costly solution, I think.

But Gerry's [Baker] point, how you get it, is a tough one, and I don't know quite how to address that. But I do believe it is to the airplane manufacturer's benefit to provide some of that data, but I think many of them look at it as a liability issue rather than a support the industry issue.

MR. BAKER: I think quite often engineering people agree with you, it's the lawyers on the staff that won't release the data.

MR. SMITH: But Dave [Kohlman], that acceleration you measure, isn't that fairly accurate to just take acceleration, integrate that for speed and distance? That's how the airplane gets speed and distance.

MR. KOHLMAN: Acceleration and speed.

MR. SMITH: And you get it on a normal takeoff, it's not an additional test, is it?

MR. KOHLMAN: That's right.

MR. HEFFLEY: The one thing that doesn't fall out is the wind.

MR. SMITH: We assume--well, you are right. Yes--well, but that gives you true ground speed, though the wind is not a problem.

MR. HEFFLEY: The wind will have an effect on the ground acceleration.

MR. SMITH: It will have an effect on the performance of the airplane.

MR. KOHLMAN: The acceleration will be a function of air speed. You do need to know the wind.

MR. SMITH: You need to know that for takeoff, don't you?

MR. STOCKING: Stu [Willmott] *(sitting beside him)* just raised a point, too, we have always talked about the flight manual, if it's acceptable to use distance to 35 feet or 50 feet, whatever is in the flight manual, you are talking about now using the flight manual as the data source as well.

MR. BOOTHE:. All right, what does that do to it, Gerry [Baker]? How much is a flight manual factored or how much fudge factor is in it?

MR. BAKER: Nothing on takeoff. You have got some--of course you don't know a lot of flight manuals--what you have got? You don't know whether it's accel stop or accel go. You have no idea. Some of them are not balanced, some of them are balanced. Some of them just publish a set of data, period. You could assume it's balanced, that is you can assume you would be accel stopping, and I mean that's the legal distance you have to have to take off, either way you go, but there are factors involved on an accel stop, they vary dramatically.

MR. BOOTHE: But if one knew the certification basis of the airplane and had available an AFM, could you then derive the correct value or is that--

MR. BAKER: I don't know why you couldn't use the data, you would have to leave it up to the aero types mostly, but you say you know what speed you have got, you know the distances required, I'm not sure why you couldn't match it that way.

MR. SMITH: Isn't most flight manual data computed and it's mostly used--it's a guaranteed number.

MR. BAKER: It represents a minimum thrust engine.

MR. SMITH: It's going to do better than that.

MR. BAKER: Takeoff performance represents a minimum thrust. The V_{MC} represents a maximum thrust, so you flip-flop there.

MR. BOOTHE: If we match the thrust.

MR. BAKER: To me I don't know why it wouldn't match.

MR. BAILLIE: How do you know what the thrust is?

MR. WILLMOTT: Usually for minimum engine thrust they take two percent off.

MR. BAILLIE: Can you get the manufacturers to say that that data is for N percent off?

MR. WILLMOTT: Where is that hidden? Sometimes there are statements in the flight manuals, sometimes you can get it from the manufacturer. Actually what I'm saying is for the jet and not a prop.

MR. BAKER: Now turbo prop engines, that's true, most of them do have a minimum takeoff torque requirement in the flight manuals that you have to match for takeoff.

MR. LEISTER: The problem with that is when you get down to V_{MCG} and tests like that, you are going to get a mismatch, because the airplane are going to be different than the hand held.

MR. HEFFLEY: From a practical standpoint, if you don't know the conditions of your data source coming from a flight manual and you don't know exactly what those flight conditions are, you are creating all kinds of work for yourself. In the end it's better to get your own and know what the conditions were.

MR. NEVILLE: Is there any reason you couldn't combine, this is what we have done at Boeing, is combine the ground acceleration test with the normal takeoff. They are really the same thing, normal takeoff is required from brake release to 200 feet. It includes a takeoff acceleration. Now you have consistency, it's the same test, you don't have to worry about different thrust.

MR. BOOTHE: I don't see why you couldn't. People do that anyway, and they take a segment of the takeoff and call it ground acceleration, so right where you were, are you suggesting maybe we only need one test, we don't need ground acceleration, all we need is takeoff?

MR. NEVILLE: You could show it as two separate segments. It would be the same test.

MR. BOOTHE: We still want to show acceleration up to rotation, so we would have to segment it. But it is the same data.

MR. NEVILLE: Right.

MR. BOOTHE: I agree with that.

MR. HEFFLEY: Question. On this ground acceleration, I guess I have always assumed that the thing that's of interest here is the acceleration profile as much as just the time to arrive at a particular speed.

MR. BOOTHE: Time and distance. But that doesn't really address the profile properly; right? Some people take it upon themselves to match the profile, certainly that's acceptable but I think the Advisory Circular just says the time and distance.

MR. KOHLMAN: I was just going to say that that's the only thing the pilot can sense again in the simulator, is time and distance. Because even in the motion simulator, you can't give him an acceleration cue that is real life. You have to wash out the accelerations or you get longitudinal acceleration by tilting, then you lose normal acceleration. So time and distance really is, to me, the most appropriate thing to match.

MR. BOOTHE: That's what I think the Advisory Circular asks for, I ought to have the Advisory Circular handy.

MR. SMITH: I am going to check. I think it says time and distance data is required unless specifically a snapshot is specified or noted.

MR. KOHLMAN: To answer your first question, Ed [Boothe], we have typically reported all of the accelerations in addition to air speed and sometimes wheel rate.

MR. BOOTHE: You have to install a sensor on the wheel.

MR. KOHLMAN: Yes. If there is an autobrake system on there, then you have a signal that you tap.

MR. BOOTHE: This leaves lots of possibilities here. It sounds like the type inspection report is not one of the better ones only because of availability, but if the manufacturer is willing to share that data, then I think the TIR would be first choice. Because you would know the conditions, you would be able to have an audit trail for the whole flight test procedure, and that data would be readily available.

But if that information is not shared, then we have alternatives such as if you have got--if you have got to have an inertial measurement system for other purposes, then you might as well use it here, in fact could one not use some sort of a GPS for this, short of having a strap-down inertial system? All of those should be acceptable, but are they cheaper than what we are doing now?

MR. BAILLIE: They are the same as what we are doing now.

MR. BOOTHE: They are the same.

MR. BAILLIE: We haven't reduced anything yet.

MR. BOOTHE: You don't make this sound very encouraging. What about this idea of using a stopwatch and markers? Can we get good enough doing that?

MR. WILLMOTT: If you do a full power then brake release so you know what your power is.

MR. BOOTHE: Oh, yes.

MR. KOHLMAN: That may not be possible. The test I just did on Monday with the Lear jet, we tried to do a full power chop standing on the ground, we couldn't get there because it started skidding over the ground.

MR. BOOTHE: Then you ask the question, does it need to be full power? We are trying to match acceleration with some thrust. As long as we match the simulator to the test condition, does it have to be a full power? I don't want to do it at 50 percent power.

MR. STOCKING: You can do it just after brake release, take it from point to point.

MR. BAKER: How do you account for all of the wide conditions, again I'm the novice on simulators, but how do you account for the high altitude conditions, the hot day conditions, without having access to thrust? I don't see how you can ever get there.

MR. BOOTHE: There are engine thrust decks normally used in simulators, quite often--some of you programming folks can help me out here, they come from the engine manufacturer and from there one is dependent upon your aerodynamic model and your atmospheric model to properly effect those.

MR. BAKER: You still have to have a thrust deck that measures that particular engine with the particular nozzle configuration. There are a lot of variables involved. Again I'm speaking of what's required for basic certification. I don't know how simulators have done that in the past for a variety of conditions. If you are checking ground acceleration, that's probably one condition, I don't know if you even specify ambient conditions or altitude or anything.

In aircraft certification you have to do a variety of weights and at least low altitude and high altitude to extrapolate the data, you are only allowed to extrapolate so many feet. Obviously you don't need the exact same data in a simulator, you are not truly taking off from an airport where you have an obstacle at the end, but I know simulators are quite frequently used like they are exact things, you know, we get in some courses, you are taking off at Denver on a hot day and you use every bit of the runway going out of Denver.

I have often wondered how realistic they are. I don't know how they are set up in terms of attempting to match data like fuel length, particularly for the nonstandard conditions.

MR. DAVIS: It's important to keep in mind this is just a spot check in the simulator. A lot of what you are talking about goes into building the simulator. The FAA can't run all the tests, there isn't enough time in the year. Again, this is a spot check, and certainly the simulator should be representative of all the things you have touched on and functionally they are checked.

MR. BAKER: I don't know how far it went.

MR. DAVIS: It goes far.

MR. BOOTHE: Stu [Willmott]?

MR. WILLMOTT: What I was going to say, I think you were talking jet when you were talking there. What we normally get from the engine manufacturer is a program that represents the engine in a steady state condition for any condition, temperature, pressure, and it also gives us the effects of power off deck for the engine accessories and for bleeding the different things, and what we normally do with that is exercise it and get what we call corrected engine curves that apply throughout the whole flight envelope of the aircraft.

When we are dealing with propeller aircraft, we also have to have power coefficient curves versus advanced ratio and blade angle, and torque coefficient curve versus blade angle and advanced ratio, which then integrates normally with the turbojet.

I haven't done a piston, I don't know if anybody knows how a piston is done, but normally that comes in the modeling side and it is modeled to cover any conceivable situation that a simulator can get into.

MR. BOOTHE: But as Tom [Davis] pointed out, the validation is pretty much a limited point validation in the flight envelope simply because of the number of possibilities. Based on the concept that if one has a complete and continuous model, then you should really be able to validate it at any point selected in the envelope and we just pick some points. I guess one could always say that in between we don't know what's going on, but I think that would show up in--I'm sure there are cases where simulators don't perform correctly in other points in the flight envelope because I think there you could find some history of simulators being designed to check validation points and the points in between are a little less rigorous.

We don't invite that sort of thing, but I know it has happened. But how far can you take a validation point?

MR. BAKER: For example, are there any validation requirements on field lengths in a simulator?

MR. BOOTHE: Yes.

MR. SMITH: How about rejected takeoff?

MR. BOOTHE: But rejected takeoff is the one that really addresses that.

MR. LEISTER: From my experience, the flight safety instructor gets in there and you do a lot of rejected takeoffs, you end up with a very solid model as far as that's concerned.

MR. SMITH: Actually along with what Gerry [Baker] was saying, international standards as well as [AC120-]40C draft incorporates some of those standards. The landing cases now are required to have three; medium, light and heavy weight landing, one of which is a flight test case, the other two can be manufacturers engineering simulator generated cases.

MR. BAKER: That's what I was leading to, though, do you really need that requirement for this category simulator? If it is, it appears to me that you are trying to train for pilot proficiency here more than anything else, not whether he is operating off the proper field length or this type of thing, if you kind of ignore the field length situation and zero in more on handling characteristics and ability to fly the airplane, I'm not--somehow you have to try to save some cost somewhere.

MR. BOOTHE: But if I could address again what I think is a typical line-oriented evaluation, then this very thing may apply. One would ask a pilot to consider proper takeoff calculations and to assure that he does have proper field length or to check that a runway is usable, are there prevailing conditions and airplane configurations and weights, and if that's part of the scenario, then you have to make sure that the simulator is not too far off, it can calculate a takeoff distance or a distance to, gee, I don't know what gets calculated, but if those distances are involved and whether or not one can use a runway or not use it, I think the simulator has to directly reflect takeoff within some reasonable tolerance.

MR. SMITH: But this test, if I might add, the test actually validates a lot--it validates the power, the power variation with speed, drag, coefficient of friction on the ground, it validates a lot of parameters of just the model integrity, so it doesn't really, you are not really just checking distance, per se.

MR. BOOTHE: Let me go back then to my simplistic approach. Is the most simple case we could use a stopwatch and accurate runway markers? Is that a fair way to say we could do this? A runway marker might be standing a person out there to observe.

MR. BAILLIE: Provided that you can characterize what thrust was set somehow.

MR. BOOTHE: Yes, that was sort of a given that I didn't address. But yes, you do need to be able to document the thrust. Otherwise it's a useless test.

MR. SMITH: Are you going to be able to accurately read markers along the runways?

MR. BOOTHE: Most runways these days have distance remaining markers. All we have to know is the approximate distance and work between a thousand foot increments to pin that down. But I think if you pin this down to a hundred feet or so, it's good enough for me.

MR. SMITH: I don't know if the model validation, if you have the strap-on inertial system, I don't see any point--

MR. BOOTHE: I agree with that, Hilton [Smith], but I'm trying to identify the least costly case regardless if you have the strap-down system, use it.

MR. HEFFLEY: Ed [Boothe]?

MR. BOOTHE: If you don't, let's look at the least costly ways here, is what I'm trying to get at.

MR. HEFFLEY: Along those lines, I think there is the case where you could have gone out, gathered all of your data, come back, developed your model, and decided you need a little bit more data. In which case you may want to go out with a minimal amount of instrumentation and just use a stopwatch and a runway marker. And in that case you want to be able to take advantage of that situation where you are just gathering some limited initial data.

MR. BOOTHE: Good point. In here I have said power settings hand-recorded, which would imply one would with brake lock set a power and go from there, if that happens to be torque on a turbo propeller airplane, then you want to hand record it. Again, the fact that you rigorously kept knee board records with the most simplistic measurement technique, I still think ground acceleration could be accurately done, I have not heard anything to contradict that, with a stopwatch and a relatively crude distance measuring system. Is there any objection to that?

MR. SMITH: I hate to be a dissenter, but from a validator's point of view I would feel more comfortable with acceleration rate.

MR. BOOTHE: I'm not too concerned about your comfort, I'm concerned whether you will accept that. I don't mean to be smart, that's what we are getting down to, what is the least costly that will suffice?

MR. STOCKING: Maybe we want to back up and look at this for a minute. We have a whole bunch of tests here and if you have to, for any one test, install accelerometers or some device in the cockpit for that test, in other words nothing else would apply, then you are setting a minimum instrumentation requirement which would be there for all of these tests. So we are dealing with individual tests when we may go back and look at what it is to satisfy the entire set.

MR. BOOTHE: I agree. I think Bob's [Heffley] point is valid there.

MR. HEFFLEY: You may have taken them out, you may have removed them, and you have to go back and get something. In that case, you want to be able to take advantage of minimal instrumentation. This is where you really do save money over having to reinstall your instrumentation package.

MR. STOCKING: When I first started looking at this I was saying gee, for each level of certification I would probably be looking at the minimum implementation, data collection implementation of some kind for each one of these. Each category would have a minimum rather than each of the tests within the standard.

MR. RAY: That's where I was going to go with my comment. You could inadvertently mislead or a person could misuse the words there because of what is stated later on in normal takeoff. You mislead, could potentially mislead the person, into thinking they need somebody standing by the side of the runway with a stopwatch. Normally on takeoff they omit that and try to work around that somehow. I think it makes more sense to use a piece of the normal takeoff. If you want to go back and validate that if you link the two together, as somebody suggested earlier--

MR. STOCKING: We have done that. We have actually used part of--

MR. RAY: If you want to validate that.

MR. BOOTHE: I'm not disputing that, I think to come up with an overall solution here I don't want to take the position oh, well, I have to have an inertial system for the other tests, I will use it for all of them, to me that violates the premise that I built this. If that's where we want to go, then we can go that way, but I don't think we will arrive at the least costly solution that way.

So my approach was to, how can I do this rigorously but the least costly way and if--oh, I know, I have got an inertial system I may need for some other takeoff, but I still think I need to address this test and say what's the cheapest way to do this test. Come to that solution, then if I end up doing it by using the inertial data system, that's okay, too. That's sort of the approach, if we don't want to go that way I don't think we are going to end up with any significant overall cost reduction.

Suppose I could get the takeoff data somewhere else but it didn't happen to include ground acceleration in the form I needed? So that's a thought to keep in mind, too. I do agree we have to look at the overall thing. But I don't know how to minimize cost without looking at each test.

MR. DAVIS: I have some concerns about the accuracy of what we proposed, I think it approaches the tolerances, 120 knot, half a second perhaps, I don't have a calculator, but I think you are approaching the tolerance on distance, I think it's a good method to get some data, get a more warm and fuzzy feeling for what you have. If that's the one piece of data, do you want to use that in the simulator? I don't know.

I think the inaccuracies are approaching the tolerance, that may be something to play with, I don't know.

MR. BOOTHE: If you guys say “Ed [Boothe], you are wrong, we need inertial system there,” that's what we will write down.

MR. BAILLIE: But the other question is, does a Level B have to be as accurate as Level D? And then that's in runway distance, do you have to match the Level D standard?

MR. SMITH: No. But you have--it's got to be the same--well, it has to match the airplane. Here again, I have to say I have to separate, it's a model validation test.

MR. BAILLIE: But how well does it have to match the airplane, I think is the crux of a lot of this.

MR. SMITH: It's one of the easier tests, of all the tests, to get accurate data.

MR. BAILLIE: If we establish on this easy test what sort of quality of model we are looking for, then perhaps when we get to the more difficult tests we won't have the same discussion over again.

MR. NEVILLE: That brings up a good point. I guess it's my understanding that the discussion here refers to the application of the Level B simulator to recurrent testing and a normal takeoff including the takeoff roll is something that an experienced pilot experiences every time he flies the real airplane. How important is it that the simulator match that extremely well?

MR. LONGRIDGE: It has to replicate the aircraft at least to the level that it's not going to interfere with the performance of a task which admittedly he already knows how to do. We are going through an entire scenario, the simulator has to be able to support all the tests from pushback to docking. If the performance of the simulator is such that his performance is unsatisfactory, we can't have a situation where that's going to be attributable simply to the capability of the simulator. Because this guy's license is on the line even though it's recurrent training every time he shows up.

MR. DAVIS: I think there is a lot of things that the simulator has to do that aren't tested objectively presently. A lot of system operations and stuff like that. I don't think anybody is saying it doesn't have to work. We want high quality data in the simulator, certainly the simulator has to be reasonable, regardless of whether there is a requirement there, to match within five percent or 200 feet.

MR. LONGRIDGE: That's the crux of the whole discussion; how do we define reasonable? Yes?

MR. HEFFLEY: Well, if it's a matter of tolerances, it's a matter of demonstrating that your test is good to certain tolerances, you can and you should always estimate what those tolerances are in any test. And even though you might use a very simple measurement method, you can still estimate what the goodness of that measurement is. And I think that if the bottom line is that we have got to demonstrate measurements to given goodness, then all we really need to know is the measurements of goodness for that test. And as part of the test you demonstrate the goodness of your measurement, whatever it is.

MR. KOHLMAN: I think another point is that we should be matching parameters that are the relevant parameters. Has anybody flunked a takeoff check because he rotated 300 feet further down the runway than the manual said, and is the instructor or the check pilot ever really comparing the lift-off distance to some other parameter? The important thing is rotation speed, lift-off speed, pitch attitude after takeoff, and climb rate. And I think we are focusing on the wrong parameters. Sure they have to be reasonable, but if we match the other things it will be reasonable.

MR. BOOTHE: It will be reasonable. Dave [Kohlman] is looking at the total package. If we could move on.

MS. BÜRKI-COHEN: The more hand-held measurements where actually a person goes and has a reaction time and takes measurements, the more important it is to think about how experienced the people who actually measure those things have to be. Especially when Paul [Ray] talks of the "me toos" of this world. And also what I'm wondering is how many measurements, because we have these hand-held instruments, we have the human reaction time, and how many measurements should we take? Do you think of taking just one measurement and that will be it? Maybe that's just by coincidence a time where the reaction time wasn't very good of the person who pressed the stopwatch. I think we should perhaps address that also, at least put in some caveats.

MR. BOOTHE: That's a good question for some of you folks who have been doing this. Don't limit yourself to one run unless you think you did a magic job on the first one.

MR. HEFFLEY: I think you expect to be challenged, possibly on a measurement, therefore you may really have to be able to describe how you achieve the certain quality of measurement. And maybe you do average three runs.

MR. BOOTHE: Maybe you do three and throw one out because you knew it was--go ahead.

MR. WILLMOTT: I was going to say a couple of things, one for you, Tom [Longridge]. We are halfway through item 3. And there are 54 tests here which is just the first part of the agenda in the discussions here. Do we want to continue on this? There are some things that I would like to say and I'm trying to discipline myself to minimize what I'm saying, so we can proceed.

MR. LONGRIDGE: I have a feeling that some of these items we are discussing now will apply across the board.

MR. WILLMOTT: The second thing, we are coming up with ways and means of getting data, like the stopwatch thing, and Bob [Heffley] has just hinted at it, somewhere along the way we have to come up with a procedure that's acceptable to the FAA for acquiring the simple data by which it can be approved by you.

I always remember a guy at [...] called [...], I don't know if Ed [Boothe] remembers him, but I remember him getting very irate one day when he was talking with the FAA--he was a pilot with [...]. And he said if he had a piece of data written down on a back of half an envelope that was good enough to program a simulator with. And I have forgotten who the FAA inspector was at the time, but he was in total disagreement with that. And, you know, the point is there has to be a way of acquiring that data that's acceptable to the FAA.

MR. LONGRIDGE: Yes.

MR. BOOTHE: That's a very good point. I would expect before an operator would undertake such a procedure as we are talking about, that he would prepare a flight test plan and coordinate it with the FAA before going out and spending money. I sort of left that as a given. But it's a good point to bring up because the worst thing one could do I think is go out, collect the data and then bring it in and say here is what we have done, take it. It also avoids Paul [Ray] and Hilton's [Smith] problems of the "me toos." I think if this ends up in a written permitted approach to simulator data acquisition, those things will have to be said very clearly, that it requires certain qualified personnel with the proper backgrounds and that a flight test plan must be presubmitted and agreed before the test would be acceptable. That's, I think, given to the process. We are just looking at the nitty-gritty here of how to do those things, but I think everybody should understand you have got to coordinate it ahead of time. So is there any reason to think otherwise?

MR. RAY: It's the assumptions that people make on what's needed. I have heard a story, I think it's reasonably accurate, that some who have never built a simulator believe all they have to do is get the data for Appendix 2 for a QTG without talking with the FAA. I am hoping sincerely that they succeed, I sincerely do, but my gut instinct is it might not work.

MR. WILLMOTT: They will go out of business very quickly.

MR. RAY: They may, I would hope not. But that's part of that front end assumption that we make and I refer to it as my motherhood statement, this is assuming that you go through, submit the flight test plan, get the interaction with us. To avoid the pitfalls of going down the wrong road so you come out the other end with data that nobody could use. That's part of the motherhood statement I keep referring to that would be embedded in part of this. To cover the assumptions.

MR. LONGRIDGE: I think your points are well taken. My bottom line as far as these two days, I want to get through these validation tables. Because that's going to establish what the FAA guidelines are with respect to the aerodynamic programming. We hope to finish that, too, that's something we recognize can continue to evolve on the part of industry whereas we have got to come out with whatever revised guidelines on the FAA side we are going to come out with. So that should be the focus of at least what we attempt to complete. And I think some of this preliminary philosophizing is important, I would hope that once we get through that we will proceed through the rest of these tables a bit more rapidly.

MR. BOOTHE: Can we move on to the next, 1.b.(2)? I didn't mean to impose my solution to 1.b.(1), but I didn't really hear any disagreement that that's a permissible least costly case. Realizing that rigor is important. Gerry [Baker] might confirm, I have done braking tests on airplanes for certification not much more sophisticated than this.

MR. BAKER: I've not done that on a Part 25 airplane.

MR. BOOTHE: [Part] 23 I mean.

Moving on to 1.b.(2), minimum control speed ground, an important number, but a number that's usually available in the airplane flight manual, again I don't know about that number in the flight manual, how good is it? It seems to me it ought to be pretty good since a good bit of the performance of the airplane is calculated based on that. And also it's an important number from a safety perspective, so is that good enough to take out of the airplane flight manual?

MR. DAVIS: It should be.

MR. BOOTHE: And then do simulator tests accordingly to validate that it's modeled to that same condition.

MR. BAKER: I don't know that all flight manuals tell the exact conditions it was determined under.

MR. BOOTHE: Yes, that's a problem.

MR. BAKER: What thrust conditions, again coming back to turbo props, most of those frankly will be flat rated.

MR. BOOTHE: I'm sorry, Gerry [Baker]--

MR. BAKER: Most of the turbo props are flat rated. Under these conditions you are going to be under some torque flat limit. It's probably a good assumption it should be--go to a flat limit, go to your test.

MR. BOOTHE: But to determine the conditions, I mean, for a Part 25 airplane this speed more or less determines a minimum V_1, does it not?

MR. BAKER: Correct.

MR. BOOTHE: So it's got to apply across the board to whatever takeoff condition I'm working with and it's of course not necessarily a constant but I would think it would have to be a pretty good number.

MR. BAKER: Oh, yes, it should be a good number.

MR. BOOTHE: If we were to simply take that from the airplane performance data that is furnished by the manufacturer, is that good enough?

MR. BAKER: I would hope you could go into the simulator as part of a validation test, put the conditions in, your critical conditions in, run the cut, run a full fuel cut there, too, it's not an idle cut but a full fuel cut here that you would not deviate more than the requirement in the regulations for that particular--keep in mind there is two different deviations, you have a 25 and 30 foot deviation, it should be equivalent to your dev cert. If I had a simulator that was more than that, I['d] have a problem with the simulator.

MR. BOOTHE: Where about certification that deviates more than that, where it has been picked by the applicant based on his purposes and the deviation--

MR. BAKER: Some of them do that.

MR. BOOTHE: So then when we test the simulator we have got to know that, so it still should be a good number.

MR. BAKER: Should be.

MR. RAY: So I guess back to conditions again.

MR. BAKER: One of the most difficult things is accurately measuring deviation. And some manufacturers are starting to go to differential GPS now, it's proposed at least, correct? To measure that. We haven't seen it yet but it should work. On this airplane I would think estimates, you know, we have done a lot of V_{MCG} where you know the size of the concrete slabs on the runway and you can eyeball it pretty darn close. You are talking 14 foot slabs in a lot of airports.

MR. DAVIS: Based on some recent experiences I'm concerned about the FAA's view on just having a number for displacement. It seems that time history is an absolute requirement for displacement, I don't know if you want to comment on that.

MR. RAY: That gets back to the conditions Ed [Boothe] and I were side commenting here, know what the deviation is. We have two cases here, experience, where in the sim if you have it modeled that it deviates 30 feet or just inside 30 feet but in fact on the certification test it only deviated five feet or less. I would think it reasonable that whoever is presenting the sim acquire accurate data somewhere. It’s probably wrong to open to page 6.5 of the flight manual, come up with a number and assume it's 30 feet. You need to do the investigation backwards to the company, wherever, to find out whether in fact it was a 30 foot deviation or less.

MR. BAKER: I'm not sure you could go wrong if you are trying to cut costs again if you made an assumption that the airplane deviated the max. And even testing--

MR. RAY: That could be reasonable.

MR. BAKER: Somewhere you have to believe the cert data of the airplane. I believe the cert data more than I'm going to believe a bunch of so-called flight test people testing it. They did it under very controlled conditions, I've done back to back opposite direction V_{MCG}, it's a fact you have to be in almost zero wind conditions to get a good V_{MCG} validation.

I will tell you this, we ran into a simulator several years ago with one of the manufacturers here that the simulator on the original validation, another guy and myself tested it on an actual fuel cut, it took off in the boondocks, we backed it in, we said the maximum it could be was 25 feet. We set it on 25 feet, I don't really see anything wrong with that. And then do some cuts would make more sense to me than spending a lot of time trying to validate something. You have to keep in mind this was done under ideal conditions, it was computed for maximum thrust engine, it has a lot of variables. If you go out and test an airplane, you are not going to have that.

MR. RAY: Tom [Longridge] has a question in the back of his mind, I can see it gnawing away. I agree with Gerry [Baker], I think it is reasonable considering the level of simulation, if you up the ante to Level C or D, different ball game, now you are talking about zero flight time initial training as opposed to when a person is exposed to the airplane, to acquire training before certification.

MR. BAKER: Most manufacturers are going to take advantage of full deviation, get the lowest V_{MCG} they can. Now keep in mind some of these don't have V_{MCG}, commuter categories do not.

MR. BOOTHE: Let me just--Stuart [Willmott]?

MR. WILLMOTT: I'd like to point out a number of problems with using the flight manual V_{MCG}, we do that when we don't have anything else on our sims, but you normally don't know the weight, you normally don't know the CG, you normally don't know the temperature, some aircraft like the Lear 25, for instance, it would run at a temperature of minus 20 because it works out that's when you get the biggest thrust.

In the case of these propeller aircraft, there is one engine cut that's worse than the other engine cut, and you don't really know how much rudder the person has put in. The nominal value is 180 pounds pedal force, if that gives you a full rudder deflection, that's fine, if it doesn't you are not really sure. And then the other thing that has a really marked effect on deviation is the delay between the fuel chop and when the guy puts in the rudder pedal. And all of those things affect the deviation that you get in the simulator.

MR. BAKER: That's correct.

MR. BOOTHE: They all affect deviation you get in airplanes.

MR. BAKER: There is even more than that, because you said 180 pounds, some airplanes are 150 pounds, all Part 23 are 150, some Part 25 are 150 pounds. You don't know whether it was a force limited V_{MCG} or a control limited, you have no idea. On the airplane.

MR. WILLMOTT: The other thing, of course you can't take credit for the nosewheel, so the nosewheel is normally castering or in the air.

MR. BAKER: There is a lot of variables.

MR. RAY: Isn't that incumbent upon whoever presents that to the FAA for certification to know the answers to that? Is it reasonable to know all the answers to that when they come in with their data?

MR. WILLMOTT: We are getting into an area we have already gotten into twice before, if this is to be a totally viable program to come up with a cheaper way in which the regional airlines can get, you know, what will be simulators cheaper, it's obviously good if all of the aircraft manufacturers can support the whole program. By data like this. You know, it may be it's a team effort on the part of the regional airline operators, the aircraft manufacturers, and the FAA. It would be very, very good to get all of that data and I'm sure it's--that's a TIR type test and they have it in the type inspection report which would be very useful to have.

MR. BAKER: Again I go back to what I said. All these factors, the odds of someone going out and reproducing all these is pretty remote. I would just--I would rather see just pick, take the number and accept it. And put a deviation in. I think it would be reasonable. That's my opinion.

MR. RAY: If we go in later and test it, let's pick a number five knots or ten knots below that, I would expect to see a significantly larger deviation, if I chop it higher than that, it should vary appropriately. We have all seen poor simulations where an engine cut simply isn't representative.

MR. BAKER: I would rather see a larger deviation, personally, than something too small.

MR. RAY: At the correct speed.

MR. BAKER: Right.

MR. SMITH: Yes, you err on the side of being over.

MR. BAKER: On the training aspect. The fact of life is there will be larger deviations than the manufacturer because of wind effects and other effects that aren't taken into account. You know, in a crosswind V_{MCG} is going to be a lot higher than what's published in the flight manual, but you don't have to take that into account.

MR. BOOTHE: Taking Gerry's [Baker] advice, the first entry in 1.b.(2) accept, now if one can get a hold of a TIR, that's all the much better. But is there any objection to leaving that as written?

MR. DAVIS: I want to clarify one point if I may, because of the difficulty we have had in the past. The FAA is saying they don't require time history?

MR. RAY: For?

MR. DAVIS: Lateral deviation. This has been a sticky point.

MR. RAY: I beg to differ. On the [Levels] C and D, different story. We are talking about B and below. The C and Ds, your other response is absolutely correct. Time history.

MR. DAVIS: I'm speaking from experience.

MR. BOOTHE: Can we leave that one? Let's get Stewart Baillie in, Stewart follows lunch; is that all right?

MR. LONGRIDGE: We have sandwiches set up in the hallway just adjacent to this room. That hallway. You can bring them in here and eat. We will reconvene at 1:00.

(Lunch break taken.)

MR. LONGRIDGE: Let's continue now with the tables.

Let me just say tomorrow before we depart, we want to broach the issue and get the recommendations of this group about what the FAA might recommend to its own management with respect to perhaps what we might do, what changes we might make in the aircraft certification process that might better provide the kind of data we are looking for. So I just want to mention that we will revisit some of the broader issues, things that we can do besides what we are doing right now that would also help us to achieve our goals of more affordable simulation.

MR. BOOTHE: Before we continue, I have one administrative matter to cover. Somebody unnamed in this room said I would figure out how to reimburse you for the airline tickets. In order to get money to reimburse your airline ticket, I have to invoice to get the money. What I need to know is how much money. So tomorrow morning could everybody have their airline ticket receipts so we can make a copy of them and then I can go home, add all that up and submit an invoice for the money, so that I can then respond to you when you invoice me. Now there may be a bit of lag here, first order, while--

MR. KOHLMAN: What's the time constant?

MR. BOOTHE: I knew somebody would come up with that one. But the sooner I can get an invoice in to get this money the sooner I can respond to you. So if we can just collect those in the morning we will figure out a way to go get them all copied and I will take care of that. But I need to know how much money that is for. So we will collect those in the morning. Thanks. It could be about 60 days. Let's see, that means it could be 90 days before you get paid.

MR. WILLMOTT: That means you get 64 percent of it in 60 days.

MR. KOHLMAN: It will be forever before we get the last bit.

MR. SCHUELER: Notice they didn't tell you this before.

MR. BOOTHE: I wouldn't dare. Now that we have the engineering out of administration.

The next item in the table is still 1.b.(2), but it's an alternative to minimum control speed and it was Stewart's [Baillie] suggestion so perhaps I would ask him to go over it for us.

MR. BAILLIE: Sure. My approach was that we are not necessarily concerned about matching the data, we are concerned about training the pilot to do the appropriate action once he has recognized and diagnosed a situation in the aircraft. As our friends from certification have said, every time you do a V_{MCG} you can get a different number based on a lot of variables, so the actual matching of center line deviation doesn't tell you whether you have actually got a good dynamic model or not.

The important thing in my mind would be those things that the pilot would see in the engine failure on takeoff, large yaw rates, visually as well as vestibularly, lateral accelerations, and that sort of thing. And the other important thing to match is the required force on controls to get a reasonable behavior.

With that in mind, I would suggest rather than trying to do what's called V_{MCG}, which is a certification maneuver, we put the aircraft in a situation of high thrust asymmetric thrust while rolling down the runway, and match dynamics that are important to the training environment, the force to keep the aircraft close to the center line, so it is no longer a V_{MCG} test, it is a test of asymmetric thrust on takeoff. The dynamics of the build-up of asymmetric thrust would be significantly different if there was a fuel cut versus an autofeather failure, which is a prop mechanical failure of some sort, and whatever case we choose is not going to be the one that the pilot sees.

So in the interest of simplifying the test, throttle chops to idle are probably acceptable with the understanding that the engine model in the simulator has all of these other types of power loss. And time constants with those. So it's just a completely different approach rather than trying to match center line deviation V_{MCG}.

MR. BOOTHE: What about instrumentation?

MR. BAILLIE: Well, if you are going to match yaw rate, control input and lateral acceleration, that's it. And somehow documenting the throttle time history and speed. It's significantly different, it's significantly more onerous than a V_{MCG} test, but it points out V_{MCG} is not any guarantee of getting the dynamics right.

MR. SMITH: That sounds good. You could do several points. You could do a couple of below V_{MCG} and a couple above just to verify the model.

MR. WILLMOTT: I think that is similar to the tests that the FAA allows us to do for quite a few years when we have not been able to get data from the V_{MCG} test, it is called a low speed engine failure test. I think it's close to that, if I understand you.

MR. BAILLIE: The main difference is let's not worry about runway center line deviation, that's a fundamental part of all of this. Let's make sure we get the first half second or second of yaw rate correct. Because that's what the pilot picks up, that's what you want to recognize and diagnose.

MR. RAY: Stewart [Baillie], you were talking about the data that you have that you built into some models, would it be reasonable, with that data in hand to then, as Gerry [Baker] was pointing out, go in and simply do the V_{MCG} test and see if it's reasonable? Within 30 feet? On just a sim result compared to V_{MCG}?

MR. BAILLIE: But within 30 feet you could have completely wrong dynamics and match it within 30 feet.

MR. RAY: I'm asking is it reasonable, is it reasonable to do, as we have done with some of the older sims, is that a reasonable test to do on just the sim itself? We are talking about validation data.

MR. BAILLIE: I guess I would say it's necessary but not sufficient.

MR. DAVIS: I don't think it's unreasonable, but let's say you go on the airplane and do that, what's going to happen? The AFM says 108, you fail at 108, I don't know what you are going to get. You get all kind of things, depending on the ambient conditions, is it reasonable to do it in a simulator? I don't know. What's a reasonable result? I don't know.

MR. RAY: There is a paper on the issue which addresses the C-130. I apologize for not bringing the paper with me, I do have one back in the office. It was written by Lyle Shaefer, I believe, who I believe is the chief C-130 test pilot, it had to do with [the] C-130 V_{MCG} tests they did. Is anybody else aware of that paper?

MR. TOULA: Is that the one that crashed?

MR. RAY: [No.] They did 186 fuel cuts on a C-130, never logged one minute of flying time. The UK came up with the issue that V_{MCG} was 15 knots higher than Lockheed's number. Setting aside a number of other issues in the paper, he went through and did an excellent job of describing the test, how they did it, the importance of the case of simulation, the correct modeling of loss of lift when the engine failed, when the wing dropped, keeping the wings level, everything being consistent, and proved the same speed time and time again.

I'm sorry I don't have a copy of it with me, excellent paper. But that airplane, because of its similarity to all prop driven aircraft, may help us in the instant case. I just wish I had the paper, I'm sorry, I will send one to anybody who wants to see it.

MR. BAILLIE: Dave [Kohlman] just asked me the question, why did he do it 180 times and to what level instrumentation did he have to get the same speed?

MR. RAY: A lot of those questions aren't in the paper. I wish I had all the data, it's just an excellent paper to read, to point out the difficulty with V_{MCG}, but properly done I think it repeatedly shows the same speed time and time again. The same weight, same speed.

MR. BAILLIE: I think the philosophy still has to be you are trying to train a pilot to initiate the proper behavior. And so you should cull out what are the significant events and try to match them rather than trying to match the whole maneuver to all of the conditions that are normally looked at.

MR. SCHUELER: I think that actually applies to more than Level B.

MR. BAILLIE: Yes.

MR. SCHUELER: C and D, the same comment applies. Matching just deviation is nice but that doesn't necessarily provide you the required--the benefit that you really want.

MR. RAY: I think it's a reasonable alternative as long as the end result is whatever is reasonable. When I do in fact cut at V_{MCG} and I have a Gerry Baker in the seat, do the maneuver, do a fuel cut, the results should come out reasonably the same as the aircraft.

MR. BAILLIE: What's the repeatability on center line deviation for a given certification program?

MR. BAKER: Probably five feet.

MR. BAILLIE: You are always within five feet?

MR. BAKER: If they are the same number, same speed every time, I don't know if there is a big variable, if the guy in the right seat hits the throttle when you are coming down a runway at a good pace, how fast you input. I mean you've got a lot of variables, it's not a matter of losing the airplane one time and not deviating at all. I have never seen anything to that extreme.

MR. WILLMOTT: One of the things I think we notice when looking at some of these results, is that at the time the engine fails, depending on who has done the test, he has the airplane actually pointing in and traveling in a useful direction. In other words, there is some variation in maximum deviation if you extrapolate the ground track that existed prior to the engine failure and use it as the datum, instead of the runway centerline. We have this situation right now on our Gulfstream IV job.

MR. BAKER: We just did V_{MCG} a couple weeks ago on a 35, I hadn't been in a 35 for five years, and we got the data pretty darn close. What would you say?

MR. SCHUELER: Five feet is a reasonable number. But--it's within the conditions, I mean.

MR. BAKER: We had ideal conditions.

MR. SCHUELER: Given the test conditions, it's a repeatable maneuver, but the conditions have to be defined and I think what you are trying to say more than anything else, and I agree with you, the tolerance requirement that's specified here does not seem to be the most logical or does not cover all of the information that you would like to get out of it. Maybe that's the basis for going to a requirement where a time history of lateral deviation is another way of saying that your yaw rate and control inputs have to be--that that's important. It's important how you got there, not just where you ended up.

MR. BAKER: I agree.

MR. SMITH: Because when you do the simulation just mathematically, if you have a time history and you've got the exact engine cut time and the rudder response, and now Tom [Davis] would agree, and you can match that thing pretty close, then what you have done, you have assured yourself you have the right response of the aircraft on engine cut, the right response to the rudder, therefore when the pilot goes in and he can cut the engine and kick the rudder within reason, within the same, you know, plus-minus four, five seconds or whatever, and actually then the math model will respond close to the airplane.

MR. HEFFLEY: I have a question here. Are we trying to set up the entry conditions or does the validation include not only the initial yawing moment, forces, but is it also a matter of matching the pilot input, too, so that we have to play the actual pilot input from the test into the math model? And then how far time-wise do you go at that point? It could be a very difficult thing to match if you have to, if you have to proceed very far time-wise into this maneuver.

MR. BOOTHE: If you have to match the control inputs, you are talking a closed loop case here.

MR. HEFFLEY: Yes.

MR. BOOTHE: It's pretty difficult, as we found out on some other tests.

MR. BAILLIE: The important thing is, it's less difficult if you don't worry about center line deviation, because runway center line deviation is two integrations further down the stream and a small error times two integrations is a huge error. I don't think the pilot really sees five feet of center line deviation so much as he sees the yaw rate.

MR. SMITH: No, that's not the point. The point is by just matching that, that's just a matter of validating the simulation. If you get that right, the yaw rate has to be close, perhaps it would be better--it would be good for somebody to do some tests to prove it might be a better verification of simulation to match yaw rate, I don't know.

Right, Ed [Boothe]?

MR. BOOTHE: Well, I have a couple of questions here. One with the V_{MCG}, I think by definition that's a fuel cut, is it not? V_{MCG} is a fuel cut? The engine is stopping somehow?

MR. BAKER: Let me clarify. If that's the critical failure.

MR. BOOTHE: Yes. Here we have rapid throttle reductions which would bring the engine to idle but would we get then the same dynamic response that we would get with fuel cut?

MR. BAILLIE: I put it back as do you need it.

MR. BOOTHE: Or do we get good enough substitution for validating a model? That's really what I'm after here.

MR. BAKER: That's a variable in itself. Depending on the engine, I think we touched on it earlier, depending on the failure, you know, it's a lot of fixed turbo props, it's more critical to put into idle than to fuel cut to get a bigger deviation, because of the way they set up the flight idle blade angles, you can get a lot more drag out of the situation.

MR. BOOTHE: So it may be a more critical case than actual engine failure?

MR. BAKER: Could be. Depends on the engine.

MR. BAILLIE: It's easy to do a chop and difficult to do a fuel cutoff that doesn't damage the engine.

MR. BOOTHE: The objective is to validate the model, so not just at single points but to validate the model so that across the board we feel we can support whatever training events are to be accomplished. And I don't have any problems with this as long as I still can get the correct response when an engine fails as per whatever reason an engine fails. Bob [Heffley]?

MR. HEFFLEY: I guess that I envision a problem here. I think I agree with this approach in terms of worrying about the basic response and inducing the right response in the pilot. What concerns me is having to match that with a closed loop pilot response into the math model. That gets nasty. What's important here, though, are the conditions just after this happens and the amount of control the pilot has to put in immediately following this.

But if you keep putting the pilot in a few more seconds down the line, then you get something really weird here. It's trying to reproduce a closed loop response, and that's an awful tough thing to do. You really want to take and extract the open loop part of this maneuver in this response. You want to worry about that initial second or so of response and show that the same amount of rudder and aerodynamic controls are being applied initially, but you don't want to follow that maneuver too far.

MR. KOHLMAN: All of our time history matches for simulators are the results of steps or doublets, then it's over with. Then you have an open loop response.

MR. HEFFLEY: That's right.

MR. KOHLMAN: It's fairly complex input and you are integrating an accelerometer twice, it's just going to lead to, I think, almost an impossible situation, and one that doesn't count as much as the initial two- or three-second response, which is what the pilot needs to make the proper reaction from a training standpoint.

MR. BOOTHE: Within the limits of staying on the runway, maybe the open loop for a second or two, whatever the pilot can tolerate, might be the thing to be measuring before he or she applies recovery controls. Then it's open loop and the rest is just recovery. We don't measure that.

Is that a reasonable alternative?

MR. KOHLMAN: I think it is.

MR. BOOTHE: It's not much time, but you get the initial response.

MR. KOHLMAN: I think it is. And the longer term closed loop response is what is checked by the pilot evaluation. If the long-term response doesn't recover or doesn't recover properly or goes into some kind of an oscillation, then we have a problem that has to be corrected. But we don't try to match it at the outset.

MR. BOOTHE: All right. Well, help me fix this up, Stuart [Willmott]. Oh, I'm sorry.

MR. WILLMOTT: The way we currently run what we call the low speed engine out, what do we call it, low speed engine inoperative ground speed control characteristic--I don't think it was you that came up with that name--when we didn't have a V_{MCG} test. We have tests which have been performed in the airplane, with the engine failure and often with the nosewheel working properly, the pilot puts in the appropriate response to that.

Sometimes we have center line deviations, sometimes we just have a comment from the pilot that the deviation is about ten foot, what we do in the simulator is just repeat that test and play back the rudder pedal and/or rudder surface input and usually stop the test as soon as you start coming back towards the runway center line.

MR. HEFFLEY: That's the idea. About how much time is the question.

MR. WILLMOTT: That's, I think, what they are doing.

MR. DAVIS: Is what you are saying not truly V_{MCG}? It is in terms of certification? No, it is not a true V_{MCG}, it is from my perspective V_{MCG} like.

MR. WILLMOTT: You can have, you know, what is it, 13 sims that have the test devices you described that were qualified back in '83. I'm sorry, '84, '85.

MR. BAILLIE: Do those include time history matches of things like yaw rate?

MR. WILLMOTT: Not yaw rate, but heading. Heading, some of them sideslip, but not all.

MR. BOOTHE: Is there a recommendation for an alteration for this language here?

MR. WILLMOTT: I'm not sure what the difference is between what Stewart [Baillie] is recommending and what is currently allowed, other than maybe you were going to get rid of runway center line deviation.

MR. BAILLIE: That was one of them. And concentrate on, make sure yaw rate is matched very good. But not concentrate on being away from the center line.

MR. SMITH: Somehow wouldn't we have to track that, know when to stop or just watch yaw rate?

MR. BAILLIE: What's that?

MR. SMITH: You want to stop when it starts cutting back, so you just--

MR. DAVIS: With this proposal do you see the engine out takeoff, as being a case you could present to show they are complying with this requirement, the yaw rate, rudder input, there has to be more to it than that. It has to be V_{MCG} plus five knots, we need to quantify what we are talking about a little more than matching yaw rate and center line deviation. We know he comes with a piece of data, he says yes, this is compliant with the requirement.

MR. NEVILLE: I don't think you can substitute the engine failure in V_1 for a V_{MCG} type maneuver. It's really a test of the airplane's response on the ground. For the engine-out takeoff, you fail the engine, you tend to rotate almost immediately.

MR. DAVIS: I agree. I want to clarify, we are still going to do V_{MCG} and do center line deviation--

MR. BOOTHE: I think what Stewart [Baillie] is recommending here is a yaw rate response to a thrust change.

That's pretty much all you are recommending, is it?

MR. NEVILLE: And the response to rudder control, too.

MR. BAILLIE: Yes.

MR. BOOTHE: But we wanted to get away from the closed loop of trying to input the control. We have to cover that someplace.

MR. WILLMOTT: Yes, but you are not going to have more than the tiniest fraction of a second of uncontrolled anything if you are cutting an engine close to V_{MCG}.

MR. BOOTHE: That's true. You are absolutely right. How do we get around that? Unless the requirement were to input full rudder. And then it would just be a matter of time rather than a matter of pilot manipulation of the control. That may not work either.

MR. HEFFLEY: I'd like to suggest something. That what you are looking for are the yawing moments and the build-up of those yawing moments with the engine cut. You would like to know what those quantities are in the absence of the pilot. You can't do that. So what would give you an answer to this is to look at the first one second or two seconds following this engine cut and ensure that there is a match, that is, some tolerance in the applied rudder versus the amount of yaw rate response that you get. You are just looking for that basic balance in terms of the applied pilot rudder versus the motion that you are getting from the aircraft. You are not looking for the long-term closed loop response because we know that gets complicated. You are looking for that first one to two seconds.

MR. BOOTHE: So if I were to do this, I would move a throttle to a lesser thrust position, perhaps idle, like you are suggesting doing it at several different thrusts, degradations, are you not?

MR. BAILLIE: I would say idle is the most important.

MR. BOOTHE: But let me say I reduce the throttle to idle stop, and what do I do, wait as long as I can stand it and then put full rudder? How would we do this?

MR. HEFFLEY: Let the pilot apply the appropriate amount of rudder to counter the yaw and record the net response by recording the rudder. Apply that, it should be approximately the same in the simulator to some given tolerance.

MR. BOOTHE: I agree with that, I'm just thinking about having to manually repeat this test in a simulator. Or even in an airplane.

MR. HEFFLEY: For the application of response in the simulator you generally play in the flight test input. If it's a step input, you play back the actual step from flight test into the simulator. In this case you would play back the actual application of rudder from flight into the simulator and that should closely balance the upset in yaw moment.

MR. BOOTHE: In an ordinary test, yes. But I'm thinking, too, of the permission for manual testing where somebody has to--the person has to make this input, then the repeatability is going to be quite different.

MR. HEFFLEY: But if you take it approximately as a step input--initially that's what we are looking at, a step input for all practical purposes--you are looking at about the same amount of rudder input to this power cut.

MR. STOCKING: We have run this as a constant heading test before where they didn't want to do it at the V_{MCG}. We did it at five knots above V_{MCG} and it was not an unexpected test, in other words he pulled the power off and he put in the rudder to maintain center line, then we played back both throttle and rudder to see how closely it maintained center line. That worked out quite well.

MR. HEFFLEY: It seems to me that gets the essential nature of what you are looking for here. It's a simple test.

MR. BAILLIE: That coupled with taxi response at high speed gets you the right answer.

MR. STOCKING: Yes.

MR. LONGRIDGE: Okay. Ready? Do we have what we need?

MR. BOOTHE: I think what you are telling me is leave it as is, as an alternative I would not want to remove the privilege of using V_{MC} ground because we use that throughout the whole range of simulators and if the person happens to have that, I think they could use it, but I think an alternative, published alternative is certainly acceptable.

Unless I hear objections, I really don't see why this wouldn't work. You guys see any reason?

MR. SCHUELER: As I understand it, the difference is what you would match. I mean, the procedure is really no different, it's a difference in whether you are going to match deviation or you are going to match rate and acceleration.

MR. BOOTHE: You are still looking at an ability to correct a rapid change with the same controls, so we are still looking at the ability to control the loss of thrust on one engine with the rudder, so whether or not you would do this with a nosewheel engaged or not is the next question we need to ask here.

MR. BAILLIE: I suppose it depends on what the operating procedure for the aircraft is. If he does a takeoff with--if he is allowed to do takeoff with a castering nosewheel, it becomes a valid maneuver to do this with a caster nosewheel. Whether it's a requirement or not is--

MR. BOOTHE: In that case we are not looking at rudder power, we are looking at nosewheel friction.

MR. BAKER: That's not a V_{MCG} test.

MR. BOOTHE: No. I would say we need to use rudder, and permit the rudder to correct the situation, because otherwise you are not going to know which is correct.

MR. BAILLIE: But if the response to the aircraft is significantly different with the castering nosewheel than a non-castering nosewheel, if the pilots are always doing a takeoff with a non-castering nosewheel you better get that one right, to heck with the castering nosewheel case.

MR. BOOTHE: But we also use these things to do takeoffs on runways that are less than standard friction. So we really need to have the rudder power tested here.

MR. BAKER: That's the reason for doing the test, contaminated runway conditions.

MR. BOOTHE: That's part of a training scenario. So if we want to validate the model to cover the entire training scenario, we have to look at the situations where the non-castering nosewheel would be happy to go sideways as well as forward. So I think we would have to adhere and the nosewheel would have to have at least castering to make it useful.

MR. NEVILLE: Another requirement for that is if you don't match a case where you have a normal non-castered nose gear, you don't know how to fix the model. You have the wrong yaw moment somewhere.

MR. BAILLIE: Right.

MR. BOOTHE: I will add caster nosewheel, but Chuck [Stocking]--

MR. STOCKING: You answered it.

MR. SMITH: I would like to mention a point. Academically it would be nice, and I don't know how we would do this, something like this, you know, come about. In the first couple of tests that were conducted to obtain data that we ask for center line deviation, but in order to correlate the center line deviation with yaw rate, even if we had to somehow or other do--that would be worthwhile data.

MR. RAY: With the cost dropping for GPS, is it a player?

MR. BAILLIE: If the aircraft has the installation already. Otherwise it is a major cost factor.

MR. RAY: To strap a--

MR. BAILLIE: To get an STC for the antenna. That's the cost. We just went through it for a Challenger CL-601.

MR. BOOTHE: In the experimental category you don't need STC.

MR. BAILLIE: You need an experimental test permit or something. But it's a big expense.

MR. BOOTHE: Big deal, yes.

MR. WILLMOTT: Two things, Ed [Boothe]. Sometimes the nose of the aircraft is pulled up in the air and off the ground before you do the engine cuts, so nosewheel castering or equivalent.

And secondly, I was going to mention a test that Boeing came up with on the 747 for checking V_{MCG}, and I don't know whether this is relevant here, but what they would do is take off with power on all the engines, start to take off with power on all engines and then pull the critical engines slowly back putting in rudder to compensate for it while it was under control, and sometime a little before V_{MCG} the engine would be cut and a small turn rate into the dead engine would result, but because it's accelerating that quickly passes and then you are turning back to the runway center line.

The point at which the turn rate goes to zero matched the V_{MCG} on the 747 in the early days. That was for the 100s. And that's a very simple way of doing the test in the simulator, very repeatable way, it matched the airplane V_{MCG} number. It's like a quasi steady yaw moment.

MR. BAILLIE: Perhaps.

MR. WILLMOTT: I don't know how people would feel about doing that test in an airplane to see if it was close to the actual recorded V_{MCG}.

MR. BAILLIE: Stuart's [Willmott] comment has opened this up a bit to point where we say the simulator company must demonstrate the yawing moment caused by asymmetric power and the yawing moment caused by rudder on the runway, but if they can come up with that test versus a V_{MCG} test, and if the FAA is involved in the acceptance of the plan before the data is collected, it should be immaterial just so long as the concept of the test is matched well with the actual procedure.

MR. RAY: I was thinking in the extreme you talk about C-130. Is the potential of doing a three engine takeoff, somewhat exactly what you described, to prove the rudder effectiveness on the ground with a castering nosewheel--can it be done in a number of ways other than a classic V_{MCG}? The answer is yes. The issue is to put forth your rationale for alternative testing before the testing is accomplished.

Coming up with one single line saying that's the only answer, that's like an ostrich sticking his head in the sand.

MR. BOOTHE: I think I would prefer to take the position of adding a statement similar to what you just said, simulator operator, applicant, must demonstrate yawing moment versus asymmetric thrust and rudder yawing moment required to compensate, and then just add that as--leave yours pretty much as it was as an alternative and we have got enough covered there to last us, I think, if that's acceptable.

I don't know how we are going to play this table out, but I will get those notes in. We spent a bunch of time on that one, but that's always a sticky one. The next one is sticky.

I don't want to cut that one off, but I think we have got enough input there to make a good case. Minimum unstick, as I understand, and I need to have Gerry's [Baker] and Daryl's [Schueler] help here, that's a required Part 25 test, I couldn't find anything in commuter category but yet it still seemed that some similar speed needs to be identified.

MR. BAKER: There is no V_{MU} required for Part 23.

MR. WILLMOTT: Do you do a minimum rotate test?

MR. BAKER: No. Part 23 commuter simply factored the speeds up to fairly high number that whoever in their wisdom generated that initially felt that that would suffice, and not having a V_{MU} or a V_{MCG}, so far it's proved successful, it's not been a real issue.

We have actually had one applicant who has a special condition that wanted to do a V_{MCG} on a commuter category airplane and actually lowered their takeoff runs by using a V_{MCG} and V_{MU}s. Which tells us it's pretty conservative what's in the rule right now.

MR. BOOTHE: Well, Gerry [Baker], what's going to happen to the commuter rule, is it going, will it stay or go on to [Part] 25?

MR. BAKER: The commuter rule will stay as a commuter rule. There won't be any commuters using it anymore, if they are used in scheduled passenger service.

MR. BOOTHE: So any user in a Part 21, any--

MR. BAKER: Any new airplane. Derivative airplanes can go on forever.

MR. BOOTHE: Has there ever been an airplane certified under 23 commuter category?

MR. BAKER: A lot. Beech, Beech 300, Beech 1900D.

MR. BOOTHE: Under the commuter rule, not one of the old appendices.

MR. BAKER: Yes. A couple versions of the Fairchild Metro and somebody else has one, Embraer or somebody.

MR. BOOTHE: So if they operate under Part 121, they can retain that certification under grandfather rights and press on?

MR. BAKER: Well, of all the airplanes I mentioned, the only Beech airplane would be the 1900D. The rest of them are not passenger hauling airplanes for scheduled passengers. 121 is only for scheduled passenger service over ten passengers.

MR. BOOTHE: What happens to the regional, is it just scheduled airplanes?

MR. TOULA: Scheduled, yes.

MR. BOOTHE: So that leaves us with a minimum unstick for Part 25 and nothing defined for commuter category. I guess the question is, then, that part but "a similar speed must be identified," you can scratch. I think I said that erroneously.

MR. BAKER: That was meaningless.

MR. BOOTHE: So we can scratch that. Again Stewart Baillie represented an alternative here which may, even if we don't apply to larger planes, we might apply to commuter category airplanes. Stewart [Baillie]?

MR. BAILLIE: I took the maneuver to try to demonstrate pitching authority on the runway. And so the primary case would just be an early rotate.

And perhaps--I see Stuart [Willmott] is disagreeing, what is the philosophy?

MR. WILLMOTT: We used to have both tests in the Advisory Circular. We used to have minimum rotate and minimum unstick. The minimum rotate is to check pitch and the minimum unstick is to check lift. It was felt in later revisions that the minimum unstick test also proved enough of the large pitching that we didn't really need to do the minimum rotate.

MR. BAILLIE: In general experience, when we are getting data other than for--from the manufacturers, we are not doing the V_{MU} because we are not getting tail contact.

MR. BAKER: That has nothing to do with it, you don't have to get tail contact for V_{MU}.

MR. BAILLIE: But we are not necessarily getting to the minimum unstick, we are getting lower than normal takeoff, lift-off speed, but we are not getting V_{MU}. And--

MR. BAKER: Depends on the definition of V_{MU}. There is two V_{MU}s.

MR. BAILLIE: The important thing here is not what the definition of V_{MU} is, but what are we trying to validate for this test? And pitching authority is one and lift is the other.

MR. WILLMOTT: And lift is the other. Unstick has always really been lift.

MR. LEISTER: Also with some aircraft, the Legacy 130 you have so much lift from the fans out there some pilots claim they can make an entire takeoff with the nose off ground. You may have to design some special tests for the specific type of aircraft.

MR. BOOTHE: What were you recommending, simply do a rotation at less than recommended to check the elevator authority?

MR. BAILLIE: And hold the pitch attitude till lift-off.

MR. BOOTHE: And hold till lift-off, which gives both conditions, the control power requirement as well as the lift requirement.

Wouldn't we have to be somewhat specific about that? How would we know what speed? As long as it's below V_R, is that good enough?

MR. BAILLIE: I would think so.

MR. BOOTHE: So would we say at a speed below V_R? Would we use full elevator? I would, but I don't know if you would.

MR. BAILLIE: Our pilots are typically pulling the column back to chest when the aircraft rotates [to] capture a pitch attitude and hold till lift-off.

MR. BOOTHE: They hold till lift-off and record--

MR. BAILLIE: We also, remember, have the second case, which is the normal takeoff, which is a normal rotate. So you have two points of rotation and two points of lift versus attitude on the runway.

MR. BOOTHE: One of the things we are doing here is putting ourselves in a position of measuring such things as when did we lift off. And I don't think I have accounted for that in any of the instrumentation requirements here.

MR. BAKER: That's not easy to do, either.

MR. BOOTHE: I guess we could always put--no, it's not--Gerry [Baker]?

MR. BAKER: That's one reason Part 23 did not instigate V_{MU}, because you have to go through a process of actually determining when the airplane is actually off the ground. There is a possible alternative solution you could use. And there is several ways you can do V_{MU}. And the Boeing airplanes traditionally use geometry limited V_{MU} type thing. Most light planes don't geometry limit but determine a V_{MU} based on lift-off attitude.

There is some guidance in FAA advisory material that talks about V_{MU}s for limited control airplanes and the biggest, what that amounts to is a lot of airplanes you cannot achieve a V_{MU} attitude at forward because you don't have adequate elevator, they allow you to use more stabilizer trim, or allow you to go to more forward CG to actually run the test.

Then you have to come back and show you can produce the required rotations at your normal rotate speed at forward CG at a speed of five knots less than required. It's possible you could just use a similar situation to that. Go to your--go in the airplane at a simulator at forward CG, most forward CG, and show you can rotate and achieve speeds or actually speeds minus five knots.

That is an alternate method you can use on the actual airplane. All you are really trying to do on most modern airplanes is show you can meet performance. It used to be a big factor. The comments were you will never get off the ground, you will drag forever. I don't think that's been a big problem for years now.

I have never seen anybody encounter the problem in most of the airplanes we are talking about.

MR. BOOTHE: What you are suggesting still measures elevator control power?

MR. BAKER: The ability to achieve scheduled takeoff numbers. I'm not sure how valuable that is to a simulator, I will be honest with you.

MR. BAILLIE: That's what I was going to ask. Is measurement of the distance to takeoff that important to the training environment? Could we do that with checking off the runway markers like we are doing for the ground acceleration?

MR. RAY: This particular test?

MR. BAILLIE: On this particular test. Or do we need--

MR. RAY: We never used distance.

MR. SCHUELER: Distance isn't a requirement.

MR. BAKER: Distance isn't a requirement.

MR. BAILLIE: Well, it isn't, but measuring takeoff time is, so it's effectively the same measurement.

MR. RAY: It's a separate test. The other test. It's not inherent with this particular test.

MR. KOHLMAN: This is just elevator authority, not the distance down the runway when you are lifting the nosewheel, seems to me.

MR. BAKER: That's correct.

MR. BAILLIE: But you are going to have a condition where the aircraft is at pitch attitude and lifting off the runway. You want to determine what speed the aircraft was at that point.

MR. SCHUELER: Speed, not distance.

MR. BAILLIE: Okay. Speed, not distance. Well, your question is, can you use another measure other than oleo deflection as the primary one to give you lift-off position? I don't have an answer here. I'm just raising the question.

But do--the other question is, do we have to match this to get the commuter recurrent training goal of takeoff performance?

MR. WILLMOTT: I think the original reasoning as to why that was in the Advisory Circular was that if a V_{MU} test is important for the aircraft, it should be for a simulator, too.

MR. BAILLIE: Why?

MR. WILLMOTT: To check that the lift simulation in ground effect is like the airplane.

MR. BAILLIE: If you want to do lift and ground effect there are other ways to do it as well.

MR. BOOTHE: So the subject I think has come around to do we need to do this?

MR. WILLMOTT: The other thing I was going to say, too, was almost every aircraft that I know has a squat switch which works from a deflection of the oleo, is there no way of just recording what that is? Whenever that--

MR. BAKER: It won't always tell you you are off the ground.

MR. WILLMOTT: Perhaps that's the nearest thing to tell you you are damn close.

MR. BAKER: I have seen them break and you roll another 500 feet down the runway.

MR. WILLMOTT: If that's all you have got, if you match that on a simulator--

MR. BAKER: I tell you better than that, use a radio altitude trace. I have seen that work. Take a radio altitude trace when the airplane starts flying.

MR. WILLMOTT: We used to do something similar to that with the minimum rotate where again it was hard to find when the nosewheel was off the ground. We used a pitch attitude of two degrees or something.

MR. BAKER: Let me read a couple of paragraphs out of the [Part] 25 Advisory Circular regarding a limited pitch control V_{MU} test. Something like this might work. It says, “one acceptable test technique is to hold full nose up control column as the airplane accelerates. As pitch attitude is achieved to establish the minimum lift speed, pitch control may be adjusted to prevent over-rotation,” which is typically what you would see, “but the lift-off attitude should be maintained as the airplane flies off the ground and out of ground effect.”

You use normal attitudes, resulting lift-off speeds do not affect AFM speed schedules. If the test proves successful and the resulting lift-off speed is at least five knots below the normally scheduled lift-off speed, that's a test that you, using starting full back the airplane starts rotating, you lift off, if it lifts off five knots less you are done.

MR. BOOTHE: Where does the five knots less come in?

MR. BAKER: That was a number that somebody created. A policy.

MR. BOOTHE: If I hold a normal takeoff attitude why would I get five knots less?

MR. BAKER: You have to back up. I didn't read it all. But it's just a number to give some pad, somebody came up with five knot pads that said the five knots provides leeway for a mistrim, CG errors and so forth.

MR. BOOTHE: So does this mean it really should be hold an attitude that would cause lift-off five knots prematurely?

MR. BAKER: No.

MR. BOOTHE: I guess I have to read the whole thing.

MR. BAKER: You have got to go back to how V_{MU} relates to your speed schedule. Your takeoff speed schedule is dictated on V_{MU}. It's a percentage. So they are related to each other by factoring. That's where it gets into the picture. So it's V_{MU} is not just a number that's done and thrown away your takeoff speed schedule--your V_{LOF} is based on V_{MU}. And one reason Boeing uses geometry limits is because they can get by with lower speeds by geometry limiting than you can by attitude number by about two percent.

MR. BOOTHE: I don't see anything wrong with using that procedure that's outlined in the Part 25 AC if we can do it with reasonable--what I get back to is lower cost, less instrumentation and I don't know whether we satisfy that requirement, I don't think so.

I see Daryl [Schueler] shaking his head no. But as far as the procedure is concerned, it sounds like a good one, that it would certainly be applicable and would address the V_{MU} for non-Part 25 airplanes, although call it by a different name.

MR. BAKER: The goal is make sure you can achieve rotate schedules. If you can meet the numbers, that's the bottom line. You don't--this is related to a pitch limited airplane, because what they allow this airplane to do is V_{MU} at some stabilizer position, now come back and validate it and make sure you can achieve those takeoff schedules, that's the bottom line it comes out to. And you don't get into any over-rotation issues.

MR. BOOTHE: For the simulator, when we compare it to that, there would be two goals. One that we demonstrate the same elevator power, so that we attain rotation at same speed, and further, then, that we lift off at the right speed so that it gets us both the elevator and the minimum C_L, I guess.

MR. BAKER: There are a lot of airplanes that have been certified that way, I can tell you that.

MR. BOOTHE: If there are airplanes certified that way it would make sense to try to do the simulator tests that way. The only problem you have is then how do we instrument to accomplish this? Does that put another double asterisk? I don't really think so.

What it means is we have to have something to measure when we lift off, that's what we are missing.

MR. BAKER: I think you could use radio altimeter.

You could try a squat switch, but they really have never worked for me.

MR. BOOTHE: I have heard stories like that myself.

MR. BAKER: You start trying those tests, you can extend the main struts--unless you had a nose strut, the main struts, you can get them fully extended and keep the wheels rolling a long time.

MR. HEFFLEY: There should be an acceleration at that point that's identifiable.

MR. BOOTHE: If installed, Bob [Heffley]. If you have that package in there, I would rather not require that.

Does this meet your scheme, Stewart [Baillie]?

MR. BAILLIE: It does, and you are right, we really don't have an improvement in instrumentation. We--our experience with trying to wire in for squat switches is that the aircraft in general has so much other electronics associated with their, you know what I mean, squat, that the signal is unusable. Oleos are easy but they are mechanically complicated.

MR. BOOTHE: How much lag is there in a radio altimeter? I don't know anything about those things.

MR. BAKER: Not much.

MR. BOOTHE: Is that sufficient accuracy?

MR. WILLMOTT: None. It just depends on how accurate, how you want to use it exactly, how accurately--

MR. BOOTHE: I want to use it when I lift off the ground, that's pretty precise.

MR. WILLMOTT: You probably won't be able to tell. It will be a real asymptotic type.

MR. BOOTHE: Maybe 19 guys looking at it, like this *(indicating)*.

MR. WILLMOTT: Some of them with magnifying glasses, too, Ed [Boothe].

MR. BAKER: The ones I have, ones I have seen are a pretty clean break.

MR. BOOTHE: I wouldn't rule it out.

MR. BAILLIE: It depends where the radio altimeter antenna is, too. If it's on the nose and you get any pitch rate at all--

MR. BAKER: The thing is--when you run these tests you are holding constant pitch, keep in mind. You are going to hold that pitch attitude.

MR. BOOTHE: It's a change we would be looking for.

MR. BAILLIE: How are we going to determine pitch attitude unless we have the inertial system on board?

MR. WILLMOTT: Hopefully we will be able to get this TIR test and the manufacture support--this is always a test that's done in the airplane.

MR. SMITH: Time history of pitch?

MR. STOCKING: If you have accelerometers you can have the same information. You don't have to have an--

MR. BAILLIE: You have accelerometers and rate gyros--

MR. KOHLMAN: If you have just a standard inertial box, you will have three gyros, three rate accelerometers and a vertical gyro. Isn't that what we have in--

MR. SCHUELER: That's what is typically referred to as inertial data independent of what the transducers are. Whether you apply inertial--

MR. BAILLIE: This would then be the first test that then needs an inertial system.

MR. BOOTHE: All right. So you are saying here that you need to add the requirement for inertial system, we can do the required test as in Part 25 for those airplanes that have complied with that and for which there is data available, we can do the test that is defined in the Advisory Circular for compliance with Part 23. Gerry [Baker]?

MR. BAKER: 25.

MR. BOOTHE: 25. So that applies to either large--

MR. BAKER: That is 25.

MR. BOOTHE: We can still do the same test for commuters.

MR. BAKER: I don't see the need for commuters.

MR. BOOTHE: You still have the need for elevator power.

MR. BAKER: Unless you want to do distance and power elevator, if that's what you want.

MR. BOOTHE: So I think with that combination of those two tests what we have done is actually increased the extra instrumentation requirement here, unless you know a way out.

MR. KOHLMAN: If you relax the resolution requirements you can read pitch off the artificial horizon.

MR. BOOTHE: If we are trying to maintain an attitude to match lift-off speed, I don't know, Dave [Kohlman].

MR. SMITH: It's a real critical parameter. As a matter of fact, I was going to say normally we have a one and one-half degree tolerance on pitch, again we don't worry about it on V_{MU} normally because you are geometry limited, so in some ways it matches the airplane, but here you may not want to allow one and a half degree tolerance, that would make a big difference.

And you have got tolerance, you will have tolerance on the V_{MU}.

MR. RAY: If you match input, the input ends up being attitude.

MR. SMITH: Whichever way you do it. If you match elevator--

MR. DAVIS: You just mentioned elevator. The present requirements explicitly state you have to use exact elevator to maintain the pitch. Do we have to measure that surface now?

MR. BOOTHE: What we would be doing, if I understand the test correctly, is using full elevator until the airplane rotates, or simulator, at which time you relax control input to match pitch attitude, which you hold constant till you lift off.

MR. DAVIS: Right.

MR. BOOTHE: I don't see there is any inconsistency there with having to measure the surface deflection, because once you have rotated, we have got the confirmation of elevator control power at full elevator. And I think once you relax the elevator to maintain pitch attitude, then we can measure how we would have measured it before. Is that not true?

MR. DAVIS: We measured it before by instrumenting that surface, that's what we are trying to get away from.

MR. BOOTHE: Before today, as we discussed this morning. By measuring pilot controller position and having a relationship then to the elevator, like we were talking about this morning. Now that may not be in the data package from the manufacturer if this is data we used from a manufacturer; but we are talking about if you have data from a manufacturer, then this discussion is really not germane, anyway.

MR. DAVIS: Still, so I'm clear, the requirements right now say that you must match elevator exactly. Your elevator must precisely match aircraft data. Are we sticking by that? Do we still have to measure that parameter if it's not readily available or forego that and maintain pitch attitude as required, whether it's 12 degrees or whatever?

MR. LEISTER: That's pilot input.

MR. WILLMOTT: For Level B you were suggesting earlier on, that we do not use surface.

MR. LEISTER: That's pilot input.

MR. BAILLIE: Do you need to match the pilot input at this point?

MR. HEFFLEY: No.

MR. DAVIS: I'm just saying it's on the books right now.

MR. BAILLIE: Ground effect elsewhere, in this case you may just want to match aircraft attitude and rotation given full elevator on the takeoff roll. So you don't care about pilot input for this test.

MR. LEISTER: I think you do, too, the elevator power is very nonlinear in that area. And by matching pilot input for V_{MU} and then for normal takeoff will cover that.

MR. HEFFLEY: Where you are interested in elevator power is where you have full aft elevator. At that point when you release full aft elevator and go to constant attitude, elevator doesn't have very much to do with where you lift off.

MR. LEISTER: Yes, it will.

MR. HEFFLEY: Well, within the tolerance of the model here, what really matters here at that point is pitch attitude.

MR. LEISTER: The elevator power is different in that area.

MR. BAKER: The way this is going to happen, the elevator will make a lot of difference because what you are going to find at forward CG, this thing is going to--you are going to be full aft elevator about the time you come up to the speed you are going, you are supposed to rotate, you are going to go forward to hold attitude, if you don't have the elevator for the right speed you are going to go through. Keep in mind you don't have an over-abundance of elevator here. You are not going to pop the nose off at 35 knots of most of these airplanes. I have seen some airplanes go to 140 knots before they lift off.

MR. BOOTHE: So elevator is important or some measure of longitudinal control.

MR. BAKER: Unless you have an exceptional airplane that's overloaded with elevator power.

MR. WILLMOTT: From the standpoint of the next phase of discussion, math models having an elevator time history is very, very useful, but for this particular thing it's not. You can get the minimum rotate speed matching because there is a variety of pitching moments involved.

One of them is the elevator, but the other one is also very important because it's a very low speed, is the pitch from the engines. And as you proceed to a higher speed than that, what happens to the pitch due to the engine is indicated to quite an extent by what happens to the elevator as you are proceeding higher up in speed.

So I don't think it's necessarily required for this test, but, you know, if we discuss later on what we really would like to have for the purposes of modeling that helps us in determining the pitch due to the engines at very low speeds which isn't checked anywhere else--

MR. SMITH: There's also ground effect on elevator effectiveness.

MR. WILLMOTT: It's a very complicated area, pitch due to basic airplane, pitch due to ground effect, pitch due to the engines--

MR. BOOTHE: What I hear--

MR. WILLMOTT: --and engine pitch particularly changes quite a lot of very low speeds.

MR. BOOTHE: What I hear you saying and disagreeing with yourself, is we need to measure something that correlates elevator effectiveness.

MR. WILLMOTT: What I said for this phase of our discussion, the validation data, you don't really need it. But when you get to our next phase of discussion, which is modeling, I think you do need it.

MR. LEISTER: You do, I don't. I can deal with that.

MR. BAILLIE: Ed [Boothe]?

MR. BOOTHE: Yes, sir.

MR. BAILLIE: I have one other comment.

Gerry [Baker] brought up a remark which makes a big difference, which is center of gravity and weight of the aircraft. We have yet to say whether we are going to require these at a variety of center of gravities or one, a variety of weights or one. And one consideration is that every commuter driver can take his own aircraft, fly it at a nominal CG, nominal weight in after hours non-revenue time and do these tests. So the simulator to meet what the guy does in the actual aircraft doesn't necessarily need the worst CG and the worst weight, given though it would be better to have the critical condition in each case.

MR. BOOTHE: Well, yes, I hear you.

MR. BAILLIE: It costs.

MR. BOOTHE: It does, but I think that that's one place I think we have not done a good job in training. We go out and train in simulators as though they were airplanes, so we use a training configuration, so when people train in airplanes they have medium weight and a mid CG, but I think to do that training in simulators we are missing the boat. We ought to be training more critical conditions that people encounter on heavy weight takeoffs and those kind of operational environments.

Why don't we use the simulator to really duplicate the operational environment? If we are going to do that, I mean go out and train in a simulator at mid CG and light weight, and then you tell me to take off in a 7--let me get back down to small airplanes. At maximum gross weight and perhaps an extreme CG with a full load of people, it's not typical of what I just did in the simulator. We need to look at some more critical airplane configurations and loading here. So I don't think we should just do everything at mid CG.

MR. BAILLIE: The important thing is not doing it at mid CG and nominal weight adds cost. That cost is probably well worth it if there's training and then the trainee uses it. But to add the cost and have training regulations not require critical configurations is a waste of money.

MR. BOOTHE: Tom [Toula] can take care of that.

MR. TOULA: This Tom.

MR. LONGRIDGE: We already do that in AQP, we actually specify the conditions to a much greater level of detail--winds, contaminated runways, all these things are spelled out in the qualification standards for a given approved AQP program. It will be aircraft specific.

MR. RAY: Ed's [Boothe] comment is absolutely right on target with what happens in the training world versus real world. There is the old story, I don't know if anyone heard it. The old pilot was being trained at 2:00 in the morning with light loads and full power takeoffs, and the airplane naturally jumps off the ground and accelerates. To compensate for the pitch forces, he starts running in nose down trim before takeoff.

MR. BOOTHE: You can tell where he is from.

MR. RAY: Run in a number of units of forward trim to avoid forces after lift off. Nobody caught what he was doing, he went out on the line, nothing abnormal. He finally gets heavy weight forward CG takeoff. Guess what he did? Same technique. He wanted to again avoid the anticipated forces after takeoff. Fortunately the copilot happened to notice what he had done. The copilot ran the trim back out when the aircraft wouldn't rotate and finally lifted off at the runway end. The story simply supports training at extreme CGs, absolutely right.

MR. BOOTHE: I more or less arrived at the opinion we need a measure of elevator input, direct or indirect to make this a useful test. If you really strongly disagree with that, I'm subject to being persuaded, but from all I've heard it sounds to me if we don't have some measure of longitudinal control input we are missing half the test.

MR. HEFFLEY: Ed [Boothe]? Aren't we trying to do two things here. We are trying first of all to validate that there is the right amount of pitch attitude control and the right amount of elevator power, if you will, for a given air speed. And the second thing is that there is the right amount of lift for a given attitude and air speed.

And they are two separate things, they both can be considered separately and they can both be considered at two different air speeds, in fact two different tests. One is driving down the runway at full aft elevator to measure where you start to get elevator effectiveness, i.e., some pitching motion. And number two, you are trying to measure where you achieve enough lift to fly, and that's most easily done at a constant pitch attitude, which represents a constant angle of attack as you are rolling along the ground.

Why does this have to be done as some sort of dynamic maneuver other than to just vary the air speed enough to measure your pitching moment and your lift at two convenient conditions? I mean, it's--we keep coming back to the minimum unstick label for this, but that's a certification maneuver and we are trying to validate simulator characteristics here.

MR. BOOTHE: So you are saying we could do two pieces, one at low speed and the other--

MR. HEFFLEY: We have two different characteristics we want to keep separate in the simulator, the simulator has a valid elevator control power and the simulator has a valid amount of lift in ground effect at a given angle of attack. Two separate points, and we--you can probably get those two separate points in the various ways.

MR. BOOTHE: They don't care what the elevator is at that second point, the lift-off point?

MR. HEFFLEY: No. Not especially, it's not--it's going to be the small stuff in your simulator math model, it could vary quite a bit and it's not going to change that answer of whether the thing starts flying very much. The amount of elevator contribution to lift is not--is not huge.

MR. BOOTHE: Especially when the wheels are on the ground.

MR. NEVILLE: I guess a question I have is how much does this alternate test V_{MU} or equivalent V_{MU} add to the normal takeoff? Normal takeoff tests pitching moment due to elevator, it certainly tests lift if you match the time history. It has to lift off at the same speed and so on. What additional information do you really get from a V_{MU}? Is it necessary for a Level B simulator?

MR. BOOTHE: So you are saying really all we need to do is something to measure elevator effectiveness at low speed, or are you saying that?

MR. NEVILLE: Just a normal takeoff.

MR. BOOTHE: Because normal takeoff normally doesn't apply elevator until V_R, slightly before.

MR. BAKER: I understand what he is saying. I think he has a point. It was mentioned earlier V_{MU} is a certification issue, the pilot never sees the V_{MU}. It's--and the important thing is you can--that's the purpose of that test, that you can rotate, you can meet your performance numbers.

In a simulator, I think there is some truth to that, you are not trying to be a test pilot, you are trying to show that you have adequate elevator authority to rotate at the proper speeds and lift off at proper speeds. I think that's all you are trying to do. At the most extreme CG, though, you have to go to a forward CG to validate that, obviously.

MR. KOHLMAN: I think that adds to inflight measure of elevator power, which will certainly be done is what Stewart [Baillie] was saying. You get an in ground effect at high power.

MR. SMITH: You get full elevator, it's not linear for normal takeoff, you don't get in the linear range necessarily at V_{MU}, you are at the limit.

MR. NEVILLE: Maybe you need a minimum nosewheel lift-off, which used to be a requirement and went away. It's a very simple test to perform, if you need an additional test, it's at lower speed, requires full elevator.

MR. RAY: It appears to be one of those where if you have classic V_{MU} data, that's acceptable. As an alternative, what I heard Gerry [Baker] say seems like a reasonable test of a number of items. It fits right in.

MR. BAKER: Pretty close to what he is saying.

MR. SMITH: Covers both areas.

MR. BAKER: Not much difference.

MR. RAY: It's a fairly mundane test to do.

MR. BOOTHE: All right. I think we beat this to death. I still don't know whether to measure elevator deflection or not. Where I have it is we either do a V_{MU}, because that's what was done in the airplane for Part 25 airplanes and that measures the things we need to measure; or we do the tests Gerry [Baker] described, which we can get a hold of the Advisory Circular or refer to the Advisory Circular for that.

So the only other remaining question I have is do we need to measure directly or indirectly the elevator input in a continuous fashion or do we just need to measure pitch attitude and lift-off speed? That's the question I need answered.

MR. WILLMOTT: If you want the opinion from me, I would say no. And the reason--

MR. BOOTHE: No what?

MR. WILLMOTT: We do not use elevator time history. For the normal takeoff you will have, I guess, control column, because we are replacing that by elevator for a normal takeoff with a lower value of elevator. That will enable you to check that the pitch is correct in that condition. You don't need this continual time history.

MR. BOOTHE: I will scratch elevator deflection here and we will defer that to normal takeoff.

MR. BAKER: Let me ask, I would assume when you go out and you conduct tests on these airplanes, that you do validate that the elevator is correct, don't you? I would hope so, we wouldn't go through a certification process without assuring the airplane is in conformity.

MR. WILLMOTT: The basic reading.

MR. BAKER: Yes. The airplane you are flying. I hope you don't pull the airplane off the line and validate the test.

MR. BOOTHE: I think that's been done, Gerry [Baker], but it gave us some problems.

MR. BAKER: You have critical stabilizer angles, you have critical elevator angles, you have to be at least at the critical tolerance as a minimum. For stall recovery you want the least nose down elevator. For stall speeds, you want the least nose up, I don't think you need to go that far but you at least need to be within nominal tolerances on all surfaces of the airframe.

MR. BOOTHE: I firmly agree, any airplane that's going to be used for testing, to acquire data for simulator validation, certainly needs itself to be validated before one begins gathering data, otherwise you are just measuring garbage.

MR. BAKER: It's not unusual to get an airplane off the line--

MR. BOOTHE: I'm going to leave that one. I thought that was going to be an easy one. And we may revisit as things go on.

Let's go on to normal takeoff. Really I don't see any difference there except what we are really doing now, although Dave Kohlman planted some words on us about reconstructing flight paths, I'm not quite sure what that means, but the thing that I have really changed here is not measuring angle of attack as we currently do in--across the board, according to the Advisory Circular. Otherwise I don't see how to do that without strap-down instrumentation.

There are some things you could do, video of the airplane instruments, but you could probably get by with that for takeoff because it's not really a--it's not steady state, but it's not really a quickly varying situation.

But since you have to have an inertial system anyway, I don't see a whole lot of difference from where we are from all simulators or how to do better than that, so I think your input--

MR. HEFFLEY: I have a question. In this particular case, suppose someone proposed to measure flight path and attitude from an external video and did the appropriate reconstruction of flight path from looking at the aircraft externally and avoided instrumentation of anything.

MR. DAVIS: I think you could get certain things that way, but there is other information you can't measure, like the control force or something, and how are you going to correlate this information off line? You may be able to get a good vertical speed or good altitude that way, but certain things, control forces as an example, you can't get that way.

You have to correlate it with these two, separately collected information, that may be a problem. Aside from the accuracy of that technique, which would be questionable.

MR. BOOTHE: Stewart [Baillie]?

MR. BAILLIE: I would think in any case the technique has to be put forward to the FAA, and you guys judge whether it's accurate or not.

MR. RAY: Before the fact?

MR. BAILLIE: Before the fact. As an example, we have done a certification program on a simulator where we did not measure angle of attack, and that was fully accepted. But before the fact we proved the technique was accurate enough. So I can come up with any other measure--

MR. BOOTHE: As long as you can prove it, I don't know why not.

MR. LEISTER: If we don't measure surface deflection, you need inertial system or some system to measure the pitch attitude, pitch heading and all those things, because you can't really derive a good model without surface deflection, if you don't have the other additional information, acceleration.

MR. BOOTHE: I have included that here.

MR. LEISTER: I know, I keep hearing, I think I keep hearing that maybe we won't have the inertial system on some tests but I think you have it strapped in on all the tests, really. So you do need all the attitudes and acceleration to derive a good model.

MR. BOOTHE: You know, I think it's reasonable to assume that if you have to put an inertial system in the airplane for those tests that require it, chances are very good you are going to use it for other tests. And that only makes good sense. So consequently, when building this table I have--could have just included it in all tests and we could all go home. But in the interest of trying to look at the minimum case, I chose to do it this way.

But if it were installed, I mean surely people would use it. But you could also consider the situation where maybe you had a partial data set, as Bob [Heffley] had mentioned earlier, and wanted to supplement it, in which case you may need not to do inertial measurements and do other tests by different means.

MR. LEISTER: But my memory was you were talking about attitudes--I built a simulator once using just video data reading pitch attitude and I don't ever want to do that again. It's not accurate, not a good way to do it.

MR. BOOTHE: I think, to answer Bob's [Heffley] question, I don't think it's something we ought to write in here, but I think that needs to be referred to these guys, but if you were to come forth in the plan that you would present prior to collecting data, here is how I plan to do it, here is what works, I think you would find that--

MR. HEFFLEY: One reason I ask that question is we have a case here in this normal takeoff where for the most part we are going to have validation of the math model in most all respects from other tests. And this is one of those tests that is kind of a, you know, it's--it lumps everything into it. It's more--I guess I'm not sure exactly what the real purpose is, what's unique about this one particular test that isn't covered by others. Other than it just represents a normal takeoff on this, you would like to see a normal takeoff being made in a simulator.

MR. BOOTHE: Good point.

MR. HEFFLEY: It's a closed loop maneuver of sorts. And it's a complex test.

MR. BOOTHE: If you don't have a means of automating the test you almost cannot accomplish it.

MR. HEFFLEY: Yes.

MR. WILLMOTT: I think there is a number of things that normal takeoff checks. The principal things being the ground effects with the nose on the ground and the ground effects once you are at the takeoff attitude or angle of attack. Particularly at the higher angles of attack with the right takeoff flap settings.

MR. HEFFLEY: We had that with the previous test, though.

MR. WILLMOTT: Maybe, maybe not.

MR. DAVIS: One thing that is unique to this test, reversible controls and a requirement to match stick force.

MR. WILLMOTT: One of the effects that you get for the normal takeoff if you haven't modeled the correct ground effects as far as the change of pitching moment ground effect with angle of attack, is over-rotation, and it's a good test to check that. This is a normal maneuver that the pilot is using for taking off in the simulator and in fact if you don't have that pitching ground effect correct you get over-rotation, and that's a common problem in simulators in that area. This helps to check that.

MR. STOCKING: Or under-rotation.

MR. WILLMOTT: Or the other way, too. You have the right slope of pitching moment versus angle of attack and ground effect at those angles and the minimum unstick doesn't necessarily check the changing effect at these attitudes.

MR. STOCKING: The number one training value I would say for a takeoff is the force required to rotate the aircraft under a number of conditions. That's really what you are aiming for. Forward CG, aft CG, gross weights, power settings, all those things affect the force to rotate. Pilots are very sensitive to that.

MR. BAKER: One of the biggest items is the stabilizer position.

MR. STOCKING: That's part of the longitudinal stability of the aircraft.

MR. BAKER: A lot of simulators don't do a very good job on that one. The positions aren't anywhere close to the airplane's, I have seen that on a lot of them.

MR. NEVILLE: Takeoff characteristics are something we found really important to get right. Because especially a pilot during recurrent testing familiar with the airplane is very familiar with what a takeoff feels like. And if the simulator doesn't feel right, he will squawk it.

MR. WILLMOTT: Take a 747, for example, during its rotate phase, it has a hesitation at about seven degrees of pitch attitude, and further application of control column is required to enable rotation through this attitude--

MR. BOOTHE: That's Boeing.

MR. NEVILLE: Not just the 747.

MR. WILLMOTT: --in order to get it to go through that particular pitch attitude to simulate that.

MR. BOOTHE: Haven't you guys managed to engineer that in every paper?

MR. SMITH: It's a wrinkle in the paper, Ed [Boothe].

MR. BOOTHE: I think--I'm sorry.

MR. STOCKING: I was going to say for a turbo prop aircraft it's more critical because you have the lift induced by the big fans out there that are really going to have an effect on this problem.

MR. BOOTHE: Are there any reasons to change anything here for normal takeoff? Other than what we--Stewart [Baillie]?

MR. BAILLIE: You are suggesting we don't measure angle of attack, which I would agree with. But what about touch or lift-off? Do we measure oleos, do we measure squat switch?

MR. BOOTHE: I have a radio altimeter in there--

MR. BAILLIE: That's going to be sufficient.

MR. BOOTHE: --which I would assume would be measuring lift-off and climb profile to 200 feet.

MR. BAILLIE: I wanted to clarify that.

MR. BOOTHE: Whether or not that's really precise or not to determine the moment of lift-off, I don't know. But then I don't know that the exact moment of lift-off is that important, either.

MR. NEVILLE: The radio altimeter.

MR. WILLMOTT: If we match pitch attitude and radio attitude tolerance, it pretty much indicates lift-off at the right place.

MR. NEVILLE: Radio altitude is a much cleaner measure of lift-off than it is for a V_{MU}, which is a very gradual takeoff, which is asymptotic, but for a normal takeoff it's pretty easy to spot.

MR. BOOTHE: Critical engine failure on takeoff, this is the one that traps us all and keeps us from doing things we might do otherwise. We need the aircraft dynamic response to the engine failure, we need correct control inputs, it is a test, everybody talks about V_1 cuts, that's the things that always keeps certain requirements in simulators that otherwise might not be so critical.

But I think a way to think about V_1 cuts is that nobody gets to do them in airplanes anymore and even when they did they didn't really do them, so the only person that does this is the company test pilot or Gerry Baker. But no person in training for operational flying ever does this anymore, to my knowledge, in an airplane, and if they do it's not a true representation. So I think it's a maneuver where proper simulation is very important because while engine failures are rare, fortunately, it's the only place where a pilot will see engine failure.

So I have left that to say that we, the subject matter experts here, need to identify the critical parameters, and I thank Dave Kohlman for putting this notion before me when we visited you, if we could identify critical parameters, then maybe we could simplify that somewhat.

I just wanted to introduce it with those thoughts, because I think that proper simulation here is as critical as that--

MR. KOHLMAN: I wanted to add that there are operators that are still doing V_1 engine cuts on takeoff in the airplane. That's why we need to do it in the simulator, because it works out not happily, occasionally.

MR. BOOTHE: True. But they don't really because they don't fail the engine--

MR. TOULA: They come close.

MR. KOHLMAN: That's right. They are coming back to a torque measurement that the manufacturer says matches zero thrust. It's a very realistic engine cut.

MR. BOOTHE: We don't want them to do that. I don't have data or statistics with me, but I think if you were to look at the past ten years of training accidents, most of which seem to occur in turbo propeller airplanes, a good number of them occur with engine failures at takeoff. And some other dumb things people did.

But the whole objective here is to get people out of the airplane and not do these things in airplanes. All the more important why the simulator has to.

MR. WILLMOTT: We are starting off by asking for parameters needed; is it useful to use what we have for tolerances? Air speed, pitch, we have angle of attack, altitude, bank, slip, column force, pedal force and wheel force. This test also helps to define an additional parameter for the prop type aircraft; the first part of the takeoff run indicates the amount of rudder pedal that is needed to offset the slip stream "turning" effect from symmetric engine power application--on some of these aircraft it's quite large.

MR. BOOTHE: I guess the next question is is there anything we need to do differently? Obviously we need the inertial measurement system for this. I don't see any relief for that. And we need control measurements, maybe not at the surface but someplace like in the cockpit.

MR. WILLMOTT: We do have the pilot forces here, which under Stewart's [Baillie] category is very difficult.

MR. BAILLIE: But probably required.

MR. WILLMOTT: But I think they are very important for V_1 cut.

MR. BOOTHE: The things we don't have are sideslip angle and angle of attack. What does that do to us? Or they are things we were recommending not having?

So sideslip, if I have inertia I can measure lateral acceleration?

MR. LEISTER: Yes.

MR. HEFFLEY: And heading.

MR. BOOTHE: Does that get me home free on this?

MR. KOHLMAN: I think it does. You can derive angle of attack and sideslip angle, they are not as accurate as direct measurements. What Stewart [Baillie] is saying, I agree with him, are the more critical parameters are control forces, bank angle and control deflections.

MR. BAILLIE: The important question is would there be a requirement to make a derived sideslip to the aircraft or the simulator model? Or is heading and lateral acceleration sufficient?

MR. BOOTHE: I think if you met--the dynamics are really lateral acceleration.

MR. HEFFLEY: That works, yes.

MR. BOOTHE: I think that's more important.

MR. HEFFLEY: Yes.

MR. BAILLIE: Me, too.

MR. HEFFLEY: They are observable and the angle of attack and sideslip are not observable.

MR. WILLMOTT: If you have the inertial platform on there, with an altimeter and heading, doesn't that enable you to get sideslip?

MR. BAILLIE: It does. But as you know, we don't do it that way anymore because it's far too much manpower.

MR. WILLMOTT: Manpower? Don't you use a computer program?

MR. BAILLIE: No. It's not something that is easily automated. And tremendously manpower intensive for a given V_1 cut on a certain simulator, it probably took a week's computing effort by somebody sitting in the terminal and tweaking to get it right.

MR. WILLMOTT: Really?

MR. BAILLIE: Whereas lateral acceleration and heading, measured directly or close to it, is a lot easier.

MR. BOOTHE: So if I add to this, this sort of description here, measure heading and lateral acceleration, and omit angle of attack and sideslip, we end up doing the same thing we are doing, we just look at a couple of different parameters that are easier to measure. Is that okay? Does that get us home? I'm sorry, Bob [Heffley].

MR. HEFFLEY: I was just going to say you want to look at angle of attack and sideslip in this particular situation as being redundant, really. That you have got sufficient information from acceleration and angular rates to see that the motion is reasonably close.

MR. BOOTHE: Now I have got testing in free air. I think that's for people like us who are going out and trying to develop some airplane responses but ultimately it seems it's going to have to be done on an in ground effect, too. Maybe I better strike that and leave that to people's own ingenuity rather than try to dictate something. I'm going to scratch the test in free air and let that be just test with strap-down inertial system, and leave that to the ingenuity of the people designing the test and presenting them for concurrence before doing them.

MR. BAILLIE: Another question I have, Ed [Boothe], is typically we have talked about V_1 cuts, but in the test environment do we necessarily need it exactly V_1? Or do we need it somewhere close to V_1 to just validate the dynamics in that regime?

And then the other question is, is a rapid throttle chop sufficient or do you need the fuel cut? Both of which cost a lot more in effort.

MR. LEISTER: You may need to ask another question, do you want to cut the engine when it's rotating a turbo prop, that's a lot more than V_1, do you want to do that?

MR. BOOTHE: I didn't understand, Dave [Leister].

MR. LEISTER: Cut the engine when it's rotating, takeoff rotation, you cut the engine there, that's more critical than V_1, or at least it's a lot hairier in a prop job. Do you want to do that?

MR. KOHLMAN: For many turbo props that's where V_1 is.

MR. LEISTER: True.

MR. KOHLMAN: Very close to rotation.

MR. LEISTER: That's a very critical area with prop jobs. I guess jets not so much.

MR. BOOTHE: Well, personally I don't see that there is anything that is so magic about the exact number V_1, I think we need to know--

MR. LEISTER: Just on takeoff?

MR. BOOTHE: I think we need to know the response of the airplane to an engine failure at speeds close to V_1, but I don't see anything magic about V_1 itself. I do think, though, that we need to find out what's more critical, throttle to idle or the engine being stopped or cut off?

MR. BAILLIE: Does it matter?

MR. BOOTHE: Yes.

MR. BAILLIE: Assuming that the engine model can do both in the simulator and will provide the thrust that is appropriate for each of those conditions, if you have the thrust for one condition that you match, can you accept the extrapolation to that more critical case?

MR. BOOTHE: Well, if you model and we test it at a point which may be a throttle, a rapid throttle chop to idle cutoff and validates, one could take the position well, if the model is good it will also validate at the other point.

So I don't know, any thoughts on that?

MR. WILLMOTT: Modeling of these propeller driven aircraft is not easy. I've only really been involved in one, which was the King Air, and I know that there are even problems with the analog simulation equations, when you look at them in detail they don't really work. And things were done so as to represent the forces and the conditions and, you know, the speed at which they feather, things like that, don't automatically come out on any models, you have to engineer something. Usually from specific flight tests.

The answer is, you know, it depends on how good that engine simulation is and that is not anywhere near as straightforward as [with] a turbo jet. Maybe Dave [Leister] can say something on this, he has done it more than I have.

MR. LEISTER: Yes. I guess the worry is that these airplanes that have negative torque sensing systems, like an MU-2, if you fail an engine on an MU-2 on takeoff and your sensor doesn't work, you are going to go on your back in a second and a half. What do you do in a simulator to do that? We can get real complicated on takeoff.

MR. BAILLIE: Do you have to--

MR. LEISTER: Do you have negative torque sensing, is that assumed on this engine at takeoff that you do in a simulator? Do you have to prove that it actually--

MR. BOOTHE: I have taken a position in the past that not everybody agrees with, but--so that's not unusual, that if the airplane were certified with a negative torque sensing system and somebody showed the reliability of that system was good enough to certify the airplane, why should I worry about it not working in a simulator? I mean, is that a reasonable--

MR. BAKER: Depends on whether it's required or not.

MR. BOOTHE: I have often said let's look at what's required sometimes for airplane certification, we certainly don't need to make simulations any more complicated. And if an NTS was good enough for the airplane and that's what's considered an engine failure, either autofeather or NTS, that's good enough for the simulator. I don't see why we need to go beyond that.

MR. LEISTER: What brought that to mind is the comment about engine dynamics on takeoff when you have an engine failure. And that test is very sensitive. Whether the--you have the negative torque sensing or the autofeather properly monitored.

MR. BAKER: Some of the King Air series, the autofeather was optional. Some had them, some didn't, so you needed to model those. Most of these airplanes you are talking about in this category have some type of autofeather. In fact, you know a Part 25 airplane basically says that pilot on engine failure, shall do nothing other than fly the airplane, it forces them to go to autofeather, the rule clearly says that if you don't have autofeather you have to let the prop windmill. Most of them can't tolerate that.

MR. BOOTHE: Not without a bigger engine, even with bigger engines.

MR. BAKER: So most of them are going to have autofeather, I don't see a fuel cut being a big deal on an airplane with autofeather.

MR. BOOTHE: I agree.

MR. BAILLIE: A fuel cut is a big deal when you get in an aircraft from an airline and you need to get the aircraft capable of doing a safe fuel cut, you have to get in the fuel system, you need an experimental or type certified valve in there. It's a big installation. It effectively adds a week.

MR. BAKER: You don't have a fuel shut-off valve anywhere?

MR. BAILLIE: In some cases, if you use a fuel shut-off valve when the engine is at high power, you have to overhaul the engine.

MR. BAKER: Most airplanes that's not true. Maybe for some airplanes, but I have never seen an airplane that there--

MR. BAILLIE: My understanding is that in these cases the fuel cut puts an unbalanced load on the fuel controller.

MR. WILLMOTT: I would suggest that the tests performed be the one that's safest for the aircraft and you rely on the proper simulation to give you the effects of the other types of failure in simulation. And sometimes it would seem that just pulling the throttle back is not necessarily the safest way of doing it.

MR. BOOTHE: If the airplane has an autofeather system and you pull the throttle back at takeoff, it's going to autofeather, isn't it? Isn't that usually--

MR. BAKER: No. A lot of them won't. A lot of them won't autofeather unless it's on at takeoff position, in King Air airplanes.

MR. BOOTHE: If the autofeather is on and if at takeoff power I reduce one engine, won't that engine autofeather?

MR. BAKER: No.

MR. BOOTHE: It won't?

MR. BAKER: A lot of them don't. You have to, in fact you take an airplane again like King Air 1900, if you lose an engine you have to leave the power levers forward, if you actually lose an engine, to get the autofeather to work.

MR. BAILLIE: During the certification flight test, the manufacturer typically gives a procedure to simulate an engine failure for training.

MR. BAKER: That's true.

MR. BAILLIE: What throttle to pull back to.

MR. BAKER: That is if you go out every day and train in the airplane.

MR. BAILLIE: Is that an appropriate match for the simulator plus knowing the engine models have the other characteristics?

MR. BAKER: I don't know. I guess I have this thing, the simulator ought to be built to represent the airplane. And when you go through the certification process in a real airplane you make fuel cuts, I don't know why you guys do it any different. You are big boys, too, the guy gets out and gets hazardous duty pay for flying these tests, so pay him. You are talking about expensive simulators here, they darn well ought to represent the airplane.

MR. BAILLIE: We are trying to reduce cost. I agree if we are trying to go Level D, if we are trying to keep the $15 million, $20 million simulator, that's no problem.

MR. BAKER: If you can rationalize the critical malfunction without making fuel cut, that's fine. We have trouble doing that on original cert on airplanes, most of them end up with fuel cut. I have never seen a full fuel cut damage an engine. So we have gone around the pattern 20 times and made fuel cuts on airplanes. Restart, come back around, do another one. Time after time after time. I have never seen an engine damaged from it.

Maybe there are certain fuel controls on certain engines that can happen. I can understand that. Some of the big huge engines do have those problems. Most of the smaller engines that's not a factor, to my knowledge.

MR. RAY: I'll start using the word “preamble paragraph,” the lead-in to this, the assumption that the engine and prop model is correct. If it's not, you may not have sufficient data to validate exactly how it should perform.

But if you go in and check it and put a Gerry Baker in the seat and it doesn’t perform correctly, I don’t really care what the objective says, it doesn't work. A two function evaluation of this device that Mr. Baker or his coworker, one of the fellows out of Wichita or Seattle, goes in and checks the device and does the fuel cut, then we have a problem to resolve.

MR. BAILLIE: That presupposes the guy that's going to do the subjective testing has done the fuel cut on the real aircraft and is fully familiar with it.

MR. RAY: That is the goal that we have in trying to get someone like that. We can't always do that. It may be in some cases we have found that it's two or three evaluations down the road before we actually get that person in there. So that word “assume” jumps up and bites us again when we assume that it passes the first test that it's good forever, that's not the case. We can't assume that that model is correct. If it's not correct, it has to be corrected.

MR. BAKER: If you can rationalize it by calculations or whatever, that's fine. As long as you know you are correct. That's the point.

MR. STOCKING: To save time we might want to talk min control air.

MR. BOOTHE: We will get to that. It's break time. A quick summary, I think we leave this pretty much as it is with the added addition of heading and linear acceleration based on data from the airplane. I know we did not resolve how we would test the airplane, we may have to revisit that.

For now, let's take a break for 15 minutes and be back here at--let's make it 16 minutes--20 after.

(Break taken.)

MR. LONGRIDGE: Before we get started again I think we need to examine our rate of progress and consider whether or not we want to reprioritize or redirect our current discussion. I think the discussion so far has been outstanding, it's exactly what we are looking for. And especially the part about lack of consensus.

But I think this discussion is important because this is going to potentially impact what the FAA does with respect to its validation requirements. On the other hand, I think we are all aware we are not likely to have a dramatic impact on costs with any of these things that we are talking about. We might be able to reduce costs ten percent, perhaps, perhaps not. It's entirely possible that we could end up increasing cost as a function of this discussion.

In light of our overall goal to reduce cost, the question is do we want to continue, given the amount of time that we have before we adjourn tomorrow, with a discussion of proposed alternatives for the FAA validation requirements, or do we feel the opportunity to impact costs might be greater by virtue of moving the discussion to the aerodynamic modeling? Which is an area that is already not constrained by the FAA, but is a big cost driver with respect to creating a flight simulator that actually handles like the aircraft.

I would like to kind of solicit the input of the group. Where do you think the biggest pay-off would be? Which would you rather do, continue the discussion of the validation tables or move on, defer that and move on to a discussion of aerodynamic modeling requirements, data requirements associated with that?

MR. HEFFLEY: Tom [Longridge], so far as the cost impact, I think that the validation requirements are the bottom line. That's where you have to do certain things to satisfy the FAA. As for math modeling, you are a little bit more left to your devices on how you solve things and how you accomplish modeling. And of course both of them kind of go hand in hand if you are working on a problem. I'm not sure that you can really split them apart that easily.

I think they are still both requiring the same sort of engineering, but certainly validation is what's required. If you are going to spend money, that's what you have to spend money on for sure.

MR. LONGRIDGE: Okay. Any other input on this issue? Yes?

MR. BAILLIE: Looking at it from a different perspective, perhaps, if we are requiring the same quality of simulation as we currently have, knowing that the people that are building these simulators are trying to get that quality at the cheapest cost already, and that you put no regulations on how they build the model, I don't think you are going to get any reduction in the modeling end of it. If you need a measure of the oleo deflections to make a good model, you are going to measure those deflections.

MR. DAVIS: In the interest of being as economical as possible with respect to building a model, you guys aren't telling us how to do it to date. What we need to do to validate, again I don't think we will be able to do much, reiterating what Stewart [Baillie] says, we can't do much to reduce cost without reducing fidelity.

MR. LONGRIDGE: There again, the more data that you have strictly for the math modeling part of it, I would think that the less of an effort you have to try to tweak, the math modeling sort of matches the aircraft.

MR. DAVIS: Say that again? Sorry.

MR. LONGRIDGE: The more data that you have to support the math modeling the better off you are with respect to handling characteristics.

MR. DAVIS: Yes.

MR. LONGRIDGE: You need that data and need to examine how to most economically get that data for that part of it, just as you do for what we are talking about with the validation side of it. Is that not true?

MR. STOCKING: There is different approaches to modeling, though. I was explaining earlier we are developing foundation models, they are models that are based on the laws of physics and whatnot. In the case of the strut model, I can model a strut and all the struts on the aircraft. I can model the tires on the aircraft using the laws of physics, if you will. And then we say for this particular aircraft tire it has this stretch because it has so many plies, it's such and such a diameter, it has so much air pressure in it.

Now we are talking about engineering data you can get out of a maintenance manual. We have developed the foundation models that uses data out of a maintenance manual, which is a real cheap source. And it guarantees, in this specific model, a level of fidelity. And meets a training requirement.

We used these models in the--for our commercial division that were built specifically to the Level C and D device machines. The only data required is nitrogen strut precharge pressure, the area of the strut, the stroke travel, things that you can measure on the aircraft. It resulted in good, high fidelity models. Total time for ground reaction was three weeks, all we did was test the output that we were plotting, check that the slalom steering was correct, when it went from understeer to oversteer at a certain speed, those things that the customer doesn't even see, right?

But they are basic engineering disciplines, if you will, right? And if you develop those models, then you can spread that cost over a number of machines. You have got something that is really inexpensive to do. So you have got--these models are a company philosophy, if you will, methodology that allows you to produce this cheaply and at the same time maintain the quality of the product.

MR. DAVIS: I think the point is, you can build a high fidelity model that people like but if you go and make precise measurements and compare some database line it may expose, I won't call them flaws, but areas that aren't as close as some engineer would expect. We can build a good model that will fly well.

We spend a lot of our time trying to make these lines close, but does the pilot perceive that? I don't know. In many instances he doesn't. That's probably a bigger cost driver than anything.

MR. BOOTHE: What was the last thing you said?

MR. DAVIS: The time we spend getting these lines, whatever the tolerance is, has minimal effect on simulator fidelity or at least the pilot's perception, but it has a big effect on cost.

MR. LONGRIDGE: So now you are talking about the data required for FAA validation?

MR. DAVIS: Right.

MR. LONGRIDGE: As opposed to strictly the math model.

Is there any other input with respect to which direction we should proceed here?

MR. RAY: I guess my question goes back to the word I won't use again as far as the preamble, if you will, the lead-in to this. Are there certain assumptions the FAA should make if you assume a reduced set of validation data, are there assumptions the FAA should assume that someone is going to go through to get to the starting point or have they gone to Microsoft and paid $39.95 for something and started from there? Or should we not assume anything?

MR. HEFFLEY: One thing that's not really covered very explicitly right now is the structure of the model from the standpoint of it being robust, being able to handle all flight conditions, all loadings, all environmental conditions. The way your documents are structured right now is from the standpoint of making spot checks. And that's fine.

But it does assume, it does assume that you have a good structural model that is going to obey the laws of physics and obey first principles. And if you are really trying to do the model right, of course, you start from a good first-principles model so that you do the sorts of things that Chuck [Stocking] was talking about.

MR. STOCKING: You design it to the training requirements.

MR. HEFFLEY: Yes. But you might not necessarily see somebody come in the door having already done that. Theoretically they could meet those spot checks very well and the in-between points not so well. So I'm not sure how you really specify the structural integrity of the model in a way that's really useful.

MR. RAY: And we wouldn't want to. We shouldn't get into how you do what you do, but there is some, I think, basic broad assumptions that we should be able to make along those lines that, if nothing else, serves the purpose of letting anyone who wants to come along and hopefully participate in this, so they don't get misdirected.

They put something together and it's not that robust model that you need. What could we or what should we do? Should we do anything? A statement like that, what I call an assume statement, as a lead-in to all this that could help on the front end.

MR. HEFFLEY: I guess I'd like to add one other thing, too. Besides that aspect we just mentioned here, there is also the context of where the aeromodel, per se, fits into the overall simulator, simulator fidelity. There are a lot of things in the simulator that are not associated with aeromodels, specifically, that have a huge impact on fidelity.

One is the quality of the cockpit manipulators. Another is the quality of the visual presentation, whether it's an outside visual scene or just simply cockpit instruments. Those things have nothing to do with aeromodel, per se, but probably have as much to do with perceived fidelity and usefulness of that system. And so there is a matter of putting all this in the right perspective.

MR. KOHLMAN: I have a question about what difference it really makes to the end goal, and I keep focusing on that, that's training pilots safely and effectively and economically. What the structure of the model is. And how many terms are in the equation. And how we got those terms, whether it was all with a very, very smart predictive program or a $39.95 Microsoft model.

But in the end when we do our checks, that's all we can do, and everything matches, and the pilot says this flies just like the airplane, and the training is effective, what difference does it make?

MR. RAY: If the Microsoft $39.95 works, then that's fine. If there is an assumption that goes along with that that it does in fact perform the full range, that it's not just these limited tests that we are doing. The fact that you need a given set of tests therefore you have a simulator, is not necessarily so.

MR. KOHLMAN: I know. That's an extreme example. But in the end when we all end up presenting the FAA with a simulator that we want to have validated, you really look at all of those, I don't know how many points, 20, 30, 100 points, and only those.

And you have pilots who evaluate it essentially throughout the flight envelope from a qualitative point of view, and if those checks all work, then we don't or you don't go into the model to see how many terms we have in the equation.

MR. RAY: Nor do we want to, ever. There is an assumption there that whether you use a room full of models or a $39.95 model, there is an assumption there.

This goes across the entire spectrum. If you put Gerry [Baker] in the simulator, a true expert, and walk away with a textbook full of problems, somebody will likely scream foul because he met the 25 cases you are talking about. I'm trying to give someone fair, I shouldn't say warning, that's not a good word, but decent advice that this isn't the end. There is a perception that if I strictly pick up Appendix 2 of this and read it and exclude all the others, I have a simulator. That's not the case.

I'm trying to be as fair as I can in passing out information, good information, to those who might want to jump in the market. The manufacturers we are dealing with right now, that's not really a major problem at all. It will be those new entrants into the market that will try to serve those who are the primary motivation for this endeavor, the commuter world. I suspect other manufacturers would want to come into it and we want to be fair to them. That's my point.

MR. KOHLMAN: Are you saying, though, that if somebody matches all of these points and the tolerances required, they may not have an adequate simulator?

MR. RAY: Yes, sir. True statement.

MR. KOHLMAN: Does that say we don't have enough points?

MR. DAVIS: You never have enough points.

MR. RAY: You never have enough.

MR. KOHLMAN: I think there is a dilemma there.

MR. DAVIS: You want to leave the points alone and let the pilot fly.

MR. SCHUELER: Appendix 1 and Appendix 3 are also considered. Appendix 2 is a set of objectives, but Appendix 1 and Appendix 3 also play in the acceptance of a sim.

MR. DAVIS: If we look at the international standards now we have an increase in tests, I don't think simulators are any better, really. Matches more points, but keep in mind that at least for us the data that goes into building the sim package is far more than this matrix calls for. We are talking about hundreds of points.

The FAA doesn't want to see that, I don't want to show it to the FAA, really. If they are interested, I will. There is--it doesn't equal the pilot flying the machine.

MR. KOHLMAN: I think that's really the final exam, is after you have met what are always a finite number of points, somebody has to fly it to see if this behaves like the airplane. Do I feel like I'm getting an experience that's equivalent?

If that happens, it doesn't matter to me if it's a totally predictive model or you do real cheap or low cost validation test or if you have done a Level C and D flight test with parameter verification and all this. It doesn't matter. If you match these and you get pilot examination--

MR. RAY: Exactly right.

MR. LONGRIDGE: Stuart [Willmott], you had a comment?

MR. WILLMOTT: I guess I'm one of the oldest people here and remember the days of AC[120-]14 and maybe even before that, but maybe I can don a little reverie here.

The current situation in simulation as far as the Level D and higher echelon simulators, C and D, is I guess we go through, you know, the IATA data standards. Boeing came up with a beautiful mathematical model, they even give you all the data points on the curves, and the simulator manufacturer essentially implements that and he knows he is going to get a simulator that is based on a very good mathematical model that covers the complete flight envelope of the airplane.

And it's been proven to be like the airplane, they have a proof of match. And somebody that I know very well, used to describe that as "socialized simulation." What we are talking about here is, you know, business jet, regional jet type simulation, and a lot of these being built today by Flight Safety, by CAE, are being built on a program as near as these people can get to the big full commercial simulator.

You go out and do an extensive flight test program, and you define a whole series of equations, what lift coefficient is made up from, and pitching moment, and the aerodynamic control surface hinge moments. You define that as a series of equations which is what I define as the model, and I'm not sure whether everybody means that when they talk model.

And then, you know, there is a proof of match done on that. And a complete envelope coverage is required of that simulator, and for this and for the previous one, of course, there is a limited number of tests that are used to spot check that. And it's my understanding that particularly Ed [Boothe] and other people at the FAA have always said that with these higher level devices, this Advisory Circular is really just a spot check of that and there has to be a lot of other flight testing and definitions of the model done in order to ensure that you have got a complete simulator.

And that, you know, is where we are right here and now, particularly for the C and D devices. But if I go back 20 years, from people like Boeing, we did have relatively good models for the aerodynamics, but for the business jet community we did not. We tried flight test programs to come up with good data and good models, which helped the simulator manufacturer, but it was up to the simulator manufacturer to come up with models that in fact describe the aircraft as best as he knew how with available predicted data and flight test data and with resources like KSR and some others.

But we still would use things. I got a list here of supplementary type things that we would use, like type inspection reports. There was a time here 25 years ago, maybe less than that, where we didn't do any special flight testing for simulation at all. We would use what was available. There were about 35 tests, I think, in the old FAA AC[120-]14. Takeoff times, climbs, some static stabilities, a few tests like that which we were able to extract from type inspection reports.

There are things like production aircraft flight test procedures, each airplane that's built has to be flight tested and there is quite often some useful information in there. Airplane flight manuals, operations manuals, maintenance manuals, so on and so on.

And I guess the point that I'm making is two-fold, one is that I guess what we are trying to do here is to back off from the optimum of building a simulator, which is C and D, building these massive flight test programs which are very expensive and try to go back to something maybe like we had 20, 25 years ago. And you know, when you look at what training has to be done by these people that are doing initial, even recurrent training, some of it they can do on Level 3 devices, 4 devices, 5 devices, we are talking about another device that is sort of in between the optimum and some of these flight training devices.

So I think that there are other sources of data out there other than a full-fledged flight test program and it's left with the simulator manufacturer to use those available resources to his best ability, and to come up with models that fit all of the basic envelopes that he has to do. I guess that's about it.

MR. LONGRIDGE: So once again I gather that the consensus here is that we should continue the discussion on the validation tables and kind of leave it up to the manufacturers what they need to do to optimize the aerodynamic math models as best they can with whatever sources they can obtain to do that. Is that a fair conclusion?

Within the validation tables themselves, at the rate we are going I'm not at all confident we are even going to finish those. Are there particular tables that we think we would like to--yes?

MR. BAILLIE: Would it make sense in addressing the validation tables prior to going through the exact procedure to just get an agreement on each of them what are the fundamental issues you are trying to match? And if we just had a list of those, I think that that would be a fairly easy thing to do that's agreed upon, that gives at least the starting point, so that someone could come back and say I'm meeting that concept or intent but a different way, will you accept it? That's a suggestion.

MR. LONGRIDGE: Discussion?

MR. DAVIS: I think there is a lot of merit in that. If I understand correctly, what do you want to do with V_{MCG}? What is the objective with that? Anybody can come up with an alternative in representing these models? Let's narrow in on what we are trying to do with these tests and find ways perhaps to simplify it. If we don't agree on what the objective is, how can we talk about some of these things?

MR. BOOTHE: Could I ask Stewart [Baillie] to elaborate a little more? I'm not sure what you are asking.

MR. BAILLIE: As an example, in the V_{MU} test that we just finished discussing, for a while we all had the idea you have to match this minimum unstick time history, but eventually it came to prove what the pitching, maximum pitching authority while you are rolling down the runway by aft elevator and prove C_L versus alpha while you are on the runway. Those two things are much easier to comprehend than a case V_{MU}.

MR. BOOTHE: They are for you. But for the industry, particularly the operators who fly airplanes and use simulators for training, I'm not certain that's true.

MR. BAILLIE: But the people who are presenting approval test guides to the FAA, I assume, are more like people like me rather than operators.

MR. BOOTHE: They are people like you, yes. One of the things, it's probably a good time, I didn't mean to take your--

MR. LONGRIDGE: Go ahead.

MR. BOOTHE: It's probably a good time to mention, it is one of the things we try very hard to avoid and get away from, is the attitude within the training community that often exists is we have got a training, let's just test for that, forget all the other stuff. And I think that's a mistake and I totally disagree with it.

The reason that this bunch of tests were chosen was, as has been said here earlier, and Stu Willmott just said it, we have a simulator that needs to represent an airplane over some operational environment and we should be able to validate such a simulator at some select small number of points, really. To say that it's good enough to do whatever training you want to do, represents the airplane good enough to do the event in a typical training program. And that's what this attempt is about, we never attempted to take a test like V_{MU} and say well, we are testing for elevator control power and lift-off speed or is proper lift generated at the lift-off speed of the airplane, I think that's for people doing the work to build a simulator validated to know, but we have to write this for a much wider community than us.

MR. DAVIS: But to facilitate discussion it may be good to focus on what the intent is, for us to focus our discussion on what are we really after here.

MR. BOOTHE: I agree.

MR. HEFFLEY: Why do you have to write it for a larger community now?

MR. BOOTHE: It's--that's hard to explain, but in writing this thing we have dealt with people like us in engineering, we have dealt with people in flight operations, we have dealt with people in the training community. We have to try to write something that all of them can partially at least understand, and use. That's sometimes--if this were strictly for us engineers, we might do it differently.

MR. BAILLIE: The thing which doesn't show up until you are starting to brief pilots, I find, is that when you say okay, we are going to do a V_{MCG} maneuver, the flags go up because that's a certification maneuver, very difficult, we have got to do a huge work-up for it. Then if you say no, we are just going to cut the engines at speeds on the safe side of V_{MCG}, it's a completely different environment. And so the--sometimes using the terms that are understood by everybody causes more problems in the engineering environment than understanding.

MR. NEVILLE: Isn't it true that tests like V_{MCG} and V_{MU} and a number of others were originally included in the list of tests just basically because they are there, they are done anyway for certification? That in itself is a potential cost saving if those tests are available, if there is enough information that you can use them, and that's fine, I think that the situation that Stewart [Baillie] is concerned about is where those tests are not available or there is not information to make them useful, but you need something equivalent to that. Let's look for something that provides the right kind of information but is maybe easier, less costly to obtain than going out and doing strictly a V_{MCG} or V_{MU}.

MR. BOOTHE: I don't have a problem with that, in fact, but I don't answer to that anymore, so.

MR. RAY: That's where the alternative wording, I believe, Ken [Neville], is appropriate. Where certainly a number of the tests in here we can come up with alternative language to that, a lead-in comment, if you have alternative testing you would like to submit, then we are certainly open to look at what alternative testing you want to use. Stewart [Baillie], you used the case if you have other tests and you come in with your case and present it. That's certainly reasonable.

The standard wording, you are absolutely right, is the assumption that you acquired it in certification as a test and it's transferred directly. To change that would probably create more confusion. Could create more confusion.

MR. BOOTHE: Yes, but if I could follow-up with Stewart's [Baillie] comment, are you suggesting that it might be a good idea where we list the test, you know, if we are going to do something different from Level B it still has to fit in the overall scheme of things, but are you suggesting it would be useful where we say V_{MU} to have another column to say what's the objective of doing this?

MR. HEFFLEY: Yes.

MR. BAILLIE: Exactly.

MR. BOOTHE: That way if you know the objective of doing this, what is it supposed to show? What things is it supposed to measure? Then perhaps you could develop alternative means more easily because you know what these guys are after.

MR. HEFFLEY: There is a real benefit to knowing what the objective of these things are. Because you may come up with better, even more effective ways of demonstrating these things.

MR. BOOTHE: Well, I think that's a good idea. It's more work for somebody to figure that out, but I also think it would cause some critical thinking to be applied to this whole set of tests to have somebody or some bodies sit and say why are we doing this? What is the real aerodynamic in this case, objective? I don't know if that's for today.

MR. LONGRIDGE: I think that's a good suggestion, but I think it's also incumbent on us to suggest one way that would be acceptable to the FAA with the proviso that other ways will be entertained.

MR. BAILLIE: The clarification of the intent then leads to the decision that is now possibly be made formally, which is, does a Level B simulator require that match? Right now we have all of these lists, many of you--as an example, we are not really sure until we break it down to the intent that we require that time history or snapshot to be matched. And this way you might be able to highlight some cases that you don't necessarily require for a Level B simulator.

MR. WILLMOTT: I was going to say, Ed [Boothe], that the handbook that was developed to go along with the international standards to some extent highlights the purpose of the tests that are in the international standards and each test in here is covered by international standards. I'm not sure if you are familiar with that document. I don't have a copy of it here.

MR. NEVILLE: I brought a copy.

MR. WILLMOTT: Maybe you could look at that.

MR. BAILLIE: We should make sure we all agree that is the intent.

MR. HEFFLEY: Ed [Boothe], also certainly the intent here of these individual tests is something that really has been falling out of each of our discussions of each of these items. I think that that's ultimately what's happening here, is we are in some cases really discovering what the intent maybe really is.

MR. WILLMOTT: I thought that one of our ground rules at the start, given ground rules given by Tom [Longridge], we wanted to stick with the current Advisory Circular for Level B simulators. Is that a ground rule?

MR. LONGRIDGE: I think that's a ground rule but I don't see anything that necessarily precludes identifying the objectives that are currently specified for the Level B, that's why we are asking for the information we are asking for the Level B.

MR. BOOTHE: That's a big job, to really do that. I guess that leaves us, shall we proceed with what we were doing, keeping that in mind? We probably are going to do that anyway, but it will take additional efforts to get that on paper. If we were to preclude that, we need to produce such a piece of paper.

MR. HEFFLEY: I think this will come out a little bit more naturally here if we have this idea in mind.

MR. LONGRIDGE: We will give it a try. Of course that will mean we will only get through about half the table. So we are going to proceed with these tables.

MR. BOOTHE: All right. We were about to finish critical engine failure on takeoff. I hope we finished that. Because I was hoping to go to crosswind and say no change.

If we have done one of those we have probably done the other, really. But are measuring those same things for crosswinds adding heading and lateral acceleration good enough?

MR. HEFFLEY: In a case like that, is precise knowledge of the crosswind, precise measure of the crosswind, is it necessary or is that something that can be regarded as basically derived data?

MR. BOOTHE: Well, we are talking about validation stuff here. I think we have said in the international standard, which is not what we are doing here, that a wind profile has to be provided so that's a good question of what do we do about that here? Should we--can we just generate a wind profile and use it?

But if we did that, how would we know what the airplane did for the same wind profile? I don't know how to answer your question, Bob [Heffley].

MR. BAILLIE: Is the intent only to deal with the dynamics of the aircraft in the first 50 feet of altitude? Or higher? Because if it's the first 50 feet, you might be able to just use tower measured wind, whereas if it's higher you need to develop a profile.

MR. BOOTHE: I think--Chuck [Stocking]?

MR. STOCKING: For Level C and D devices we use the one-seventh law profile, which is what they use to certify the airplane. They certify the airplane at a 25 knot crosswinds, at 50 feet, it's probably 16 feet, whatever it is above the ground, above the ground level. The friction of the earth's surface changes at wind speeds.

MR. BAKER: It's ten meters now. The international standard is ten meters.

MR. STOCKING: But that is always a given, that is a steady state wind at one-seventh profile.

MR. HEFFLEY: If it's steady.

MR. WILLMOTT: The big problem--

MR. STOCKING: That's right, if it's steady.

MR. WILLMOTT: --with crosswind and any wind is that it never stays the same, it is always gusting, and normally what we use in simulation is just the tower reported wind and do the best we can in the simulation with that, and there is always gusting on top of it.

You can't measure sideslip or even the control surface, we use some sort of boundary layer, the one over seven law is the standard boundary layer whether you are at Wichita with flat ground or Chicago with buildings all around. That's the standard we use. Usually after the aircraft leaves the ground, the controls are centered, you know, the crosswind component using the rudder, you normally let the rudder go, so you are not so interested in it once you decrab the aircraft, and it's mainly the ground run and initial decrabbing that you are interested in.

MR. BOOTHE: I think an important part is the transition from the ground to the steady state condition. And beyond that it's just flying in the wind, it doesn't make any difference.

So that's really what this is about, and I think we would be measuring the same stuff we would be measuring in previous takeoffs. So I don't know that there is anything really different here except we might have a little more interest in lateral acceleration and heading.

What I have to tell you, I have seen simulators put before the FAA that automatically corrected for crosswind, I don't know how they did that, I don't know how they ever got such an idea.

MR. RAY: I can tell you why. The engineer said he saw an airplane take off one day, turn into the wind, therefore he made the simulator do it.

MR. KOHLMAN: I think Ed [Boothe] is right. If it's right within a few seconds after lift-off, it's no longer a crosswind event. And so it's that transition that's really important. Along the ground until you take out the sideslip.

MR. BOOTHE: So maybe we don't need to do it to 200 feet. Just like all takeoffs are to 200 feet. I want to tell you this is relief. It used to be 500 feet. But do we need to do a crosswind takeoff in a Level B simulator? Do we need to record a time history to 200 feet or do we need to record it to off the ground or something? I don't know.

What do we need to do?

MR. DAVIS: I don't think it makes much difference, frankly, probably best leave it alone. As you have already said, there is not much happening once you get rid of sideslip. I don't think you would cut costs by 100 feet, leave it.

MR. BOOTHE: Sideslip, heading, lateral acceleration, otherwise we are left where we were. We need the inertial system anyway.

MR. WILLMOTT: The thing that would be real nice to get is the actual wind where the airplane is.

MR. KOHLMAN: That would help.

MR. WILLMOTT: That gives us the biggest problem.

MR. DAVIS: Remember we are talking cutting costs.

MR. WILLMOTT: One of the simulators that we recently had, I had enough data that theoretically enabled me to extract the wind and when I did that I got something that you would normally find in a round container. For whatever reason, it didn't work out.

MR. HEFFLEY: That's what you find when you do estimate what the actual winds are in situations like that, is that they are nothing like you were really assuming. And the only way you get it is extracting the stuff from the flight data, deriving it from the flight data.

MR. BAILLIE: The important thing to remember, too, there are aircraft that accurately do measure the wind in the short-term high frequency range, and that process takes a tremendous amount of calibration of an aircraft to do it. Much more so than what we are doing for any of these tests.

MR. WILLMOTT: I think you have to actually be in the air for that to do it. You can't do it on the ground.

MR. STOCKING: When Mr. Kohlman has his radar gun in there to give me ground speed, I can tell the tower what the wind was. I mean, it was that accurate between correlation with your sideslip and your side forces on the aircraft, and your ground speed versus air speed, it was quite accurate.

MR. BAILLIE: I would say to do that--

MR. STOCKING: That's the only source I had for ground speed that was accurate enough to do that with.

MR. BOOTHE: Okay. That's interesting, but we need to go on.

MR. STOCKING: I wanted to get that in.

MR. KOHLMAN: Thanks, Chuck [Stocking].

MR. BOOTHE: What do you call the things you put in wind tunnels? Straits? You can build a 30 meter wind tunnel strait and put all the--

MR. WILLMOTT: I guess when people like Boeing are testing it they have anemometers in places down the runway; is that right?

MR. SMITH: A rake. R-A-K-E.

MR. BOOTHE: Rejected takeoff, I don't know if it's worth talking about separately, I don't see that it's anything more than an acceleration and stopping. We are doing both of those things somewhere else. I question why it's in here except that in the international standards it seemed to be necessary, so it fed over. Because the reason it got in there is because at that time, and I really haven't heard of any since, but there had not been a successful rejected takeoff almost in history without running off the end of the runway or some other at least incident in airplanes.

So the idea was to get something in simulators that was checked and no matter--no amount of argument would work to say well, we already measure acceleration and we already measure stopping distance, what more do you want? So we put it in. I would just as soon pass it by and say it's already covered, if that's all right with you. In fact, do we need that for Level B at all? That's the question I should ask.

MR. BAILLIE: What was the intent?

MR. WILLMOTT: Do you need to do a rejected takeoff in the training curriculum?

MR. TOULA: Yes. Unless you change the training program.

MR. BOOTHE: But we are measuring acceleration, time and distance, we are measuring stopping time and distance, the rest is pilot technique in between. Transitioning from acceleration to stopping, which is a variable that's not really that well controlled anyway. Why do we need to measure the total maneuver?

MR. BAKER: There are differences.

MR. WILLMOTT: Flap deflection.

MR. BAKER: Flap deflection.

MR. BOOTHE: You have takeoff flaps instead of landing flaps.

MR. BAKER: Usually you are rejecting a takeoff from a higher speed, so deceleration rates could be substantially different. They are usually due to braking differences. You can probably compute it.

MR. RAY: You can change the test, instead of a rejected takeoff you can do a deceleration with takeoff flaps.

MR. BAILLIE: The other question might be what is the accuracy requirement for that maneuver in the training?

MR. BAKER: You could possibly compute it. I would agree with that. I'm saying they are not exactly the same.

MR. BOOTHE: I realize that. But going back to objectives, if we are measuring an acceleration in the simulator, and comparing that to an airplane, and we are measuring a stopping time and distance or deceleration in a simulator, and comparing that to the airplane, even though there is perhaps a difference in flap setting, we still have the calibration of those two events.

Is that sufficient, or do we need to have it an exact duplication of that condition, is what I'm asking?

MR. KOHLMAN: By "exact" you mean a time history match as opposed to a--

MR. BOOTHE: I mean a total rejected takeoff from brake release to full stop, with all that happens in between with takeoff configuration

MR. HEFFLEY: You are not measuring anything different as far as the simulator math model characteristics would be; right?

MR. BOOTHE: I don't see that you are. Gerry [Baker] points out a different flap setting, that's true, and maybe decelerating from a higher speed, and that's true.

MR. STOCKING: Also with a turbo prop aircraft, you are planting it back down, I don't know whether you test to make sure that you had that effect.

MR. BOOTHE: I didn't hear you.

MR. STOCKING: On a turbo prop aircraft when you go in reverse thrust you are really planting the airplane again because you are losing all the lift on the wing. It's one aspect that you want to make sure you have modeled.

MR. BOOTHE: True.

MR. BAKER: On a turbo prop it would be different. I keep thinking jet. A normal landing is going to be a symmetrical event, too. On RTOs it's probably going to be an asymmetric event.

MR. BOOTHE: Okay. Seems it's good reason for leaving it in, but I don't see it makes any difference on how we measure it. We would measure them the same way the way we measure them for acceleration and deceleration, just under different conditions.

Okay. Gets us over to climb, which is all steady state stuff, as I see it. There should be information available in the type inspection report if that were available in the airplane flight manual, you can just as well do all these climbs with a calibrated altimeter and air speed indicator, stopwatch, which is what I've tried to indicate.

Is there any reason to discuss that? I don't know of a simple test one could come up with.

MR. BAKER: Why don't you use published data?

MR. BOOTHE: I don't know.

MR. WILLMOTT: Airplane flight manual?

MR. BAKER: Why would you need to repeat the climb data? Some of the data is not in the flight manual, perhaps the higher altitude, usually you have an operator's manual that gives that kind of data. Anything below 1500 feet, first segment, second segment, final segment, that's all in the flight data.

MR. BOOTHE: Gerry [Baker], is that data in any way factored? Is there something we would need to deal with there to remove any factors applied so we can get back to the--

MR. BAKER: It has a net factor, you can get the numbers out of the FAR.

MR. SMITH: If we match thrust with torque it ought to match up.

MR. HEFFLEY: Here is what happens sometimes. You think you have the flight manual but then you get some flight data that are different. And those flight data that are different are going to be consistent with everything else that you are measuring. So when you get that model finished it winds up maybe not matching the flight manual.

MR. LEISTER: It very rarely does.

MR. SMITH: We checked simulators on evaluations against flight manuals and we always found, and we always ensure that the simulator actually did better than the flight manual, because that's what we expected.

MR. BAKER: That's probably because--

MR. SMITH: They use conservative data.

MR. BAKER: The flight data is a min spec data. You can correct all that. Frankly, that's what you should be putting in the simulator, is a min spec engine.

MR. HEFFLEY: It's known what the conditions are.

MR. SMITH: You have to match the rest of the data package, I guess. Aeromodelers probably--

MR. BAKER: I will believe a flight manual data any day before you get any airplane off the line.

MR. LEISTER: The problem I have run into is that some of the flap transients are functions, not some but all the flap transients are functions of lift and drag and pitching on the course, if you fiddle the lift and drag to make those times come out correctly, well, then your dynamic tests will not be so easy to come by, if you can even come by them.

I have never yet found flight test data that matched the simulator. Maybe a couple of jets, but not prop airplanes.

MR. BOOTHE: But if that flight manual data were corrected to a spec engine, then would you have a better chance of matching it?

MR. LEISTER: Probably so, yes.

MR. BOOTHE: I think what we are doing here again is just calibrating the simulator, or validating the simulator, so as I see it if we are simulating the same powers the airplane had, then we should get the same climb. And I don't really care where that data comes from as long as it's a valid data source.

MR. LEISTER: If you make the simulator match that data, then the simulator is not going to match other data, mostly your dynamic data at some other point in the sky unless you have flight test data that are way off--

MR. BOOTHE: I'm not suggesting that. We should find out how the flight manual data got to be what it is and correct it back. And use that.

MR. LEISTER: It's so obvious it's just an average. I used to work at flight manuals years ago at GD.

MR. BAKER: GD flight manuals are not FAA approved.

MR. LEISTER: You are right.

MR. BAKER: This is FAA required standards.

MR. WILLMOTT: To my knowledge they are usually produced with 0.8 and 1.1 percent gradient in hand depending on which flight condition it is, they use the minimum engine and humidity effects on the engine. If those things were taken out to represent the true aircraft with an average engine, I would have thought we could have used them.

MR. BAKER: Sometimes you have bleed extractions, if the bleed is on, the heat is on, typically anti-ice are included in approach data. If you ask the right people, you can find out what's there.

I have had good luck producing climb data on Part 25 aircraft in particular. I'm just saying if you could cut out doing a lot of climbs, why not cut it out? Sounds like everybody wants to go climb.

MR. KOHLMAN: I agree. In all cases I have been involved with we are validating the simulator to a specific serial number airplane, the one we did all of our flight testing in. If it has a real good engine in it, it's not going to match the flight manual data. So let's correct the flight manual data, but then I hear other people saying well, we still don't usually match the flight manual but what are the tolerances, how much is that mismatch, and can that be taken care of by having reasonable tolerances on the rate of climb? If it can't, I agree with Gerry [Baker], let's get rid of any test we can reasonably get rid of.

MR. BAILLIE: To corroborate what you just said, if you can measure an aircraft from the line that has 300 feet per minute higher rate of climb than the flight manual, you shouldn't be matching flight rate of climb to 50 feet per minute, you should be rating it to the amount of variation that's up there. And maybe it's opening up that tolerance is the important thing.

MR. KOHLMAN: That's a good guideline for tolerances.

MR. BOOTHE: How you find out what that is is another question.

MR. BAILLIE: I'm just asking questions here.

MR. WILLMOTT: I thought the position of the FAA was always as far as the performance and handling is concerned you pick an airplane, and you match it.

MR. BOOTHE: Yes and no. I never took that position. I took the position that if you are going to model a cockpit, you have to have some cockpit, there is a variation in what's permitted in type certification, not every cockpit is the same, you can't model them all, so you have to pick one.

I never applied that to performance and handling because I don't think that one airplane is a good sample, necessarily. But if you only test one airplane, that's all you got. So you can't reject it, either.

MR. WILLMOTT: I remember the days of the 747 where we had problems with column friction, and somehow we get results from about half a dozen different aircraft that showed that the basic static control force varied considerably. And we were going to use the average, but I guess we were told at that time to select an aircraft and match it.

MR. BOOTHE: Well, at that time I hope I didn't tell you that. I wasn't there, I hope.

MR. WILLMOTT: I think it was before you, Ed [Boothe].

MR. BOOTHE: All right. Well, we have got here in climb two data sources, actually certification data and TIR, about the same thing. And AFM. And I think if there is a way that those things can be used without flying the airplane, then we ought to do that. If for some reason that's a problem, and one has to do tests, then that becomes your problem.

But do we need to change this? I mean, it's a simple test technique. I would certainly look for data sources that may be available and go from there.

MR. BAKER: I would trust flight manual data any day over somebody who does two check climbs, which is probably what anybody is going to do at the most.

MR. BOOTHE: You are absolutely right. I have seen results of that by some very reputable organizations and it was just to fill a square. Say here, here is a climb thing, and I have seen climb schedules that bent in the middle, they were really screwed up and had to go use the flight manual data anyway. So I'm with you.

MR. BAKER: You have--it's just like any other flight test, you have to have good atmospheric conditions, proper lapse rates to get the--

MR. BOOTHE: So if we have to do it we can do it with a stopwatch and some calibrated instruments. And hopefully we don't have to do it, we can use existing data, and in order to get an airplane certified that's one of the requirements of the flight manual is performance data.

That gets us over to--we are all the way up to page four. Which is really stopping deceleration time and distance with wheel brakes and deceleration time and distance with reverse thrust. Two different tests. Level B doesn't require any contaminated runway stopping. Again, if you can get it from certification data, great.

Do you now do certification tests with reverse thrust, or reverse thrust only or is there credit given?

MR. BAKER: It's--you can do it, but it's difficult. There is some new standards coming in, it's a mess in itself, in Part 25 it's going to allow the use of reverse thrust as long as you have accountability. There is a bunch of things coming in, all new requirements, most of those are not in the older airplanes.

The answer is yes, they are going to allow the use of reverse thrust, but you have to go through other things with that. In 23 they allow it but hardly nobody has used it. I think maybe one of the Jetstreams used it, the 23 Jetstreams, that's the only one I'm aware of.

MR. BOOTHE: So to get reverse thrust stopping distance we almost have to do some sort of testing within the airplane before this change comes. After that comes, maybe there is a way to look at that. But for wheel brakes, certainly landing distance tests have to be done and that data, again if we can get a hold of the type inspection report, that data should be available.

Now I said that there is no additional testing required, but if there were, I would suggest the same techniques that we would use for acceleration. I don't see any difference.

MR. WILLMOTT: The only thing is with the reverser you are operating the engine in, if I pronounce this properly, the beta range, and am I right in saying that is variable?

MR. BAKER: It can be.

MR. WILLMOTT: So, you know, with a regular jet pull the reverser up and go with whatever, with these it's more complicated. And I'm not sure what it is that you could record to determine exactly where the reverse thrust is with a prop plane.

MR. LEISTER: You use torque or something like that. It's nebulous.

MR. WILLMOTT: Even if you have a given torque, you get a variable amount of reverse thrust.

MR. LEISTER: It hasn't been that variable, it's been variable in the beta range as you would range. I know you didn't want to say it that way.

MR. BOOTHE: You sound Australian and he sounds Scottish.

MR. WILLMOTT: I'm mid-Atlantic. When I go back to England they think I'm American. Here they think I'm English.

MR. BOOTHE: You must have been to Australia, too.

MR. WILLMOTT: Yes.

MR. BOOTHE: I know you picked it up somewhere.

MR. SMITH: Got that outback.

MR. WILLMOTT: They call me a POME, P-O-M-E.

THE REPORTER: Thank you.

MR. WILLMOTT: Prisoner of Mother England, that's where it comes from.

MR. RAY: The other was beta.

MR. BOOTHE: Yes, it was beta.

MR. WILLMOTT: So we are able to tell the reverse thrust by--

MR. HEFFLEY: Torque and axial acceleration.

MR. LEISTER: Yes.

MR. BAILLIE: Although most prop models I have seen don't work well in dynamic cases. So you really don't have a good measure or good model of the prop in that regime.

MR. LEISTER: Yes, you are right.

MR. RAY: I'm sorry, what regime?

MR. BAILLIE: A transient regime.

MR. BOOTHE: But if we measure stopping distance we would be measuring--

MR. HEFFLEY: Overall, yes.

MR. BOOTHE: You are not going to measure the transients once you have established the reverse thrust setting, then you measure acceleration from that point.

MR. BAILLIE: It's a transient because the advance ratio on the props is changing all the time.

MR. HEFFLEY: But your prop model ought to be able to take care of that.

MR. BAILLIE: No.

MR. HEFFLEY: It ought to be able to take care of it to the extent it gives you the right answer in the end.

MR. BAILLIE: Exactly.

MR. BOOTHE: Well, is there anything we add to take away from this stopping thing? I don't know of any way to simplify it. I guess that's the question I have.

MR. BAILLIE: The only thing might be that whoever runs the test has to somehow document what the throttle or the pilot control was doing.

MR. WILLMOTT: Right.

MR. BOOTHE: Yes, but that's a given.

MR. BAILLIE: It's not written down.

MR. WILLMOTT: In other words, if you are running the test manually you have to know where to put the control.

MR. BOOTHE: Well, give me something to write down.

MR. BAILLIE: I'm not sure what to write down, other than the thrust reverse control must be documented.

MR. KOHLMAN: We have video down here.

MR. BOOTHE: Yes.

MR. KOHLMAN: If we have a proper field of view we will get that.

MR. BAILLIE: Perhaps.

MR. BOOTHE: I'll just say thrust control and engine output must be measured, or something like that.

MR. WILLMOTT: Must be noted.

MR. BAILLIE: Documented, something.

MR. WILLMOTT: The engine which also operates the propeller and the fuel control, normally the prop would be somewhere.

MR. BOOTHE: The next block addresses engines, and all we really do about engines is measure an acceleration and a deceleration, under [AC120-]40B it says acceleration approach or landing, I guess that was for--if that's the airplane configuration or the flight condition. I thought we would just--you didn't accept just a static acceleration--

MR. KOHLMAN: Our training device includes both air and ground accels and decels.

MR. WILLMOTT: The acceleration was supposed to be for the go-around situation.

MR. HEFFLEY: Question. On this, though, acceleration of what? I mean, we have three or four indicators there, all of which have different time constants and really all of which ought to be about right. Torque, N_1, ...

MR. SMITH: Primary condition of pilot--

MR. HEFFLEY: Fuel flow.

MR. SMITH: Torque.

MR. BAKER: Torque and rpm in most turbo props.

MR. BOOTHE: If it were left strictly for me, I would use for a given throttle change propeller speed, because all the other stuff is in between. And if the torque is not there I won't get the rpm built up in the proper time.

MR. HEFFLEY: I guess I was worried about those distinctions and you all are saying you don't really have to worry about the distinctions in the individual cases?

MR. BOOTHE: I wouldn't say we don't need to worry about them, because they need to be presented correctly to the pilot, but I would be reluctant to say we want to measure all of those things because I just don't see that that really gains us that much. If we take an end-to-end engine simplified performance measurement, which is all this really is, that's sort of--that includes all those things but it doesn't mean they are correct.

I mean, they could be compensating for one another. But then the other part of that equation is I think those have to be cockpit instruments, and if the simulator is wrong it should be noticed during some subjective test in that respect. So I think an end-to-end measurement is good enough here. That's what we have accepted. In fact pretty much across the whole spectrum of simulators.

MR. BAILLIE: The intent of this may be twofold. One is thrust transient as in how fast the aircraft accelerates, and there are probably other tests to do that. And the second is when a pilot is making abrupt movements on the throttles or condition levers he has to track a little to make sure it doesn't go on limits.

Perhaps the best approach would be to define for a given type what the parameter is, whether it's torque, temperature, rpm, that's the one that has to match, and the others are subjectively similar.

MR. WILLMOTT: I think the international simulator standards spell that out, I think it's either N_1 or torque in that order for the engine acceleration. And the other thing is fuel flow, ITT, and the other engine parameters are normally checked by the qualitative, subjective evaluation, there is nothing in the requirements for the regular jet for this, subjectively evaluating, start, shutdowns, climbs and chops, looking at all engine parameters.

MR. BOOTHE: Well, that's exactly right, it does say what you said. This is not the international standard, but 40B says the same thing in that respect. I guess what we need to do is leave that as it is, it already says what can be measured, and see if we are content to do it with something as simple as a stopwatch and calibrated aircraft instruments. That's the issue here.

Can we? Is that something that is within the time frame we could do that or does it happen too quickly?

MR. LEISTER: It happens too quickly, you could do it with a video camera then transcribe it. It's too quick to do it. I can't see that fast. Most of them are too quick.

MR. SCHUELER: Too dynamic.

MR. BOOTHE: We have video in the block, so it's there.

MR. BAILLIE: Do you need to document the input?

MR. LEISTER: Yes.

MR. SMITH: Yes.

MR. LEISTER: You better.

MR. BAILLIE: Okay.

MR. RAY: Absolutely.

MR. LEISTER: And video is a real good way to do it. You just can't do it really otherwise.

MR. BOOTHE: Also there is a reference I have put in there to AC120-45A, which is the training Advisory Circular which simplifies that somewhat, I think. The point being is that all we need for Level B? [AC120-]45A gives a plus or minus one second for Levels 2, 3 and 5. Otherwise it just says ten percent of time. Whereas for a simulator we say we establish a time initial and a time final and time total. Which you almost have to do anyway, but I was looking at some simplification.

Giving it a second look now I don't think it works. Because at a recent training device case we had to go to 40B and come up with an initial and total time to make this work, anyway, so just scratch the 45A bit off of there. It doesn't work. And the Advisory Circular already gives you the latitude of using whatever engine parameter that is here called critical, so I don't think there is much more to say about that really.

MR. LONGRIDGE: Good.

MR. BOOTHE: I think we have closed down.

MR. LONGRIDGE: Keep going, you are on a roll.

MR. BOOTHE: This gets us over to handling qualities area, so we are about half through here, static control checks, and I couldn't find a lot to do to simplify this. You notice there is a single asterisk, which means there is some test instrumentation required, and in this case it's a force and position measurement system.

The thing that I have changed is that perhaps as we began discussing earlier today, the surface position measurements could be simplified by doing some on ground calibrations, and Chuck [Stocking], you said you did that in one case.

MR. STOCKING: Established the control laws, right? And as long as those hold when you are airborne, there is no reason you can't use the control position to develop your surface position.

MR. BOOTHE: I said here surface position could be measured from the flight data recorder sensor, or if there is no flight data recorder sensor at selected column position using a control surface protractor. There are such things, I don't know if that's the proper name for them these days. Which would do what I think you said you were doing.

MR. STOCKING: If you are going to record the control positions continuously when you are doing a flight test, off line, you can generate what the elevator position is to go with that by knowing what the control laws are.

MR. ELLIS: How much do you have to get into cable stretch and things like that?

MR. STOCKING: Well, I measured it in the aircraft. For that aircraft, I put in gust locks and I looked to see where the cable stretch was. In that aircraft it was in a T bar in the front of the cockpit, and that's what we used in the simulator, so our model didn't have stretch in it, it was already part of the simulator hardware. And--

MR. LEISTER: Works quite well.

MR. STOCKING: Go ahead.

MR. BAILLIE: How do you take into account things like dynamic pressure caused by engine slip stream over the tail and its effects on trim tab, string tab, all these tabs into that model?

MR. STOCKING: I can calculate those.

MR. BAILLIE: All based on approximated dynamics?

MR. STOCKING: Yes.

MR. DAVIS: You are going to calculate them and use that, this is my calculated elevator position, that's probably used in your simulation.

MR. STOCKING: It's not elevator position, it's the force you are generating.

MR. DAVIS: I'm sorry, I thought we were talking about the--

MR. STOCKING: As long as it's still connected by the control to your control position you are just talking about the generation of forces, and if you are recording the forces and the positions, you have got everything. If you want to back out what those are, your power effect on that surface, you have to include that in your aerodynamics. That gives you the force that represents it. Otherwise you won't get the correct force. It's a reversible control system that's being reflected back.

MR. BOOTHE: I don't hear much objection to what I have said here. In fact what I hear it's already been similarly done.

MR. STOCKING: Yes.

MR. LEISTER: Hundreds of times.

MR. BOOTHE: Hundreds of times. Then Stewart [Baillie] suggests small control sweeps in the air. Could I ask you to describe that for us?

MR. BAILLIE: I wasn't sure what I meant by that other than perhaps--

MR. STOCKING: To get a control system inertia, things like that. We do a test, you start off very slowly and just keep increasing frequency with it, but you need really fine test equipment in the aircraft to record the aircraft response to that to get the proper--see where the flight control system rolls off, that type of thing. That's really a high fidelity simulator that we do that kind of work.

MR. BAILLIE: That is certainly something for the modeling side, but whether it wants to be a validation--

MR. STOCKING: Yes.

MR. LEISTER: I think it should replace the control force dynamics test strength, they degrade a simulator worse than anything after you put them in the simulator. If you make the simulator work. Because the control force dynamics test, rapid control, let it go. I think most [of] the time you are meeting the dynamics response of the stream, whatever you are measuring the position with into the data.

I never have seen a simulator that flew better after those things were tuned into it. I think the small inputs like that would be much, much superior.

MR. BOOTHE: What do we have to do to instrument for it?

MR. BAILLIE: We are just comparing control applied force versus column, as an example, position. We are not instrumenting anything further back.

MR. LEISTER: Yes.

MR. BAILLIE: But we are getting the effect if I have inertia of the whole control system as seen by the pilot.

MR. LEISTER: That's what you really care about.

MR. BOOTHE: So we could instrument to do this on an airplane in flight?

MR. HEFFLEY: But you have to use a string gauge.

MR. BAILLIE: You have to measure applied force at the column wheel, pedals and column position, wheel position.

MR. BOOTHE: But you have to instrument for that, anyway.

MR. BAILLIE: Unfortunately.

MR. HEFFLEY: In this case, yes.

MR. BOOTHE: So am I hearing that it would be better to do a frequency sweep than it would to be doing a control dynamics?

MR. SMITH: They aren't required for [Level] B.

MR. BOOTHE: That's right. For B they aren't required anyway. Thank you.

MR. SMITH: But that's an interesting subject, because Ken [Neville] could explain what they did for CFDs on the 777, they used a method of, it was--essentially eliminated hooking the wire up.

MR. LEISTER: CFDs are okay if you use a laser, but if you put a string in there--

MR. BOOTHE: Thanks, Hilton [Smith], I sort of overlooked that. Do we need to even mention the frequency sweep in that case? Since for Level B we are not doing a dynamic case anyway.

MR. KOHLMAN: If it's not required, let's not add requirements.

MR. BOOTHE: All right.

MR. KOHLMAN: We are going the wrong direction.

MR. BOOTHE: I'm going to scratch it here.

MR. WILLMOTT: I have made a note to myself that the maintenance manual gives you good data for the ground surface to pilot control reading, as Gerry [Baker] said, you normally check that the aircraft that you are testing meets those standards before you go and test it anyway. So it's another source of data for surface position versus control column.

MR. STOCKING: As a matter of fact, that's where you start, with the maintenance manual.

MR. BOOTHE: Well, we can enter at column four, maintenance manual, if you want to as a data source. For surface to controller calibration or something like that.

MR. STOCKING: Yes.

MR. WILLMOTT: Surface to pilot.

MR. BOOTHE: Okay. I don't see anything that should be different for the wheel or the rudder pedal.

MR. BAILLIE: One point I would like to make, that if in a Level B simulator if we are not looking at the dynamic force versus position characteristics of the controller, we should reduce the requirement for matching control force applied on maneuvers such as V_{MCG} and those type of maneuvers because we are not requiring to match them dynamically. It's sort of if you have reduced the requirement to match the dynamic cases separately, then why should you have to match them in a dynamic maneuver, which is harder to match?

MR. RAY: There is a bigger question, though, in a training scenario the accuracy of what you are giving to the pilot can't degrade one area that you've set no tolerance for, no standard for it and negate the training implications, the potential there of avoiding the test will have a big impact on training.

MR. WILLMOTT: I think the biggest influence on those forces, too, is the static friction more than it is the viscous friction.

MR. BAILLIE: It would have to be an inertia.

MR. STOCKING: I was going to say if your controls people need an inertial, you can do that on the ground, you can do oscillations on the ground and measure just the inertia of the control itself.

MR. HEFFLEY: You also have downspring and bob weight. All the things need to be in there in the right way. Then you add the air loads to them after you get them off the ground.

MR. STOCKING: I can disconnect a downspring.

MR. WILLMOTT: All of that has to be simulated and normally what you do to get the force deflection curve is put a Fokker unit on it. If you have a Fokker unit on it you can get inertia or mass out of it.

MR. BAILLIE: The comment I was trying to make is we have just said that a Level B simulator you don't have to look at the dynamic force, which is position, and yet the essential part of making some of the other matches we have already agreed upon.

MR. SMITH: Maybe we ought to say we don't require a validation test for the dynamic control characteristics, we trust you to model the control system properly.

MR. BAILLIE: Effectively it means that regardless of whether it's in the ATG or not, the simulator guys are going to have to measure it anyway. So the fact that we are not putting it in the test doesn't reduce any cost to the simulator company. Or to the owner.

MR. DAVIS: I think to be fair, V_{MCG}, steady sideslip, they are more interested in the static force required to hold a pedal position, not within five pounds dynamically. My experience is they are generally practical about that, how much pedal force is what they are focusing on. They don't say that, but when it comes down to it, they are not worried about dynamic, oh, a small shift in time, they don't seem to get hung up on that.

MR. LONGRIDGE: Okay.

On that note I think we will adjourn for the day. Unless you would like to keep going.

MR. BOOTHE: Thank you.

(Time Noted: 5:00 p.m.)

Transcript of the

Joint FAA/Industry Symposium

on

Level B Airplane Simulator Aeromodel Validation Requirements

To the Memory of Daryl Schueler

Part 6 of 7

Transcript of Day 2

Washington Dulles Airport Hilton
March 13 - 14, 1996

Transcript of Day 2

MR. LONGRIDGE: We are going to continue with the tables.[1] Hopefully we will get through the tables today. We will get through the tables today, and once we do that, I want to open it up to some of the broader concerns. And this is really a rare opportunity for a select group of people to make input to the FAA on perhaps ideas that you might have on how we can do things better outside of specifically the tables, and I'd like to open it up to discussion in that area later this afternoon. Okay, Ed [Boothe]?

MR. BOOTHE: Let me put my administrative and logistics hat on for just a moment. If you would be kind enough to pull your original ticket receipt like this, and I'm going to give them to Judith [Bürki-Cohen] who has kindly offered to get them copied for me at break, so that I can submit an invoice to get some money and you can submit an invoice to me and, like we said yesterday, probably about a 60-day time constant. I'm sorry about that, that seems to be the way, what do they say, the epoxy oils the wheels of the bureaucracy or something like that. If you would pass the tickets around to Judith I would appreciate it.

If for some reason you don't have it now, please get it at break time because it's the only way that we can reimburse you.

Yesterday I think we got up past--did we resolve the engine issues and we are happy with them?

MR. LONGRIDGE: You were in the static control.

MR. BOOTHE: Okay, static control. I don't think we were quite through the controls, we didn't go through it all piece by piece. We stopped, we got through wheel and pedal position saying that those would be the same as column position for anything here.

And the next is nosewheel steering. I've made a suggestion here but if I could get your input on it. I've even suggested using the training device Advisory Circular to simplify this and I think you can measure break-out force with a hand held gauge, fish scale type thing, and then you could even measure the force for a bit after that. Carefully. And once you are out of break-out and trying to force gradient I think the rest could probably be predicted with sufficient accuracy.

But you tell me. I haven't built one of these, you see, so I'm just making a suggestion for your filling in the blanks here. That's 2.a.(4) on page 6. Everybody must like it.

MR. LONGRIDGE: Good. We are going to get through this in a hurry.

MR. BAILLIE: It's not a trivial thing to do but it's probably good enough.

MR. BOOTHE: Yes, I don't think it's trivial, I think it's probably going to take a learning curve till you figure out how to get it right, but I think it can be done without laying on layers of

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[1]The final tables resulting from the Symposium can be found in Part 7 - Appendix: Longridge, T., Ray, P., Boothe, E., & Bürki-Cohen, J. (1996). Initiative towards more affordable flight simulators for U.S. commuter airline training. *Royal Aeronautical Society Conference on Training - Lowering the Cost, Maintaining the Fidelity* (pp. 2.1-2.17), London, UK *(Appendix.pdf)*.

instrumentation. Frankly, I think the break-out and the beginning of the force gradient are the most important parts. Okay. We will just check that one.

MR. BAILLIE: What happens if it's a mechanical--is there such a thing as a mechanical tiller which the forces would change versus taxi speed and are tremendously nonimportant when you are sitting stationary?

MR. BOOTHE: Well, how does one normally do that? I would strongly suspect that one would base a simulator design on airplane design data there and just get a calibration point or two. Is that an erroneous assumption?

MR. DAVIS: I think that's a pretty fair statement. Then again it's something we are not addressing at Level B, it's an interesting point but if we want to include that in the discussion today, I don't know. We are not addressing it beyond this level, so maybe we should leave it at that.

MR. BAILLIE: Do most Level D simulators have mechanical connections?

MR. DAVIS: I'm not sure. Not that I'm aware of. But I'm not sure.

MR. WILLMOTT: A lot of these aircraft types that we are talking about do have a bungie that connects between the pedals and the nosewheel and its pedal forces that you get are a dynamic process, depends on the speed, depends on the forces on the nose tire which you build into the model.

When you test it when the airplane is static you really have got a very, very strong resisting torque that you are trying to twist the tire and normally can't move it very much. And often the test is additionally done on a grease plate so that you can get the basic relationship between the pedal and the nosewheel deflection. And then at speed, usually from the nosewheel response tests, they are done at a couple of speeds, and you get the dynamics of how it moves and the forces involved with that from those two things.

MR. WILLMOTT: It's quite complicated.

MR. STOCKING: The torque on the nosewheel is quite predictable. It's a mechanical equation, if you will. When you are generating a side force on the tire, you have got a moment arm that is measurable when you are in the hangar, most of the mechanical and pneumatic trail is predictable. You can calculate real close exactly what the torque is on the tire.

You feed that into your model and you can generate or know what the forces are on that mechanical tiller with a reasonable degree of certainty.

MR. BOOTHE: If we can do that with a reasonable degree of certainty for an airplane in the class we are talking about and keeping in mind a Level B simulator, do we need to do more? I mean, because Stuart [Willmott] outlined a fairly sophisticated data acquisition scheme which I think would apply to a Level D, probably a Level C simulator, but at this level do we need to go to that length? Can we just use what Chuck [Stocking] has suggested and make a couple of measurements, simplify the measurements?

MR. STOCKING: The decision maybe is to whether you want to make a dynamic loop out of it. That is the biggest shortcut, once you make it a dynamic loop you have to have in the simulator something to feed that force back, that's the biggest cost decision as to whether this class of aircraft, if you really want that honest of a tiller.

MR. WILLMOTT: I think for the purposes of doing your V_1 cuts, you were putting quite a high emphasis on that yesterday, you need to model those forces well. But I think from, probably from the ground static test on the grease plate and knowing what the forces are on the tires, which there are very good models for these days, as Chuck [Stocking] says, it's based on the arm of where the contact is between the nosewheel and the ground, and the point about which [the] nosewheel turns, and there are fairly good numbers that you can get for that and models for generation of the side force on the side.

MR. BOOTHE: So we have progressed to rudder pedals, I think, from what you are saying.

MR. WILLMOTT: I'm sorry, did I hop?

MR. STOCKING: Either way you have torque feedback from the wheel to feed the rudder pedal or the tiller.

MR. SMITH: Most tillers like the ones I have seen in the ATGs recently, the tiller basically has a break-out force and hardly any gradient to it. The rudder pedal steering, the inspectors really, subjectively that's something they squawk a lot if they don't think it's fairly representative of the airplane because it's, like you say, it's pretty noticeable.

MR. BOOTHE: I'm not suggesting it not be represented, I'm just suggesting maybe we could use the airplane design data to limit the testing. I've still got, we would have to measure some pedal force or some break-out force on the wheel. If you have got a powered system there is a flat gradient but if you have a mechanical one it's usually not so flat.

MR. SMITH: Yes.

MR. BOOTHE: So is what we have here adequate, I guess is the question?

MR. BAKER: A lot of these mechanical steer airplanes don't steer very well, they are pretty heavy so the tendency is most pilots have to thrust to steer these things, I hope that's in the equation somewhere.

MR. BOOTHE: Yes, it should be in the model.

MR. TOULA: They also vary from plane to plane, same model.

MR. BAKER: That's true.

MR. WILLMOTT: Back talking about the tiller.

MR. BOOTHE: I think we are mixing tiller and rudder.

MR. WILLMOTT: I don't know of an airplane that has a variable force on the tiller. I think it's a fixed force. With the tiller you are usually controlling it electrically.

MR. BOOTHE: In which case all you have to do is work the tiller and close the loop.

MR. WILLMOTT: It sometimes produces a different nosewheel, like the Lears at low speed, you get 55 degrees with a full tiller input as the speed profile. You put it in a computer and at high speed it's eight degrees, it doesn't affect the forces on the handle.

MR. BOOTHE: From a perspective of validating the simulator, for the nosewheel steering we just have a hand held force gauge to measure simple things like break-out force and the beginnings of the force gradient, relying otherwise on design data or prediction, and likewise with the rudder pedal, force pads on the pedals and otherwise design data. Is that going to be good enough for Level B?

MR. KOHLMAN: *(Nodding affirmative.)*

MR. BOOTHE: Considering I've got some affirmatives on this side.

MR. BAILLIE: With force pads you are also going to have to measure with pedal position.

MR. BOOTHE: Yes. That's true. I'm going to leave that one, then, for the moment and--these are always subject to reconsideration if you have more thoughts about them. But in the interest of time I think we don't want to dwell too long, so we will press on and we can always come back.

The next thing I think is not even worth mentioning, it's just a calculated value, it's like that from [Levels] A to D, and not worth spending time on here.

MR. WILLMOTT: That's item 6?

MR. BOOTHE: 2.a.(6), yes.

MR. WILLMOTT: Some of the aircraft don't have a calibration in the cockpit, like the Cessnas, they just have a little white band they put in for takeoff, so you have to put some sort of a tape or something like that in the cockpit to check that it's on the right places in extremes.

MR. BOOTHE: I don't think we need to specify that.

MR. WILLMOTT: No.

MR. BOOTHE: As long as there is a reference installed that can be used. All right.

Power lever versus engine indication. In fact I've suggested here doing just what Stu [Willmott] said for the trim, is make a scale to put on a throttle quadrant with the reference so that you can repeat, and since this is really a series of steady state events, I don't see why you couldn't make a scale for a throttle quadrant and then use a video to read engine instruments at various settings and put it together from there.

MR. BAILLIE: Do you even need a video?

MR. SMITH: You could record it.

MR. BOOTHE: If you want to record it on your knee.

MR. SMITH: If you want steady state.

MR. BOOTHE: I think everybody has a video. Except mine, every time I use it something happens.

MR. BAILLIE: I don't know who I was telling but I personally have problems with videos because most the time the lighting is bad or you can't read the scale, especially if you don't get to inspect the video until after you have done the flight.

MR. WILLMOTT: We have found you have to rehearse that in a simulator so you can see what area you can photograph and then have it when you are playing it back to a high resolution so that you can read it. We have used a Super 8 for that, doing engine stuff and it works okay.

MR. BOOTHE: I will just add there hand record steady state engine readings because all we are doing is a series of steady states, I think that's sufficient for an answer.

MR. WILLMOTT: The comment that I would have with that, Ed [Boothe], is that we probably need to do it for all three levers for prop aircraft, the throttle for the engine, the propeller and also the mixture control. I'm sorry. I don't mean mixture control.

MR. BOOTHE: I was going to say, I haven't seen one of those for a long time on a turbo prop.

MR. WILLMOTT: The condition levers.

MR. BOOTHE: Condition levers, yes.

MR. WILLMOTT: And also there is not usually design data for that. We have got in the column here aircraft design data. I don't think there is any for that.

MR. STOCKING: Or maintenance manuals, sometimes.

MR. BOOTHE: Surely somebody had to specify to design this linkage.

MR. WILLMOTT: You would think so.

MR. SCHUELER: But it doesn't relate to engine parameters.

MR. BOOTHE: Did some mechanic just go in the shop and do a fitting and make all the parts like that?

So what shall I put in that, maintenance manual, that would relate to engine power settings.

MR. STOCKING: It doesn't really relate to power settings.

MR. WILLMOTT: It may give you travel for each of the levers and what you have to make them when you are rerigging the engine or something, but it will not give you the parameters versus the position.

MR. BOOTHE: Usually fuel control has some sort of a reference gadget on it so there is a correlation between a power lever position and something on the fuel control, is there not? I know in some airplanes there is.

MR. WILLMOTT: The fuel control has a low idle and a high idle, usually, and you can usually relate that to the engine, but again--

MR. BOOTHE: There has to be a way--

MR. WILLMOTT: --how do you define the idle airplane, the idle conditions are not specified in terms of the exact torques.

MR. SCHUELER: There may be rigging points but that will be minimal, two, three points.

MR. BAKER: A lot of this depends on the engine and air frame you are looking at. There are two lever systems, three lever systems, fixed shaft engines are usually different than free turbines. You can take some condition levers and you can have a takeoff position which is typical on a Garrett like 97 percent rpm on the ground, 100 percent in flight, those are pretty well defined but it varies from engine to engine.

You have to look at individual circumstances as far as position. But on a basic power lever, unless you have got a FADEC control, or something--

MR. SCHUELER: There are no flats.

MR. BAKER: --all you have is flight idle, some have ground, some have flight idle, some have idles, it varies.

MR. SCHUELER: This is an easy test to do. We can do it with a knee board for Level D, it ought to be acceptable for--

MR. BOOTHE: We will scratch aircraft design data, since I'm told it doesn't exist, and add hand held steady state engine readings.

I guess we need to note it would also apply to other levers that control the engine.

MR. BAKER: As somebody stated earlier, jets are easier. You don't have many levers.

MR. BOOTHE: You know, I remember going to ground school on the Convair with the Allison engines, and there was--it was a coordinator on the fuel control, they beat that into my head so strongly, I guess I figured most fuel controls must have something like that. I never did understand it but they kept beating on it.

MR. WILLMOTT: I've never worked on a piston engine and I guess this class of aircraft we are also talking about piston engines.

MR. BAKER: No, not for this task I don't think.

MR. LEISTER: 421.

MR. BAKER: 421 is not a ten place [passenger seats].

MR. WILLMOTT: There are 50 DC-3 aircraft in regional carrier operation.

MR. RAY: We are not addressing those particular category of aircraft, the standards that apply to Level B would apply to any, whether it's a 727 or DC-3.

MR. WILLMOTT: I wondered if anybody worked on a piston and whether there was anything different with those things that perhaps should be included.

MR. LEISTER: Nothing different, they are certainly included but they aren't different.

MR. TOULA: You don't have to worry about nosewheel steering.

MR. WILLMOTT: Chuck [Stocking] has a question, Tom [Toula]. Does this cover Air Force One? Because it's a 20 passenger aircraft.

MR. TOULA: You have a good point. People are taking seats out, so it will apply.

MR. BOOTHE: Brake pedal position versus force, I suggested we go to the training device standard for that. And use the IATA predicted data and see if we could meet it that way, which would eliminate what's reported to be a fairly difficult measurement.

Daryl [Schueler] is shaking his head over there.

MR. WILLMOTT: It's a real tough thing to do.

MR. SCHUELER: It's a ground test, though. The difficulty is you are standing on your head in most airplanes, unless it's a Twin Otter where you open the door and reach inside.

MR. BOOTHE: I guess the question is, can this be closely enough approximated without doing measurements just from design data or is a measurement really necessary? We are talking brake pedal position versus braking force. I know in some simulators we have had a big problem with a totally unrepresentative system in that respect. And when there was a series of rejected takeoff accidents we got more interested in this, and I don't want to diminish that need, but is there some other way that we could assure that the brake pedal force is proper and that pilots could be demonstrating what maximum braking is and what it feels like?

MR. SCHUELER: I never had access to any design data, so I don't know for a braking system, so I don't know what's available.

MR. LEISTER: I don't think there is any good data available for brakes that will tell you the force you will expect, I don't think there is--at least I have never been able to find it.

MR. SCHUELER: You might be able to compute it from the geometry and work backwards.

MR. STOCKING: It's real hard to do on a stopping test, determining what is really maximum braking. I mean usually when you fly this test the pilot will not put on the braking, it will skid the tires. He backs off just a little bit less than that.

You need some measure of what that force to braking relationship is. Which is really hard to get. You have to put a sensor on the brake pedal so you can record the force. I haven't found any alternative to that.

MR. BAILLIE: In general these systems, is there a feedback force or is it a hydraulic? Generally it's a hydraulic system, so it's a non-reversible control system, so if you measure the force versus displacement on the ground then you put at most a potentiometer to measure displacement, then you have calibrated the system.

MR. WILLMOTT: The last aircraft I worked on with the brake system is the Citation 5. We tried measuring the force versus deflection with a Fokker unit and were not successful with it. It's got such a small travel, it's I think only like about a two-inch travel in the brake forces from zero up to 150 or something like that. And the Fokker just doesn't seem to be accurate enough to get that.

Once you have got the brake deflection, we use the airplane design data that relates that to the hydraulic system pressure upstream of the anti-skid system and then you have to model the anti-skid system to get the retardation forces on the airplane, and on this Citation 5 we had modeled that and we meet the stopping time and distance and the system pressures that were recorded, but for the most part, the people that fly the simulator say the airplane brakes a lot better than that. And we are still actually trying to resolve that.

But it's an area that you have to, I think, use an airplane manufacturer's data, they are helping us trying to resolve that. But I don't think that is what you really need, if you were doing the airplane test properly, you need to do one at speed that has this ground static condition and you need to get, you know, the anti-skid modulated pressure, and for whatever reason, they actually design the thing so that the anti-skid systems works on a dry runway. I have never really understood that, other than when you first touch down at real light weights, even on the ground for moderate weights the anti-skid is modulated.

You would think they would design so the brake pedal torque would be not limiting on a dry runway, but apparently they don't. But you need the pressure downstream of the anti-skid and then upstream and relate that to the toe brake force.

MR. BOOTHE: Can you do all that accurately enough without measuring anything on the airplane? Is what we are getting at.

MR. WILLMOTT: I think for this class of machine, yes.

MR. BOOTHE: Anybody else? Okay. Thank you, Stu [Willmott]. We will go with that.

Now dynamic control checks is the next entry here. There are no dynamic control checks required on Level B, as we pointed out yesterday, I think we already discussed this in-flight control sweep that Stewart [Baillie] presented up on column position versus force and unless there is some reconsideration or further thoughts on that, I think we eliminated that yesterday, did we not? So we will scratch that block, then.

Now the next several tests have to do with the dynamics resulting from a configuration change, power flaps or spoilers or landing gear, and the current requirement for Level B, I think addresses the dynamic response, and I'm suggesting that we use these steady state force response in lieu of recording the dynamics strictly as a means of reducing instrumentation requirements. But as was said yesterday, if one already has the instrumentation, certainly you are free to go back to the dynamic case, but if one is collecting data with hand held instrumentation, it's pretty hard to measure time history.

So I was just suggesting before and after here of trimmed airplane, change configuration, maintain the flight condition and measure the results steady state later. So I throw that out to you, is that good enough? Do we really need the dynamic response in this case? This really is an area where Level B is using more of a training device concept. I lost myself in the Advisory Circular here, I think this is one of those cases where we are looking at something that is currently adequate for a Level 6 training device, but can we extend that to a Level B simulator and get satisfactory results? Is the question if so--

MR. KOHLMAN: We need two things. One is the trim changes or pitching moments associated with all of these configuration changes involving power, gear, flaps, or whatever. But we also have to have an airplane that responds properly dynamically. We get that if you are going to do the phugoid and short period. That will tell us if we have the proper inertia and damping.

By doing this it greatly simplifies the number of dynamic maneuvers you have to do.

MR. BAILLIE: The power change dynamics and the like, it's the short-term effects that don't show up in the trim change. That we know--perhaps more importantly, things like gear change dynamics than power change dynamics with the aerodynamic configuration in one trim condition and the second trim condition aren't the only aerodynamic configurations the aircraft goes through. And the response of the aircraft is not the linear interpolation between those two points with dynamic inertia, there are more forces involved. I think the same is true for power and flap changes.

MR. SMITH: From an evaluator standpoint.

MR. STOCKING: I guess the question would be, is it good enough to record what happens by just observing? In other words, you've got a video of what's going on. You apply power, it pitches down two degrees and then it pitches up and stabilizes in trim five knots higher than the trim condition was before. You are taking that on a knee pad. Is that good enough, is the question? Or do you have to actually record it?

MR. DAVIS: I think either you record the stuff, or you go with the static trim before, force after test. One or the other, but just recording the video stabilized five knots above, I don't know how good that is.

MR. STOCKING: That's the trim of the aircraft, the trim of the aircraft afterward, but you need some record of what it did in between. Quite frequently airplanes will go the opposite way. The pilot says I apply power, it pitches down, it doesn't pitch up. Later on he doesn't notice what the change in trim is.

MR. BAILLIE: A video certainly would lend credence to the subjective evaluation of that maneuver. And if we are happy with just a subjective evaluation, I think that's fine. But if you are trying to match data, you have to measure attitude not with a video.

MR. STOCKING: You have the video before and after.

MR. BAILLIE: Well, for the dynamic case either you measure the dynamics or you subjectively evaluate them.

MR. SMITH: As an evaluator I would rather have the check point in the ATG for the dynamic cases although it's true that you have the gear and the flap change and the power change cases, but they are in different speed and configuration regimes, whereas if you only have the phugoid and short period in the ATG, which are at higher speeds--cruise--you don't have good coverage; it's just a couple more points to evaluate the model and verify it.

Granted that you guys, before we look at it, check it out in many other cases, it's just a couple points we feel better about.

MR. LEISTER: Hilton [Smith] is absolutely correct. Actually you can't build a solid model unless you do the dynamics that actually describe the pitching moments and the lift and drag, you can get a first cut out of trim points, but the dynamics are really what make the whole curve solid. If we go without measuring control surfaces, then we need a lot of dynamic tests like these to allow the model builder to drive his model.

I think the dynamic tests are much more important than the force tests, frankly.

MR. BAILLIE: We are not talking about what the model builder is requiring.

MR. LEISTER: I'm thinking about that.

MR. DAVIS: The premise is we have a model.

MR. BAILLIE: How do you validate that?

MR. LEISTER: I was going to address that later, I don't think we can have it--

MR. DAVIS: I agree.

MR. BOOTHE: I'm not getting your private conversation over there. Go again, please.

MR. DAVIS: I think the point is you need this data to build your model. Is that your point?

MR. LEISTER: Exactly.

MR. DAVIS: And I tend to agree you need dynamic data to build the model but I thought the point here was we already have a model, let's define what set of data we are comfortable with to validate that model.

MR. LEISTER: The only problem I have with that is that in this type of airplane you don't have the model. Where are you going to get it?

MR. BOOTHE: Okay, that's a very important point you two have brought up. All along we have been talking about validation. And unfortunately I didn't hear the whole conversation yesterday when what to do about modeling data was discussed. But I don't think that they are independent totally, and if some of this validation data is important to feed into the modeling data, I think that's a really important consideration here.

And especially if we are dealing with a group of airplanes that the airplane manufacturer for some reason didn't see fit to produce a model themselves, so if it's important to modeling and you think that the extra effort for collecting data for validation tests feeds over into the model in an important way, then I would say we need to keep that thought in mind as we do this.

If you think that we are quite comfortable with a model and all we have to do is validate it, maybe we could get by with less. Maybe we could see what Ken [Neville] thinks about that.

MR. NEVILLE: I agree with what you are saying. You have to take into account that the model may change because when you are doing your validation tests, if it doesn't match, you have got to have enough information to know what to do or the right thing to do to improve the model. You have to keep that in mind.

MR. BOOTHE: So you are confirming my thought, I think that these are not totally independent. We have got a mutual dependency here we need to consider in the validation data collection process. That's a good thought. Stu [Willmott]?

MR. WILLMOTT: We are talking about just simplifying the validation tests, doing the force test is the old fashioned way of doing it. But if you go back to the days when we used to do that, the problems that we used to have were with these transients. You can meet these force tests within a reasonable tolerance, but you still don't have the right little change that you have when you are moving the flap or moving the power and you often do not get the correct dynamics, you often do not get the airplane pitching in the correct direction.

If there is one thing that gives us problems, particularly with pilots, it's what happens when you move the flap. And even in here it just says for two flap transients. We always do them for every single detent in the airplane. That is something that the pilot is doing all of the time and he wants to get the right direction of pitch and the right feel on the control.

MR. BOOTHE: He--

MR. WILLMOTT: So you can make this simpler and stick to the force if you want. I don't think it will give you what it is that you want. And you have to somewhere do tests that allow you to get the individual effects of each detent of the flap going up, detent of the flap going down, if there are detents. The same with the gear change.

But we recently had a problem with a Westwind that, you know, you are aware of, Paul [Ray]. We were not getting the correct pitching with one of the gear transients, I forgot which one it was. And we did some tests in the airplane, completely redid the longitudinal pitch aerodynamics, and we did this in fact just by a still camera with a rig ahead of the pilot and we could fire it off every one second. And we were just measuring, you know, pitch attitude, rate of climb, the altimeter, we had an angle of attack indicator in the aircraft too, that helped us and we had a simple way of measuring the control deflection. From that we were able to retune the aerodynamics.

There are two things I would say, firstly I think it's important you can either put the dynamics in here or you can put it over to the design data. You definitely need that for the design of the simulator.

And the second thing is that there are simpler ways of getting that transient data just by measuring instrumentation in the aircraft, but because these controls are reversible, you have to measure them in some way, and the simplest way is measuring the column deflection. Because the aerodynamics of what happens at the elevator often determines what happens when you move the flap or the gear.

MR. BOOTHE: Well, I thought the issue was worth discussion. And I did, though, say that if force measurements were not acceptable, then you would have to do as per [AC120-]40B, which means an instrumentation system generally would be required and the double asterisks are included. I think what you are telling me is scratch out the ifs and leave the double asterisk, as far as the gist I'm getting here. So we should do that, I think.

MR. WILLMOTT: Of course you could put under spoiler speed brake change dynamics if appropriate.

MR. BOOTHE: Oh, yes.

MR. WILLMOTT: They don't have many of those in the Beech machines.

MR. BOOTHE: Okay. That follows through really the next three squares.

2.c.(3), and (4) all fall in that exact same--they are the same test, just a different input. So there is no point in discussing those individually because if it applies to 2.c.(1), it has to apply to the next few.

Which gets us down to gear flap operating time, which I think there is lots of alternatives besides the dedicated flight test, not the least of which might just be production flight test schedule that says the gears have got to operate between certain limits and if you are between those limits it ought to be okay.

Everybody seems to be nodding okay there.

MR. BAKER: You know the flap time in particular is very important. Because that obviously affects the dynamics of the airplane. I've seen extremes on flaps during development programs you can take a flap, an extremely fast flap extension on an airplane, and it gives you a tremendous pitch, you say my God, this is unacceptable. Yet you take that same flap and slow it down by a factor of five or ten and it's a hands-off maneuver literally in the airplane. And you can do that and you can screw up a simulator the same way. It can become a hands-off maneuver because the airplane decelerates when you are on a slow flap. And it just blends right in, everything matches. It's not unusual at all.

I have seen flap times in simulators that are definitely wrong that screw up the aerodynamics.

MR. BOOTHE: The thing is, if you use the production flight test schedule to check flap times, then you are getting in-flight times. Is that not correct? That's what I would recommend, but on the other hand you could easily measure them as you do the previous four tests.

MR. KOHLMAN: The data on these previous four tests will give you the times.

MR. BAKER: You would have the data.

MR. BAILLIE: I have often wondered why that's separate from dynamic cases because it's the same test.

MR. BOOTHE: Well, I have, too.

MR. SMITH: As a matter of fact that's something I never really check on an evaluation, really that can be covered with a statement of compliance and you have done this, because like Gerry [Baker] said, you can't get it wrong if you get the dynamics right.

MR. DAVIS: The dynamics are only two detents we are looking at versus the whole range. For a flap that's a small point. Gear you are right, but for flap you need to look at the whole range.

MR. BOOTHE: Well, would it be sufficient just to say statement of compliance and refer back to these other four tests?

MR. SMITH: I could accept that. Here again, from what Tom [Davis] said, I would trust him to do the entire flap right.

MR. DAVIS: Whoa, did you get that?

MR. SMITH: That's right, the inspector will catch it.

MR. BAKER: I think every one of these items, the configuration changes, as a pilot, to me these are probably the most important things in the simulator. If you put the right characteristics of the airplane in, gear flaps power, and just stuck it in any old simulator, you would be 90 percent there, I think. Because a lot of other characteristics change, the static stability, dynamic stability changes sometimes as a function of the CG alone in the same airplane.

These are relatively constant, they change some, but you get in an airplane, you extend the flap, it pitches, the proper rate, direction, those are things the pilot, as somebody stated yesterday, really is going to recognize this is wrong. And if I were concentrating on something to make correct, those would be the ones. I think if you make those correct you are going to get a lot less squawks on a simulator.

MR. STOCKING: From the point of view of validating your math model, and not specifically just for this, that's something you routinely check in the hangar, if you have got an electrical or hydraulically actuated flap system, you need to know what it's doing at what particular time. A lot of flaps, they extend and rotate, you need to know when those events occur with your aerodynamics, know what you are looking at.

I routinely check them in the hangar or by some backup method so I know where they are at any given time. In the cockpit quite frequently you don't know what they are doing till they get there.

MR. BOOTHE: True. Okay. We will leave the double asterisk on the dynamic changes. And operating time sounds like a statement of compliance that it's right is good enough because the dynamics would have indicated whether or not it's in compliance anyway, I believe.

MR. STOCKING: You want to be careful, sometimes you can tweak the dynamics to come in right and they aren't doing what they are supposed to be doing. You are just meeting the one test.

MR. BAILLIE: Isn't it the dynamics that are important? I don't care if the light comes up a second late, that's not nearly as important as if the aircraft has a double time, time to doubling or--

MR. STOCKING: If you are looking at this particular test that's true, if you slow down 20 knots and do it at a different speed or something then it will not respond the way it does in the aircraft. I've seen simulators that are like that.

MR. WILLMOTT: I can't remember why we continually left that in as a separate test. I mean, I've been to lots of the 14 and 40 [Advisory Circular] meetings. But I think one consideration may be that some of these things do vary with air speed. And I think we were probably trying to give us another case where we could put in another air speed.

MR. STOCKING: Eliminate one uncertainty in the variables, the flap.

MR. WILLMOTT: As far as operating time.

MR. BAILLIE: If that's the intent, then the requirement for that test should be changed. In most cases you take the time off your dynamic case and say look, we matched that as well.

MR. WILLMOTT: I think we did in the international standards.

MR. BOOTHE: I don't remember.

MR. WILLMOTT: And we certainly added the alternate gear extension and alternate flap extension. And I think we had more than one speed.

MR. BAKER: Some of these times could become important. Some airplanes have no pitching limit at all. There are airplanes that don't pitch. The original Cessna 500 didn't pitch with anything. Gear flaps or power, you can do anything, it was great. You had no pitching moment associated with anything. So the times would become independent then completely.

MR. STOCKING: You have a craft like the G-3 and 4, they have a schedule on the stab that's driven by the flaps so you really need to know what that is.

MR. BOOTHE: Are we okay having written what we have? Or statement of compliance on the times assuming that they would either come from the dynamics or they would come from some other source, but that should be available rather than going out with a stopwatch and measuring it? If that's the case we will move on to longitudinal trim.

MR. WILLMOTT: Could I ask Gerry [Baker], are there any aircraft that do not have feedback or flap indication?

MR. BAKER: What do you mean by--

MR. WILLMOTT: Well, business jet type aircraft have little dials telling you where the flap is, Citations have the pointer.

MR. BAKER: Follow-up pointer.

MR. WILLMOTT: Do they all have?

MR. BAKER: Most of them have an indicator.

MR. WILLMOTT: Some of them I wondered if they had the indicator.

MR. BAKER: You see a lot of detented flaps on newer flaps but most of them still have an indicator. Citations are about the only ones that have follow-up pointer flap positions.

MR. WILLMOTT: Sorry.

MR. BOOTHE: Thank you.

Moving on to longitudinal trim. I've not tried to specify how many trim runs one may do, however I've suggested that a number be added so that we could get a trim at various configurations and various speeds within a configuration and level flight, that way we could relate angle of attack because angle of attack and pitch angle ought to be the same in that case.

I have done this with the privilege of removing angle of attack measurements from other tests because it's difficult to measure, it's difficult to calibrate, it's very important but I thought if this were a reasonable trade-off, then this would simplify some Level B data collection.

So I throw that out to you as a thought and see what you think.

MR. DAVIS: All of the 2.c.(1) through 2.c.(4), what we have is a longitudinal trim there, do we not? There is probably other areas in the test data we can look at. Do we simply call for X number of tests here?

MR. BOOTHE: I don't know how specific we want to get here. But I'll be quite frank with you, on some of those trim runs you just mentioned, I'd like to meet the guy that thought he was trimmed. Because I've seen some absolutely horrible stuff that a person said was trimmed. People just don't take the time to trim. Now if you can combine things and you can get a nice trim run prior to initiating a configuration change, if I were still evaluating this data I would be quite happy about that because I would have an opportunity then to see a period of trim flight before suddenly there is an input.

What we normally see is 43 milliseconds followed by an input. And man, you can't tell much from that. So the combination would be good. But I don't think we should say how you should do these trim runs, I think we should simply say we need enough at enough different configurations and since each airplane is different I don't know how to specify that.

Maybe you have some ideas. Sorry, I didn't mean to jump on pilots, but it's terrible some of the stuff. Being one, I guess I can do that, right?

MR. WILLMOTT: I believe for a Level B simulator, even if you don't do much flight testing, flight testing that you should do is for each flap configuration a complete speed range of trims because it gives you the basic lift, drag and pitching moment that you want to put in the model. Then you pick two or three of those tests that you put into there for the validation.

MR. BOOTHE: When you say "a complete speed range of trims," you have to tell me what that means.

MR. WILLMOTT: From the maximum flap extended speed down to probably 1.1V stall.

MR. BOOTHE: How many do I need, one every ten knots, one every--

MR. WILLMOTT: An adequate number.

MR. SMITH: Very good.

MR. KOHLMAN: But Stu [Willmott], again, are you talking about modeling tests or--

MR. WILLMOTT: Yes.

MR. STOCKING: Modeling.

MR. WILLMOTT: Absolutely. You have to get that even for the modeling, even for a Level B simulator, is what I started off saying.

MR. KOHLMAN: I agree. Those would be key data points for anybody building the model but the question here is how many are we going to require.

MR. WILLMOTT: For the validation I would recommend we stick with the same as usual, which is just--it used to be two, I think it's three now.

MR. BOOTHE: Keep in mind we used to say you must measure angle of attack through all these dynamic maneuvers, now we are saying knock that off.

MR. WILLMOTT: For the purposes of collecting the design data you have to measure pitch, which is your angle of attack--

MR. BAILLIE: There has been the suggestion in conversations both formally and informally that some people might try to meet the modeling requirements without flight testing the aircraft and relying on the ATG to validate.

MR. WILLMOTT: If that's the case, then, and we are cutting out angle of attack, we have to do more for that test.

MR. BOOTHE: That was my conclusion as well. But--

MR. WILLMOTT: I would make it so that it goes to the flap extended down to probably 1.1 and maybe one or two in between.

MR. BOOTHE: But I'm reluctant to tell a person they have to do 23 trim runs. I don't know how many they should do, I think that has to be germane to the situation. Chuck [Stocking]?

MR. STOCKING: If you are checking the absence of angle of attack I think at each flap setting you need a minimum speed, maximum speed, and normal operation range for each flap setting and then low altitude, intermediate and high altitude. If you call that three tests for each one, that's 3, 6, 9, another 9, that's 18 tests.

MR. BAILLIE: And three centers of gravity.

MR. STOCKING: Two maybe.

MR. BOOTHE: It's almost sounding cheaper to put in angle of attack.

MR. BAILLIE: What about power setting? These aircraft are different if in climb or descent.

MR. SMITH: For modeling you have to have a range of TCs for every condition.

MR. KOHLMAN: But for trim purposes you have angle of attack if you have pitch attitude.

MR. WILLMOTT: I'm just wondering about that, again. Ed [Boothe], I thought we said we didn't really need angle of attack for a lot of tests, takeoff tests and things like that, because we have pitch attitude, we have air speed, we have altitude rate of change, that gives you the flight path angle.

MR. BOOTHE: But what we said, what I said, I don't know what we said, but what I said, we can eliminate those measures of angle of attack if we compensate by doing more trim runs to get a better definition of the configurations in the first place. But in anything other than steady flight, you don't know flight paths, so how can you get angle of attack other than maneuvering around if you are not in steady state trim condition? I don't know how you--

MR. WILLMOTT: From the flight path angle, from pitch and flight path angle.

MR. BOOTHE: That's right. If you know those or can construct them, but if you are going to do that, gee whiz, you are not reducing cost.

MR. KOHLMAN: I think you can easily. Measured parameters will be rate of climb, air speed and pitch attitude, and as Stu [Willmott] is saying, you can calculate angle of attack from those.

MR. WILLMOTT: I thought that's what we were recording for virtually everything we spoke about.

MR. HEFFLEY: Recall one principle here was that if you can't see something, i.e., angle of attack or sideslip, why do you need to provide a direct measure of it?

MR. BOOTHE: Well, Bob [Heffley], we are trying to validate a model to say represents an airplane within a certain limit here. I can't see angle of attack, it's a very powerful critter that affects everything longitudinally. And while I don't see it, it sure affects, it affects what the airplane feeds back to me when I fly, I know that.

MR. HEFFLEY: That's true. But you can have equivalent variables that can be used to derive angle of attack. If you want to look at it, to the pilot it's fictitious. It can be just as fictitious as anything else. And you can pick all kinds of different state variables.

MR. DAVIS: I don't see the difference between angle of attack and elevator position. So if we are willing to forego elevator for column position, I don't know why we are not willing to forego angle of attack--

MR. BOOTHE: Are you telling me we can eliminate angle of attack measurements and also not have to do a whole bunch of trim runs which you guys do anyway unless you use a totally predicted model?

MR. HEFFLEY: I think the idea is you can eliminate angle of attack if you are substituting that with something else that's a reasonable equivalent.

Furthermore, the angle--you know, the actual measurement of angle of attack is always a pretty doubtful thing in itself. And sideslip is even worse.

MR. BOOTHE: I know.

MR. HEFFLEY: So it's not as if giving up angle of attack is really giving up a really great thing. I mean it's kind of a nasty little variable.

MR. SMITH: I don't--

MR. WILLMOTT: They like it because they also define lift.

MR. SMITH: Your aero--

MR. BOOTHE: Hold it guys, we will never get it recorded.

MR. SMITH: Ed [Boothe], all your aero data model is is coefficients versus alpha, at constants TCs and flap setting; all your data tables, like you say, longitudinal parameters--

MR. HEFFLEY: It's strictly an engineering construction and nothing that the pilot sees.

MR. SMITH: That doesn't matter. The essential parameters, all the data is based on the program. We want to validate that.

MR. STOCKING: It depends on what type of model you are doing. The model I'm doing right now uses alpha FRL, which defines the stability axis, but that's the only reference it has, no internal meaning to the aerodynamics. I compute angle of attacks at all different places on and about the airplane. None of them are the full built up angle of attack. Angle of attack really defines what our reference is. Angle of attack.

MR. HEFFLEY: There is a way of modeling aerodynamics where you do not really use angle of attack explicitly. I typically use u, v and w velocity components. And therefore you avoid all kinds of problems that you get by using angles of attack.

MR. SMITH: If you start off with stability data--

MR. BOOTHE: You can still use u, v, w for stability axis.

MR. KOHLMAN: Angle of attack is almost always, not always, but almost always one of the primary driving variables in the aerodynamic model. It doesn't mean, though, that you have to measure and match angle of attack to prove the model is acceptable. Because if angle of attack is correctly modeled, the pitch attitude and the load factors, accelerations and pitch rates and everything else will come out within the tolerances.

So why do we have to add one more variable to match this very difficult and expensive to measure in flight? It's not that it's unimportant, it's that if you have it right all these other parameters will match. And that ought to be good enough.

MR. SMITH: We are not verifying all the other parameters, though.

MR. KOHLMAN: We are getting enough of them, we have pitch attitude, accelerations, angular rates, if we are going to have the strap-down box in here, and I don't think you can match all of those within the tolerances unless you are also modeling angle of attack appropriately.

MR. WILLMOTT: By the way, Bob [Heffley], a lot of these aircraft do have angle of attack vanes that are used to do a variety of things, and they often have a little dial that gives usually speed ratios.

MR. HEFFLEY: But that is not true angle of attack.

MR. BOOTHE: It's a reference number.

MR. HEFFLEY: So you have to go off and figure out how to calibrate that.

MR. WILLMOTT: It's the angle of attack of the vane itself. You can calibrate those and get a reasonable indication of either, you know, the body reference--

MR. BOOTHE: Can we hear from the Northwest [Mr. Neville] on this subject?

MR. SMITH: Northwest territory.

MR. NEVILLE: Well, you know this really gets down to the philosophy, what the flight test program is going to be used for. If it's only going to be used for validation data, you only need to collect the data required in the AC, and it doesn't require an angle of attack, but if you are going to use it for updating the model, you need angle of attack. In our experience when we do our flight test program there is a twofold purpose relative to simulation. One is to gather data for validation. That's actually a smaller part than the effort to go out and gather the data that we need to flight update the model, because when we go into a flight test program we have a predicted simulator model. And we use the flight test program to provide the information we need to update the model so that the simulation matches flight data within the tolerances.

And for that purpose you need to have an angle of attack or the equivalent. There may be other ways to develop a model, but angle of attack is the most important independent variable in the aerodynamic model for us. There may be some other equivalent ones, control surface deflection[s] are probably the next most important.

So I guess I don't know how you can do the full program without measuring those parameters or deriving them.

MR. DAVIS: It leaves us with are we building a model or validating a model?

MR. HEFFLEY: Validating.

MR. DAVIS: If we are building, I am uncomfortable with one of the compromises we have already made. I thought we were validating.

MR. BOOTHE: We are validating. However we said a few minutes ago that validating the model and developing a model are not mutually exclusive. We got into that discussion with the configuration change dynamics. So--but that's a question that remains to be discussed here, hopefully today, is what can we do with a totally predicted model and is that cheaper, can we--I don't want to get ahead of this, I would like to get through the tables fast so we can discuss that, but it's a valid point.

What Ken [Neville] has said, he needs that data for fine tuning, I guess, your model. But do you need it for then validating that model or would other parameters such as Dave [Kohlman] and Bob [Heffley] have discussed be adequate for that, because I think Dave has got a point, if the angle of attack is very far off, a lot of other things are going to be very far off.

I mean, it just won't work. It's either there directly or it's there implicitly, it's there.

So Ken [Neville], can we for validation purposes, can we eliminate angle of attack measurements which we have agreed to up to this point and through these--I threw the extra trim runs at you, the question is do you need the extra trim runs or can we just eliminate angle of attack as a validation measurement? That's the question.

MR. NEVILLE: When you add the additional trim runs that implies using the data for model tuning purposes. You are saying confirmation.

MR. SMITH: I think he is saying you are checking angle of attack there in lieu of checking it on all these other time history cases that we normally did.

MR. BOOTHE: That's the thought I had in mind, but now I'm being told you don't really need to do that.

MR. NEVILLE: Different parameters are interrelated. If you measure pitch attitude correctly, or if it's accurate, and climb rate is accurate, I think you can safely say that angle of attack will fall out.

MR. HEFFLEY: Yes.

MR. NEVILLE: So if you are just talking about validation purposes, I'm not sure you need angle of attack.

MR. LEISTER: You are going to be hard-pressed to build a model without a lot of trim points, but I don't think you need to show them in the approval test guide. For that matter, if you really want to validate a model you should add a lot of other things in this approval test guide. It's just a spot check. I think that's all this should be, is a spot check.

MR. BOOTHE: All right. Let's take a fallback position here. In which Advisory Circular is that? In 40B we have a trim run, is that all we need?

MR. SMITH: Just to validate the models, let's take two speed points at each flap setting instead of the one--instead of three. We have trim points in there now, we have three.

MR. BOOTHE: Well, what have we got?

MR. SMITH: And we were thinking about maybe nine a few minutes ago, three speed points at each flap setting, let's take two.

MR. BOOTHE: What I'm being--what I'm hearing, anyway, maybe it's not what I'm being told, but what I'm hearing is that it has to be in here someplace.

MR. SMITH: That's from the guys saying trust me, and I'm from the guys saying show me.

MR. BOOTHE: We have three trim points, cruise, approach and landing in 40B, and what I am hearing from the majority I think is that that is adequate without measuring angle of attack anywhere else. Is that what I'm hearing?

MR. DAVIS: Yes. An angle of attack can be calculated from those.

MR. WILLMOTT: There are a lot of other tests that we are going to be doing here for which there are effectively trim points like the landing. You have trim points for that. And even the last part of the takeoffs, you have quasi steady trims for that, the climbs, there are many trim points in there. I don't think there is any need to put more than what we have in 40B.

MR. BOOTHE: I think in terms of the objective here, proof to be seen later, that that's the most cost effective solution and it works. I know you would like more trim points but I think the majority is saying we don't need more trim points. Because of the implicit, the implicit measurements of angle of attack in almost every maneuver.

MR. HEFFLEY: Right.

MR. BOOTHE: As Dave [Leister] and some others have said, if it isn't pretty close, the only problem I have with that is some of the tolerances we have on other maneuvers, like maneuver stability.

MR. WILLMOTT: Right. That's the only exception.

MR. SMITH: Can we put a note in there, then, that all these other tests that start off with trim points that they have three or four seconds of steady trim shown?

MR. DAVIS: I think it already calls for five seconds.

MR. SMITH: How much?

MR. DAVIS: I think it calls for five seconds hands off.

MR. BOOTHE: We added that because of the problem I mentioned earlier.

MR. SMITH: Yes.

MR. BOOTHE: We weren't getting any trim.

MR. WILLMOTT: We didn't need to put in angle of attack for maneuvering stability anyway.

MR. BOOTHE: What I said, angle of attack is implicit there but I'm allowed plus or minus five pounds on maneuvering stability, so I think that gives me a pretty good margin for error on angle of attack. But that's not the only rules, so.

MR. RAY: In fact with this that test ends. One being a front end of the other tests. You have all three configurations listed, power change, flight change, et cetera. When a person does longitudinal trim cases, he is going to pick 15 seconds in front of the other test, say that's my test and repeat it.

MR. BAILLIE: Unless you define you have to have a second test.

MR. RAY: Sure.

MR. BAILLIE: In your notes here you are saying FDR sensors, surface positions.

MR. BOOTHE: Yes, I did, because I was assuming we might measure them. What I'm doing is just saying per [AC120-]40B and scratching all that at this point. This was my alternative solution that turns out that you concur is not necessary, I think. So what we do is scratch that and say per 40B, which puts us back where we were on trim. But according to consensus still permits us to not measure angle of attack, which I--tell me if I'm correct, tell me if I'm wrong, I just perceive that as a significant cost driver of gathering data. Because you have got to have some sort of sensor, whatever you use you have got to calibrate it, you can't calibrate it without flying.

You have got to fly the kinds of things we say in here to calibrate it in the first place. You don't really know how good its transient response is after you calibrate it if you don't know local flow effects.

MR. BAILLIE: Alpha isn't that bad. Especially if you put a strap-down package on it and you have some mathematics behind it you can get alpha routinely. Sideslip is the one that has all the problems we have discussed. Alpha isn't that difficult.

MR. KOHLMAN: Once a nose boom or differential pressure system is on the airplane. That's the expensive part, is modifying the airplane.

MR. BAILLIE: Or a good inertial system in the software.

MR. BOOTHE: That's not a direct measurement, then. I'm talking about a direct measurement of angle of attack.

MR. BAILLIE: You can never get a direct measurement, you are always calibrating versus inertial systems, whatever, you are never directly measuring angle of attack.

MR. WILLMOTT: I don't know what you mean by that, Ed [Boothe], there isn't any means of measuring angle of attack directly?

MR. BOOTHE: We measure something with a differential pressure system or a vane or whatever you can dream up, and we call it angle of attack. That's what I mean.

MR. BAILLIE: Anything external on an aircraft like a Dash 8 or any other turbo prop aircraft is extremely affected by power setting and slipstream effects.

MR. BOOTHE: I think we have beat that to death. I have indicated we will do the trim runs per [AC120-]40B and we can move on to longitudinal maneuvering stability. I think that that can be done accurately with hand held instrumentation. See what you think.

MR. LEISTER: Well, in the course of what I do, I go on flight tests with these pilots, I will tell you I think it's extremely difficult to do this test with a hand held force gauge because if the air speed changes over three knots either way the test is invalid.

Pilots have a lot of difficulty holding constant air speed, holding something solid, but if they are holding a force gauge I think it's all over. I think you need to have a sensor to measure this. My opinion.

MR. BOOTHE: Okay. A force sensor on a wheel--

MR. LEISTER: Yes.

MR. BOOTHE: --or stick or whatever you have got?

But still it's not a test that requires an installation on an inertial system, is it? Bob [Heffley]?

MR. WILLMOTT: It's nice to have a accelerometer.

MR. BAILLIE: It's a far better--stick force per g is what everybody measures and that's what we should be trying to validate. Not stick force per air speed or bank angle.

MR. HEFFLEY: I think you need the inertial package, but I guess it's been my experience that if you have a good enough pilot, you can get some reasonable results from a hand held gauge.

MR. BOOTHE: Dave Ellis rigged up a deal one time to do this without--you had a home made accelerometer, that's what you had.

MR. ELLIS: Yes.

MR. BOOTHE: But he was doing it with wings level.

MR. ELLIS: Symmetrical--

MR. BOOTHE: Which was difficult, I must tell you.

MR. WILLMOTT: I'd like to say that one of the programs we had at SimuFlite, we tried replacing the maneuver stability by push-pull maneuvers. And that proved to be very, very difficult to accurately simulate because you have a lot of altitude changes and you have a lot of speed changes that go along with that and you can't really measure what it is that you are trying to measure, which is the force.

One of the things that these validation tests did do was if a pilot had a question about some of the characteristics of the simulator, you could pull out this test and run it in tight turns with one of the tests that the pilots do frequently as part of the training, and this gave us a check for the forces that were required in those tight turns tests, steep turn tests we called them. So having the force in the steep turn is a good thing to do still, I think.

MR. BOOTHE: What I think I'm hearing is that I've overly simplified this and we really need to use at least an accelerometer. And some more convenient way of measuring forces.

MR. KOHLMAN: We have a number of other tests that, if I recall correctly, we at least have pedal force transducer, and we may have specified some that have a force wheel. I don't remember. But if we have, then that equipment is going to have to be in the airplane. We may use it for all the points but it was installed in the airplane, then it's a very low incremental cost to go ahead and do some of these tests that you need that kind of data for.

MR. WILLMOTT: The thing with this, too, Ed [Boothe], this class of aircraft where you are involving the aerodynamics on the controls, that's very difficult to, almost impossible, to estimate the in-flight characteristics, theoretically predict them in any way. Wind tunnels are bad, this gives you a true check of the forces that are on the control surfaces.

MR. KOHLMAN: The other thing is sometimes it's very hard with a hand held gauge to know when you are stabilized at the appropriate points. If you have a time history, even though things are changing you can often look very carefully and say here is a good five-second segment where everything is stable, and use that point.

MR. WILLMOTT: What CAE does when they are plotting the maneuvers, they plot force versus g and it's scattered all over, there is considerable variation. How about that? You take the average of the result of the particular g you want to do the test for and that seems a good way of doing it.

MR. BAKER: Well, I have seen this done a lot but a hand held gauge is difficult. I mean, I've seen, talking to Daryl [Schueler], I've seen people who use just a mechanical accelerometer for steady state stuff, but it depends on the airplane. I think a lot of it, too--and capabilities of the airplane. Most the airplanes we are talking about here are fairly low altitude airplanes. You are not talking a tremendous maneuver like you might get in a high altitude jet trying to do wind up turns at 45,000 or something. But I would personally go for a control wheel input.

As Daryl [Schueler] points out, it ends up being a dynamic maneuver a lot of times where a recorded control force versus a recorder accelerometer you can pick up a multitude of points during the maneuver that way. It would be a lot simpler task.

MR. SCHUELER: It tends to be easier for a pilot to maintain a slowly increasing wind up turn type of maneuver rather than trying to stabilize at a fixed point for a period of time. It tends to be easier for them to keep a rate of change through that maneuver, slow rate of change rather than locking on a particular point.

MR. BOOTHE: Okay. I think the consensus is, I think, give up that simplistic approach and throw a double asterisk and a wheel and column force measurement here. The reason I say double asterisk, I know we really just need the accelerometer. If you are going to have some sort of inertial package I would doubt you would have a separate distinct accelerometer, it would be part of the package. So I guess that's where we are on this thing.

MR. ELLIS: Could I just note that we developed this symmetrical pull-up technique especially for the case of low speed small airplanes where you tend to, in order to produce g's you have to develop high pitch rates. And if you try to do that in a wind up turn you get, at least for the low g conditions you get a lot of air, you have to get to high g's. I agree that what you need in the simulator, probably most, is some representative force for the turns. The effort should focus on that.

MR. BOOTHE: Yes. Thank you, Dave [Ellis].

I remember using your system and it was difficult, but when I got it right it was so satisfying. Okay.

Well, we will double asterisk and go to column wheel force measurement and get us on longitudinal static stability. Again I have gone through ships instruments and a hand held force gauge. That's easier maneuvering stability. Everybody seems to agree we can do that one. Okay?

Which brings us to stick shaker air frame buffet and stall speeds. How much can we get from certification data on that? And can we simplify this test to shift calibrated systems and some video and some hand recording?

What we are really interested in is identifying that we properly model these three factors if they apply. So have I overly simplified that? What's your--

MR. WILLMOTT: My experience is that type inspection report data is very good to use for this.

MR. BOOTHE: If you can get a hold of it, as Gerry [Baker] said.

MR. WILLMOTT: If you can get a hold of it. And of course normally the simulator manufacturer or the customer pays for a data package and that's available.

MR. BOOTHE: One of the things we are addressing here is cases where there may not be a data package.

MR. WILLMOTT: Well, if there is not a data package and you want to represent that, then you have to do a whole series of stall tests.

MR. BOOTHE: True. But can you do it with just the instrumentation that I've outlined here, is the question?

MR. LEISTER: Well, you have a little difficulty identifying buffets sometimes unless someone calls out “start a buffet” or something like that, but I don't see any reason why you can't do it.

MR. WILLMOTT: The very definition of the stall test means you have to do quite a number of them, because the definition of the stall test is that it's defined as being the one knot per second entry rate and normally when you are testing the airplane you plot the minimum speed versus the entry rate between 1.1 times the minimum speed, and the minimum speed that you get, and you normally have a scattering and you draw a line across them and you read them off at one knot per second.

MR. BOOTHE: Stu [Willmott], that's why the stopwatch is in here.

MR. WILLMOTT: I--yes. I think you've got to get the TIR tests for this, otherwise you are talking about the same type of series of tests that you have to do in the airplane to define it in the first place.

MR. BOOTHE: I agree.

MR. BAILLIE: One question I have, maybe a fundamental one is, is it important to just nail the one knot per second stall speed or should you require two stalls at different deceleration rates, whatever they are, two knots, three knots, four knots, whatever, and match two so you have the right trend and the right variation of speed rather than trying to nail the one certification parameter? Once--

MR. KOHLMAN: This is not a certification test. It's just matching a known condition. I think that's an appropriate observation.

MR. BAILLIE: But it requires you have to do more than one test.

MR. DAVIS: Is that even necessary though. One test is enough if you compare apples and apples. If you have a knot and a half per second, when you go in the simulator go a knot and a half per second.

MR. WILLMOTT: But you have three or four attempts to get that.

MR. DAVIS: You have three or four attempts no matter what, in a simulator.

MR. BOOTHE: It's a pretty critical speed.

MR. BAILLIE: But is it--

MR. BAKER: Yes, it's critical for certification, yet for a simulator you've got to keep in mind nobody ever goes below stick shaker. How precise does this stall speed have to be? I've gone to airplanes, I have gone to simulators, Lears with pushers in it, the pusher doesn't represent the actual pusher at all. It's nothing like the real airplane. It's a disaster on most simulators because there is no criteria that it be like the airplane apparently, so why does the stall speed have to be so precise?

It seems to me if you want anything precise it's stall warning.

MR. BOOTHE: More so, but I think the pusher, doesn't that identify--doesn't that define the stall?

MR. BAKER: But the dynamics of a pusher are very dramatic, particularly ones with alpha-dot. I have never seen a simulator that represented the airplane very well.

MR. BOOTHE: So if we--there has got to be for these airplanes and airplane flight manual, it has to contain performance, performance has got to include stall information, is that correct? So why don't we pick numbers out of the AFM and use them?

MR. BAKER: The point is you do have defined stall speeds. And again, it's like rate of climb, I don't know why you can't use some of these things. I would be more interested in matching characteristics and warning in a simulator than the exact stall speed. I mean, it takes a lot of work, like you say, to precisely define stall speed. You go out and run half knot entry, one knot, knot and a half, cross your data and draw your line. You don't want to get into that business here.

MR. BOOTHE: Not if we can help it.

MR. KOHLMAN: I think that it's a relevant point that Gerry [Baker] raises. This is a training simulator. It's something less than a Level C and D. And if it's training you bust the ride if you go past shaker anyway. So do we have to model that precisely exactly where the airplane stalls? You don't train the pilot to stall the airplane.

MR. RAY: That's true, but it has potential implications when you realize you can also do the wind shear training that's required by [Part] 121 in one of these devices. So it has a negative--

MR. KOHLMAN: But the point is still you don't get past shaker.

MR. RAY: If the wind shear training is required, they are not required to do the wind shear in a prop, but if you go to jet.

MR. BAKER: The point is, if you went in the real world and take an airplane, take one of the airlines we have been flying recently a so-called representative Lear 35, I would have hated to use that airplane to model a simulator on. Nothing was right on it. It's been two weeks now since we flew the airplane. I would not have wanted to model it. I would have rather used the design data to model it to. Which is what we are making this guy do to get it back to configuration.

It's so far out at stall itself, at shaker no problem, you get to full stall, you have one air speed indicator that drops off dramatically, one stays where it should, it goes on and on and on. Who knows what you are going to get.

You have a better representation of a real airplane, I think, if you use the design data where somebody precisely went out and defined the stall speeds. To me you would, at least.

But characteristics I would agree. You need good characteristics. You need proper--if it's rolling tendencies or buffet, that's got to be there. The stall is not going to be far off. On certification stalls you are nit-picking. You are taking a knot or two difference in stall speeds.

MR. BOOTHE: The only problem that we have with the stall speed itself, why in the United States it's not a big issue for pilot training and certification and I don't think it's a big issue in the UK and Europe. However, the UK requires that simulators stall. And since we have got a harmonization program with the FAA, that could lead to problems for Paul [Ray]. But I still think, regardless of that, using certification and AFM data is good enough for this. Is that your position?

MR. BAKER: That's my point. I agree.

MR. BOOTHE: What I have done is changed this block that says acquire using blah, blah to use TIR and AFM. And as far as I'm concerned, issue closed.

MR. WILLMOTT: Could I ask a question of Paul [Ray]?

As far as I know, the training requirement in the simulator in this area is approach to stall, you go down to stick shaker or whatever the warning is, and you apply power and recover.

MR. RAY: Right.

MR. WILLMOTT: That's the only time you get to the stall? The wind shear requirement is not in this class of airplane?

MR. RAY: Not for maneuver training. But the side part is these standards would apply to even a turbo jet.

MR. WILLMOTT: And for that fly at stick shaker--what about unusual attitude type training, is there any requirement to have anything beyond the stick shaker modeled in that?

MR. RAY: Not that I'm aware of.

MR. BOOTHE: That's sort of industry--

MR. RAY: The industry has picked that up.

MR. TOULA: Voluntarily.

MR. RAY: It's not required.

MR. NEVILLE: They wouldn't use Level B simulators to do that.

MR. ELLIS: Related question. Is there any requirement to model stall characteristics like roll off, things like that?

MR. SCHUELER: No.

MR. BOOTHE: No. In fact that would be--they are different each time you do them, so I don't know--people do model something.

MR. STOCKING: We also have a class of aircraft here where you control stall speed with power.

MR. LEISTER: Did you say you were changing this to use TIR and/or AFM? If you don't have TIR data then you can use AFM data, don't you need to model the pitch attitude of your stall much better than just something you pick out of the air?

MR. BOOTHE: Well, it was my opinion that that gets covered in some other test and I was more relating this strictly to the pertinent speeds. If that's not right, somebody tell me.

MR. LEISTER: I know that wasn't a requirement in some of your earlier advisory circulars.

MR. BOOTHE: Let's see what this says. The only thing that--here is air speed and bank angle. While people often provide additional data, and I think that's very informative data, and certainly it's important, I think in this case if we were to take the position that those relationships are covered in other tests, while I don't know of any other tests that we really get down to speeds this low, but maybe Stewart [Baillie] can help this.

MR. BAILLIE: Bob [Heffley] and I were just suggesting you are going to have trim points at 1.1, so you have some attitude relationship, some drag relationship.

MR. BOOTHE: But that doesn't show up in the validation data, it shows up in your--

MR. BAILLIE: In your trim you have to have power setting.

MR. BOOTHE: You mean trim for the stall itself?

MR. BAILLIE: No, I'm saying in the trim data--oh.

MR. LEISTER: You are probably going to be doing power-off stalls, too. I think it's important but it may not be. It's easier for me as a modeler not to have to.

MR. BAILLIE: Chuck [Stocking] did point out in most of these aircraft the stall is completely different depending on the power settings. So getting one validated point may or may not suggest your model is good for pitch attitude and for--

MR. BAKER: You take a typical turbo prop that has a lot of prop wash across the wing, a power idle stall is going to be tremendously different than with the power on.

MR. LEISTER: The handbook shows--

MR. BAKER: One knot per second.

MR. BAILLIE: Is the training intent more for downwind turn on to final or the departure turn on takeoff?

MR. WILLMOTT: Sometimes in simulators, what they do is just let the airspeed bleed off on approach. On approach to landing demonstrate what the stall is like.

MR. BAILLIE: That's a low power stall.

MR. STOCKING: That's worst case.

MR. WILLMOTT: If we are going to use flight manual stall speeds, then we need to know the margin between stall and stick shaker, I guess that's normally seven percent.

MR. BAKER: Well, yes. I say I would still put in high speed characteristics.

MR. WILLMOTT: Also the flight manual does not give low speed, I think some of these aircraft that occurs before stick shakers.

MR. KOHLMAN: Do most of the airplanes have stick shakers?

MR. BAKER: Most have a shaker or aural warning in this category.

MR. WILLMOTT: So you can't get buffet speed--

MR. BAKER: Some airplanes in this category, some do, some of the transports, but Part 23s, no.

MR. BOOTHE: The only way you would get buffet is if it is significant enough to be the stall warning, then you would get it. But if it's not enough buffet to in and of itself be stall warning, I don't think anybody relies on that, anyway, do they Gerry [Baker]? Most people have a stall warning system.

MR. BAKER: Most of the airplanes I see some kind of artificial--

MR. WILLMOTT: The 747 flaps up. That is the buffet. You get plus or minus one g.

MR. BOOTHE: Hilton [Smith]?

MR. SMITH: Could I say I have heard a lot of words about the stall speed is not that important because we don't train to it. But if you train to stick shaker and you say the trainee busts the ride if he stalls, then if we don't have the proper stall speed represented and pitch angle brake, stall speed and load factor brake or whatever defines a stall, if he goes to stick shaker and two knots beyond and it stalls, he is going to holler foul. We have to have the stall speed properly represented to give him a proper, you know, representation of not stalling.

MR. BAKER: That's true, but I think you are going to get a better representation of proper stall speed by using certification data.

MR. SMITH: Whatever. We need to recognize, I just want to remember that it's not totally--

MR. BOOTHE: We are not suggesting not having the correct stall speed.

MR. SMITH: I realize that.

MR. BOOTHE: We are saying the source should be AFM or certification data.

MR. SMITH: Though we don't check pitch angle and load factor, they need to be properly represented.

MR. RAY: We are not going to go through there and check it mathematically.

MR. SMITH: We are not.

MR. RAY: It may be from listening to Stu [Willmott] and some others, that the AFM number is correct, supported by a video of a maneuver in the aircraft to acquire those, if you don't have comprehensive data.

MR. WILLMOTT: There is a number of things that you normally get from the TIRs that are really useful, of course one is the buffet speed that you can't get from the airplane flight manual at all. The other thing is the g break, that occurs in the cockpit, you can see that on the vertical speed indicator. If you use flight manual data you don't have any way.

MR. RAY: That's--

MR. WILLMOTT: I would find it very, very difficult to, I'm getting into modeling, do anything in this area without having the TIR data on the stall test on the aircraft.

MR. RAY: Is it reasonable to say the TIR is a reasonable source for the data?

MR. WILLMOTT: Absolutely, yes.

MR. RAY: But if you are using only AFM, then support that with another source.

MR. WILLMOTT: You have to have visual data, you can't get buffet speeds.

MR. RAY: That's my point. There are crucial items to make sure the simulator is flying properly.

MR. BAKER: I don't think there is anything wrong with what you are saying. You are still going to get some stalls, but instead of trying to take that airplane with its static system or whatever and use those numbers for stall speeds they could be way off. You would be better off in my opinion to take precise numbers that determine certification. Characteristics you define from what you saw in terms of g brake, stall warning, rolling tendency, whatever, I didn't mean to say don't go stall an airplane.

MR. BOOTHE: Well, okay. I guess what we can maybe conclude here is the TIR is available, that's the primary source. If not we can use AFM and a video to confirm these other parameters that you are concerned about. Is that fair?

MR. KOHLMAN: Yes.

MR. BOOTHE: All right. I think it's coffee time.

MR. LONGRIDGE: Let's reconvene about 20 to 11:00.

(Break taken.)

MR. BOOTHE: I guess we are down to that notorious maneuver or that notorious response mode called the phugoid. We won't have a history lesson, but what I've done here, since the phugoid is usually something on the order of a one-minute period or thereabouts which for a given airplane configuration and flight condition, is pretty much a function of speed, think we can measure the period accurately by sight.

And that's what I have indicated here, that the damping ratio, there, is another animal. So--but how close do we need it? Because with some careful recording you can probably get a pretty good handle on the damping as well. What do you think?

MR. HEFFLEY: Well, to put the phugoid into context, the phugoid is the one thing that always goes away immediately when the pilot starts flying the airplane. The mode disappears with regulation of pitch attitude. And I guess I've always wondered what the significance of really having the phugoid mode nailed very precisely, what it really adds to a training simulator or most any simulator.

MR. BOOTHE: Well, I think Dave [Leister] put a finger on it earlier. I don't think the period really tells us a whole bunch. I think the damping is pretty indicative of some longitudinal modeling, that's a validation point that's useful. That's why it's there. It's for a model validation and on the concept, you recall yesterday I said if we can convince ourselves we have a good model of the envelope, then we can support whatever training task is in an operator's program. So that's sort of why it's there.

Now if we measure only the period, then I have to agree with you, you could use it for a speed indicator, but if we measure the damping as well, then I think it's indicative of some longitudinal modeling, and particularly the drag characteristics, and I think it's important in that respect. So I hope that's not a disappointing answer, but that's--

MR. WILLMOTT: I think one of the things that it does, too, is often in simulators not being modeled properly the phugoid is quite unstable. This gives you a check for that. Particularly when you have got aerodynamically loaded controls.

MR. BOOTHE: There is one more point I would like to make why it's there. You say the pilot closes the loop, that's true. We can handle widely unstable phugoids on approach because of the closed loop. However, it almost exclusively determines the trimability of the airplane. And I think that's important. Because if the airplane has different trim characteristics--or if the simulator has significantly different trim characteristics in terms of pilot trimming capability than does the airplane, then we have messed up.

So I think that's probably even more important than is the drag characteristic indicators. It's an important mode. Bob [Heffley]?

MR. KOHLMAN: It is one of the fundamental dynamic modes, so it's a good measure of how well you have modeled some of the more prominent stability derivatives. Because of that, it's not a terribly onerous burden until you make the tolerances way too tight, because it responds relatively quickly to just a few of the primary stability groups, even though I agree with Bob [Heffley], you don't see it that often in a simulator, it's still a good measure of how good the model is. If it's very far off then you will see it in the simulator, then it will be a disconcerting characteristic.

MR. BOOTHE: But the pilot in the loop, hopefully it's totally suppressed but it still has a strong influence on trim characteristics.

MR. HEFFLEY: I really don't disagree with anything that's been said here, I guess the bottom line is how close that phugoid damping really needs to be matched.

MR. BOOTHE: That's a different question, okay. All right. I think that's open. In [AC120-]40B we have a 0.02 on the damping ratio, I believe, and we were only talking about damping ratios on the order of--that's twice as big as some of the damping ratios you get on a phugoid. So while it's a small number, an absolute value, I don't think that's a small tolerance.

MR. DAVIS: The damping ratios do tend to be very small, if not neutral.

MR. BOOTHE: Of course, that's why we need that, it's hard to get ten percent of nothing. So you have the 0.02 and the position has been taken that you may use the larger of the tolerances specified. So you think 0.02 is too tight for that?

MR. HEFFLEY: It has been in certain occasions.

MR. SMITH: Ed [Boothe], if we are going to have an inertial system for the configuration change dynamic cases, would it be unreasonable to just lump that test in with those?

MR. BOOTHE: No, it wouldn't. In fact I don't see how we can do a short period without an inertial system and those two, you know, are coupled, more or less.

MR. NEVILLE: Phugoid is something that you can measure easily with less sophisticated instrumentation because it's such a slow maneuver and I think a stopwatch would work quite well. I agree with you it is an important test of some very fundamental longitudinal characteristics. But one thing that's interesting is that I don't think there is any difference in any of the tolerances between [a Level] B and a C [or] D and this may be one area you might want to consider as a slightly wider tolerance band on it, on the damping, because it is, compared to most tolerances it is pretty tight.

MR. HEFFLEY: I would ask if that particular tolerance that we are talking about, the 0.02 value, is that really commensurate with the method of measurement that we are maybe talking about, which is just a direct observation of a couple of cycles?

MR. BOOTHE: Well, Bob [Heffley], if I were to use the airplane instruments, assuming they're calibrated, and with some help I could almost with--speed--pick something if I had a fairly well burst of speed indicator and I kept track of the variations, got a little pick of the peak each time when I'm dealing with a mode that has a damping ratio of possibly zero or 0.01, I don't think 0.02 is really that tight. Because if you can't meet that, I would say something is wrong with the dry equations. I think that's a clue. That's just my opinion.

MR. WILLMOTT: Well, with this class of airplane [you] can get into the modeling of the controls very, very significantly, it's a very, very critical thing as far as the damping is concerned, you can just blow it. [Change] some of the aerodynamic terms involved and you will change from stable to unstable. In a simulator where I changed the friction on the control column by half a pound, it changed it from stable to unstable.

And in fact one of the things I was going to say, I don't know whether I'm baring the soul of simulator manufacturers, is that one of the problems with simulators is trimability. And it still exists and I think it probably is related to the motion feel that the pilot is lacking in simulator[s], delicate motion feel, if he is not in trim. One of the ways that we used to make trimability easier is by making the phugoid very heavily damped. And in fact by including this as a test you are making it more like the airplane but you are making the trimability of the simulator harder.

MR. HEFFLEY: That's a good point.

MR. KOHLMAN: Should we make it stick fixed or stick free, stick free is where the friction and the controls--

MR. WILLMOTT: Normally it is a stick free.

MR. KOHLMAN: I know. If we are really collecting inertias and aerodynamic damping and those terms, you ought to make it stick fixed.

MR. BOOTHE: At stick free you get such an overwhelming influence from bob weights and downsprings, that's what you end up measuring rather than the airplane.

MR. SCHUELER: Particularly for this class of airplane, you are going to have a lot of thrust effects as well. You have got slip stream changes occurring with changes in speed and altitude, those can be significant, those changes in the thrust model have a big input into the phugoid response.

MR. DAVIS: With respect to fixed versus free, we want the whole answer to be right, not part of the answer to be right. If there is something in the control modeling that is in error, we want to bring that out, do we not? So what's the point of having a beautiful aerodynamic model if the whole simulator isn't flying like the airplane?

MR. KOHLMAN: But if what Stu [Willmott] is saying applies across the board, that is, very small changes in the friction in the control system have a big effect in the phugoid, you are going to see the same effect on any particular airplane you test, that is, very small changes in the same airplane in friction, which I'm sure take place, are going to change a stick free phugoid.

Why not model separately, do the control sweeps within a reasonable tolerance on friction, bob weights and downsprings and all those things, then we determine the inertial effects with another test. Put them together and you will match within the tolerance bands that you see in the field.

MR. HEFFLEY: But wait now. Stu [Willmott] is bringing up a really important point here, that it's kind of beyond this matter of the goodness of the match. We are almost suggesting that this is one of those cases where as a simulator designer, you may really want to have the freedom to fudge this particular characteristic because it's something that you are in effect trying to compensate for something that is not there in the simulator.

I had a recent experience where I matched the phugoid very well. And my client did not like it because it was too tough to trim compared to the real airplane. And it was because of this lack of other cues and things were made better by adding a little bit of damping, in this case making it easier.

MR. DAVIS: How do you know it's not throughput? I'm not saying it is, there are many things that could be the source of your problem. Maybe you are covering that up.

MR. LEISTER: That's a controls problem if you can't trim it. I don't have any trouble trimming the simulators I have worked on, and pilots don't either.

The phugoid, though, you better get it very close, damping ratio or not, you better get all the peaks and valleys close to the airplane or you have done something wrong. You better go back and do some more work.

I don't ever look at damping ratio until I have to look for you guys. I just do the phugoid so it's very, very close to the data. That goes for all the phugoids induced by thrust or flaps or whatever. They are very important tests.

MR. BAILLIE: Is this maneuver conducted stick free and is the column position matched during this test?

MR. LEISTER: Yes, they better be or you really--

MR. BAILLIE: It wouldn't be if we just used stopwatch.

MR. BOOTHE: I think it's a dual answer, for validation we have not measured the elevator floating or the stick position floating, which may come from control system components. We have typically just measured the period and the damping and so we have measured the overall response in that respect. But if you get all of that right, then there has to be either something right in the model or some very strong compensating effects. And you don't know which, of course.

MR. LEISTER: But you can get the phugoid by letting elevator float in a way that was not on the flight test. You can get those matching within tolerance, you have got to get the whole thing right. You have to have the elevator float, everything right, or you might as well start again.

MR. BAILLIE: Don't you want the validation maneuvers to prove that you have it right?

MR. LEISTER: As a modeler I'm not really that concerned. But I would do it myself, I would prove it to myself, yes.

MR. BAILLIE: While we are on this discussion, before I forget, the other question I have is, the majority of simulator training in these and other simulators is in the circuit and yet the phugoid is done in the cruise. I don't understand why that's the case.

MR. LEISTER: It should be in approach or at least approach.

MR. WILLMOTT: When you are flying tests and you do them for all configurations.

MR. BAILLIE: I know. The validation maneuver, which is the one you hang your hat on and say this is a good simulator, should be at the configuration most important.

MR. WILLMOTT: Normally I think we chose the cruise because that's the place where he is going to try trimming it out and essentially let it go while he is doing other things during the cruise, see how it tends to wander in that state of flight.

MR. BAILLIE: Is that the most important configuration?

MR. WILLMOTT: In approach and other situations he is never ever going to be letting the controls alone for more than a few seconds.

MR. SCHUELER: Plus you have the change dynamic tests that provide you--

MR. WILLMOTT: Give you an excitation.

MR. BOOTHE: I must say that you folks never cease to amaze me, when I think I come to an easy one.

MR. LEISTER: We got together before the meeting.

MR. SMITH: See, Ed [Boothe], you did such a good job before you retired we are not going to break away.

MR. BOOTHE: Well, the thing is, if we have to measure it for Level B qualification, can we do it well enough by the method described here or must we have more? I guess that's the most important question to me now. Because if we need more than this, from some of the descriptions I have heard that I would indicate quite a bit more, if we were to keep track of column position and elevator position and bob weights and downsprings and all those other things that may be in airplanes of this class. But if we were simply to take what's here, measure the period in the damping, if we get that right, all of those other things are either right or somehow they have got compensating features and it could be either.

But we, traditionally, have accepted for even Level D simulators a period of damping ratio or damping, and I don't, certainly don't see that we would want to be any more stringent for Level B, but I do think if I had to flight test an airplane I have a pretty good chance of getting a decent answer, I just fly the airplane with some decent instruments.

MR. LEISTER: Most of your Level C and D simulators are, or a lot of them, they don't have elevator float, the airplane itself doesn't have an elevator float that affects it. That's the primary thing that you need the column addition for is to determine if the column is actually moving, and it does actually move quite a bit on the phugoid on these little airplanes.

MR. BOOTHE: You do see a little bit of elevator float.

MR. LEISTER: You do in a non-reversible system, it's not like a reversible.

MR. BOOTHE: No, it's not. And airplanes that have a sophisticated control system that's done by means other than bob weights and downsprings, you don't see nearly the effect that you see. But you do see an effect. Because it's still fed back through whatever affects that control system.

MR. SMITH: These C and Ds require time histories, and on airplanes with reversible controls, such as prop jets, before we asked for elevator, a time or two we found in the automatic program they were locking down elevator, I remember that on a Saab 340.

Since we are not measuring control surfaces here, I would think we would want column position and a time history and just require this data along with the configuration control dynamics data.

MR. BOOTHE: Comments on that?

MR. LEISTER: You really need that on all the transient tests. You need the column, too. I hate to say it, but I think you really do. If you are not going to record external surfaces.

MR. BOOTHE: What you are saying here, then, is you are removing my simplistic approach and saying we have got to have some kind of a position sensor on the control column and we have got to have a system to record the time history of the response.

MR. LEISTER: To be a valid check, I think you do. That's what this is about, the check on the simulator, I think without that I could play all sorts of games if you don't require me to show the elevator.

MR. STOCKING: To validate modeling itself, not to certify the machine, you have got to have a real accurate column position. Control position force and position tells you everything about your model you need to know in a reversible system.

MR. BOOTHE: But you get the model correct, then for just a validation checkpoint do I need that or can I be happy with just frequency and damping? That's all we have specified for any simulator, in fact.

MR. STOCKING: It's just like recording angle of attack. You really need it.

MR. BOOTHE: Well, the modeling is implicit, it may be wrong, and have compensating features, but it's implicit.

MR. LEISTER: In this case it isn't, really, because you can attack the problem two ways, you can make the phugoid react by making the elevator float one way or you can do it like the airplane does and then you have got to get all the other numbers correct. It's not something that proves itself with just a period and a damping in any of these phugoids.

Pardon me for talking with my mouth full.

MR. BAILLIE: If you are changing the float parameters, isn't that going to catch up with you in the longitudinal static stability test?

MR. LEISTER: It will. You can still build a model that probably passes these tests. Pilots probably won't like it but they won't know how to tell you what they don't like.

MR. BAILLIE: If the pilots don't like it, it's not going to get qualified.

MR. LEISTER: Maybe.

MR. RAY: If you don't have the right pilot, if I don't have Gerry [Baker] or someone of Gerry's caliber in there that can quantify to the engineer what's wrong with it. The worst answer in the world you would expect is comments like, “I don't like it, it's no good.” That's not a very acceptable answer.

MR. LEISTER: Doesn't fly like the airplane.

MR. RAY: Get the technician in there that can fly the test, he can make it work every time, that’s of limited value.

MR. LEISTER: I'm saying from a modeler's standpoint I would rather I didn't have to show you where the elevator or stick or anything went. But I'm saying as a validation test it's really not until you do include that one thing.

MR. BOOTHE: Sounds like we are inventing a Level E simulator.

MR. WILLMOTT: I was going to say the name of the game is to try and make this device cheaper than what the standards are right now for C and D. And going back by what we said at the start, anything that the pilot can't see is not really relevant to a validation test.

You might see the column moving a little bit, but there are lots and lots of things for all of these tests that we need to have right in order to model things correctly that we are not showing, and I don't think putting it in validation tests is the place to put it.

MR. HEFFLEY: This goes back to the relative importance, I think, of this particular characteristic. And if its importance has to do with unattended operation, trimability, then there is some of these effects such as the amount of float and column motion, that aren't very important to the pilot at that point in time.

MR. BOOTHE: Well, it looks like a solution here is to insert the infamous double asterisk and assume we are going to have a system to measure it. Because other suggestions I'm hearing even exceed that in terms of instrumentation because if we got an instrument to measure the control column movements as suggested, since we don't have the surface, and that makes a big difference on the response, but we have traditionally, we have traditionally seen it because we have that comment about having to verify flight condition and show enough data to illustrate the response, but we have never put any sort of limit on how much it should be except frequency and damping. That's the only limit we have ever had.

MR. LEISTER: I don't want to mix model and ATG that much, but I think that maybe we are all, maybe I'm not talking what you guys are talking, but to me a simplified flight test is one where you don't go out and tear up the airplane and put sensors on the surfaces and you don't measure angle of attack or sideslip, you do go in, you have force and position and transducer on all the major flight items, column, wheel, whatever. And you have to measure those positions, those forces, you have to have also a system to measure the attitudes, the pitch attitudes, roll, heading and acceleration in order to build a good model that will fly like the airplane.

Or, you have to have surface, angle of attack and all this other stuff. You can go either way, but you still have to have acceleration and attitudes for that kind of test. You can do a cheap flight test by instrumenting the internal parts of the airplane and get a very, very good model but you do have to do that.

And by going test to test here, some tests you don't have to have all those things to get the modeling data or the proof data but most the tests you do. One thing or the other.

All I'm saying is that if I don't have external position data and I don't have angle of attack and sideslip, then I want the whole system working inside the airplane on all the tests so I can use it not only for validation but for modeling. I don't know whether I have made that very clear, I can't build a model unless I have all those things. Not a good model. I can build an old time model like we used to see 20 years ago.

MR. RAY: Is it a fair question, what's the reasonable cost saving incurred by doing that?

MR. LEISTER: I don't know what the dollar amount is. But it's considerable. And you know Flight Safety used to do their tests that way, they had it on a gyro that had a precession in it, it was a modeler's nightmare. They have a laser now that's very nice and no precessions to speak of. It gets you attitude and you have positional forces, it's good flight testing.

MR. BAILLIE: I would suggest his saving would be two weeks in instrumentation time.

MR. LEISTER: And a lot of dollars.

MR. BAILLIE: Time is money.

MR. LEISTER: In the small airplane, getting in the airplane and tearing some holes in some guy's airplane that you leased, they don't somehow like that.

MR. BOOTHE: Okay. We are talking two things here, one is validation, stuff you are going to give the FAA; the other is, is finding data to fit your model. I guess I can say fit it, what you do is find responses so you can go tweak numbers to make them work; is that right?

MR. LEISTER: I didn't understand what you said.

MR. BOOTHE: You are finding responses so you can now go tweak some coefficients to make them meet those responses, so that's part of the modeling process. But it's stuff you are going to send the FAA is what I want to address right here.

MR. LEISTER: I don't think you can separate them. In all honesty, I can't look at Mr. FAA and say all we need is the period of damping, no sweat. That will prove the phugoid. It doesn't, I think you need the other thing, the elevator float characteristics.

MR. HEFFLEY: But we are getting those already in some of these dynamic and these transient maneuvers.

MR. STOCKING: If you put elevator position on this test you couldn't apply a tolerance to it because the movement is so small it's well within any--

MR. BOOTHE: Sometimes. Other times--

MR. STOCKING: I would say 99 percent of the time.

MR. BOOTHE: Let me go back to what David Kohlman said. Maybe these control system responses are seen somewhere else. We have all the transient responses for configuration changes, every last one of them will excite the phugoid, although we don't let it go very far, because we tried to but we got shot down on that. Maybe we should just look at the aerodynamic model of the airplane here and not of the control system and do a stick fixed phugoid for Level B.

MR. LEISTER: That's very hard to do. What do you define the stick fix--

MR. BOOTHE: Okay.

MR. WILLMOTT: We are really going to do tests in the validation tests that are things pilots will do and will recognize. The stick fix thing is not something that he would do.

MR. BOOTHE: But I don't want to invent a higher level simulator to do this.

MR. WILLMOTT: I'm all in favor of leaving the darn thing as it is and go on. If I wanted to do anything, I'd take it out because of what I said first. I still believe that trimability, pitch trimability is a significant problem in all simulators. That's my experience. And by taking the phugoid out I can do something to make the pitch trimability easier, but if you want it in, leave it as it is.

MR. BOOTHE: When you say "leave it as it is," do you mean leave it as it is in the current Advisory Circular?

MR. WILLMOTT: Just have the period and damping.

MR. RAY: The piece is missing, what I hear Stuart [Willmott] saying is our present ATG requirements would include the controls. In the instant case we are talking about with this particular test, we would not see controls, it goes over to Dave's [Leister] point.

MR. WILLMOTT: All the phugoids we currently do for [Levels] C and D we give you the time history of elevator, air speed, of pitch rate, pitch attitude, all of those variables are already in there. Whether they are spelled out or not. So you can see what they are doing, you can see what the elevator is doing.

MR. RAY: Correct. In this case what we are saying right here, we would not. We would neither see the control position or the surface position.

MR. WILLMOTT: I did go back and check what we needed for B.

MR. RAY: The testing requirements are the same. The tolerances are the same. It's period and time and damping ratio. But the part that will be significantly absent--

MR. WILLMOTT: I was presuming that since Dave [Leister] was talking surface position that it didn't have it in there.

MR. RAY: Didn't have surface, but Dave's point, you would have control position in lieu of surface. At least that's what I heard him say.

MR. LEISTER: Yes. If you really want a validation test. If you don't, well then don't include it. Because it's not a validation test.

MR. WILLMOTT: I'm sorry, Paul [Ray], I guess it's a bit late for me or something, I'm missing the point.

MR. RAY: Maybe I am. I think Dave's point is we need to see the control or surface. We are not going to see the surface, we already agreed to that. Before the--for the test results in the ATG, if we do it as printed in the draft tables, we will neither see surface position nor control. All we will see is a number.

MR. BOOTHE: Two numbers.

MR. WILLMOTT: A damping and altitude or a speed profile.

MR. RAY: However, it is derived. Dave's comments and some others indicate we need to see the control position in there also.

MR. STOCKING: We don't do that currently for the other.

MR. RAY: Yes, we do. Because supporting information requirements in the QTG for the varying tests we would also ask for surface position as supporting information on how that test, the test results, were derived for that tolerance we are applying on the particular item.

MR. BOOTHE: I think probably we have arrived at retaining the language in the current Advisory Circular and moving on because other thoughts I'm hearing here are inventing a higher level of qualification and we certainly don't want to do that for this application. And anything less than that is inadequate, so standing on a razor's edge here I think we better stay where we are.

MR. NEVILLE: There is a general statement in the Advisory Circular about additional parameters beyond those that are just required for tolerances, all relevant parameters related to a given maneuver or flight condition must be provided to allow overall interpretation. Providing this kind of thing, control system information, falls into that category that covers every test.

MR. RAY: My point being if we did it this way we would not have any of the other information. All we would have is a number.

MR. BOOTHE: But what we have done is delete my comment about a stopwatch and airplane instruments because we cannot do that with only those measurements, and that's why I have suggested that we simply stay with the current Advisory Circular and leave it be. Because I'm certainly not going to be popular in the industry if I raise a new level of simulator here, and I certainly don't want to not get a decent measurement and have a not good simulator.

So I'm going to be a coward and take the easy way out and leave it as printed in the Advisory Circular, and unless all your hands go up I'll take the coward position.

MR. RAY: I don't think it begs a double asterisk, I don't know.

MR. BOOTHE: It does if we are going to have time history. Good discussion. Thank you.

It doesn't leave much to talk about on the short period, I guess.

MR. SCHUELER: Knock on wood.

MR. BOOTHE: Well, we already have an inertial requirement. While I personally believe the short period is very important, very important to handling qualities, primary maneuver mode, it's hard to see, and you've got to have some decent measuring equipment, and I think that the--strap-down system is a minimum that one could really get by with for that. So I've left it that way.

Unless there is objections, we can start on lateral directional. And while I know you all have a lot to say and contribute, we've got some things to discuss that I would like to get to, and they have to do with well, the cost increment. If we can come to some estimate. So I would like to leave time for that today rather than run out of time.

And also I still think we need to discuss somewhat about what if we just use a predicted model at a Level B and don't have it adjusted from flight. Is that a possible thing to do and come up with a decent simulator? I don't expect an answer now but I would like to discuss that a little bit later.

So what I'm saying, I want to hear you out on lateral directional but I want to see if we can speed it up just a little bit. And lateral directional begins with, on page 8 of this book, with minimum control speed in the air. Can we get that from the AFM and the certification data? It's certainly something that's strongly--that's something that's tested and certainly available, I would think, but maybe I can ask Gerry's [Baker] input.

MR. BAKER: You can get the speed if you had the TIR, obviously you could. The AFM. Only you are back to the situation you don't know the specifics as to whether it was a force limited or control limited V_{MC}, for example.

MR. BOOTHE: So really it's in the TIR if we can get it.

MR. BAKER: If you are just looking for a number you can say yes, this is the way we are going to do it. How important is it? And go on from there if it's a matter of doing it that way.

MR. BAILLIE: Isn't the intent of matching V_{MCA} to be sure that the pilot in a simulated engine out condition in the simulator has to use the right forces and right cross controls? That's more than just matching a single speed number to V_{MCA}. And perhaps the Level B simulator should have OEI trim and a variety of OEI trim conditions rather than matching one V_{MCA}. That's the intent, I think.

MR. BOOTHE: So are you suggesting that perhaps we should just do a number of trims with one engine inoperative at speeds approaching V_{MC}?

MR. BAKER: They are not related.

MR. BAILLIE: But the intent of this maneuver is not to validate V_{MCA}, it is to validate the handling qualities of the aircraft in a one engine situation.

MR. BAKER: I don't relate trim at all to V_{MC}.

MR. LEISTER: Yes, trim--

MR. BAKER: Nothing to do with it.

MR. STOCKING: You can point at min control speed by taking a series of trims, increasing speed.

MR. BAKER: You don't trim in a V_{MC}, first of all. You can't use the term, you trim in a takeoff scenario, remember, for V_{MC}, not for in-flight condition. To me it's a controllability maneuver. Some airplanes are rudder limited, some airplanes are stall limited, some airplanes are aileron limited, some are force limited. You can get a lot of combinations on V_{MC}, it's a pure controllability issue.

MR. BAILLIE: But I guess the question is, for a simulator, is it as important to get that as to get the handling quality required on the climb out with one engine?

MR. BAKER: Well, it's debatable.

MR. BAILLIE: What's the training intent, is the question I have asked a number of times here.

MR. BAKER: Somebody else has to answer that.

MR. NEVILLE: The idea is to get engine out trim requirements or characteristics. There is already a test that does that. The V_{MCA} test is a more extreme condition that tests the model for full rudder. If it's a rudder limited V_{MCA}, you have maximum rudder, very low speed as well as having a maximum thrust asymmetry. So it really tests the extremes of the model.

MR. BAKER: I agree. It's the control at the extreme ends of the model is what you are looking at, which I would think would have a very important factor in the way it blends in the rest of the model.

MR. SCHUELER: It's more than a number.

MR. SMITH: I think you want the time history approach to it. Because it's very dynamic. I can remember one we just looked at, the 601, roll critical, if not limited, in that you are full wheel into it--

MR. BAKER: You can build it all wrong. Let's say you built it in as a force limited rudder problem and it's really a roll problem.

MR. BAILLIE: You don't get that from an AFM.

MR. WILLMOTT: You get that information from the TIR.

MR. BAKER: You could get it from TIR.

MR. BOOTHE: Scratch AFM, obviously that's inadequate from the discussion.

So then the question is if the TIR for some reason, and there seems to be a number of reasons, were not available, then what are we left with? If one were to have to do tests, perhaps it's not as simple as I have indicated here. From what you are saying I was just looking at speed and there is a lot more needed in here than just a speed in order to do an adequate simulation, and so therefore for validation we traditionally just looked at a speed, haven't we?

MR. SMITH: We have looked at time histories on a lot of these.

MR. RAY: Supporting data.

MR. BAKER: You can validate it in a static V_{MC} in most--most airplanes if you can meet the static V_{MC} you can meet the dynamic case. It's rarely a problem.

MR. WILLMOTT: Would you like to describe how you normally conduct the test in an airplane?

MR. BAKER: Start out with static maneuver, and just--it's everything, you know, again you need some analog instrumentation force into it, particularly for rudder force. Usually a rudder, I have never seen an aileron force limited V_{MC}, but rudder is quite frequent. It's possible you get a lateral control limit-force but I have never seen it.

But it's a matter of just slowing the airplane down, and all manufacturers are going to use the full five degrees bank. I've never seen anybody that didn't, because it's very significant. And the bank angle is extremely important. A degree of bank can make a lot of difference in V_{MC}. On some turbo props I have seen the difference in V_{MC} between wings level and five degree bank as much as 20 knots. I have personally seen that. It's a very, very important item.

I've actually run into problems where you play with it so long you get a precession on the gyro and it screws up the whole test. Usually you relate it back to some data pack or you need to make sure that the roll angle is correct. That's very important. And just progressively slow the airplane down and feed it control until you simply run out of some control or you can't slow down anymore without getting a heading change. Or reach of force limit. That's the static maneuver.

Some airplanes you can't hardly get light enough to get V_{MC}, that's an issue on some airplanes. It's very difficult to get light-weight conditions. It's important that you use takeoff trim settings in your airplane, you don't trim for a V_{MC} because you could have a force limited V_{MC}, rudder trim should be takeoff, your lateral control should be takeoff lateral control, and then normal practice is to determine the static number and then come back and validate with a dynamic cut, engine cut, actual fuel cut.

I have never seen a problem on an airplane yet as far as the dynamic cut. The dynamic maneuver becomes horrendous on some airplanes, particularly at the light-weight on some high power airplanes because of the attitude. People have looked at alternate ways of doing the dynamic cut. Slowing the airplane down and dirty up the configuration, accelerate, as you clean up you hit the speed more in level attitude.

I personally think validating with a static maneuver would be adequate and forget the dynamic cut. That could be horrendous, you could take a Lear jet, 45 degrees nose up, light weight when you are climbing out and you cut the engine the biggest problem is the speed decay, you are pushing to catch it.

That's not a very real maneuver, it does not simulate what you see on a climb out and acceleration at all. So it ends up being a horrendous push.

The other thing is you are allowed to get a 20 degree heading change on a dynamic cut. That's why I say you can almost always comply with a dynamic cut, when you let the nose turn up to 20 degrees. So the static maneuver generally sets the test.

I would think for here if you get a static V_{MC} it would be plenty adequate. You do need to instrument the forces and positions. You have to have that good--turbo props you have torque, and if you are torque limited you are in pretty good shape. You have your maximum torque available, but some of the airplanes are not as highly torque limited as others. You want to do it at a reasonable safe altitude. But some of them will be off the torque limit, then you have to correct the data somehow.

Obviously it's better if you can do it on the torque limited level. And you still may have some direction to it depending on altitude.

MR. WILLMOTT: You do it for both engines or you know which one is which?

MR. BAKER: Generally you know, depending on rotation of the engines you can make that assumption.

MR. BOOTHE: Okay. So that was a good description, Gerry [Baker]. I appreciate it.

Now we have come down, we have to have force and position measurements of the controls. What other measurements do we need? Do we need to put the whole inertial system in to [get] enough information or if we have control information and speed do we have enough?

MR. BAILLIE: Attitude.

MR. BAKER: Attitude.

MR. BOOTHE: We do need attitude, right?

MR. BAKER: If you have got a good attitude system, I mean inertial or AHRS system or whatever it is.

MR. HEFFLEY: Given what Gerry [Baker] just described, though, I guess, I guess it sounds to me like you really can come back to what Stewart [Baillie] just suggested, was an engine out trim that sufficiently approaches V_{MCA}.

MR. BAILLIE: That's the same--

MR. BOOTHE: I think what Stewart [Baillie] was suggesting was a series of measurements as you approach.

MR. HEFFLEY: Yes. So you get close enough so you get a reasonable match in controls--control forces.

MR. BAILLIE: Could I maybe reiterate or clarify what I was suggesting? The idea that I had which makes it easier to conduct the test, given that we don't have certification pilots usually on board, makes it more repeatable to do the tests, is to take the aircraft at a variety of speed conditions, both engines operating, get a trim point, pull one engine back, measure the forces and accelerations on the aircraft to keep heading zero. Or heading rate zero. So you measure asymmetric thrust, high thrust on the one engine and you can predict V_{MCA} by the extrapolation of those points.

MR. BOOTHE: But you are going to measure control force and control position.

MR. BAILLIE: Exactly. And acceleration.

MR. BOOTHE: At a number of points as you approach critical speed.

MR. BAKER: It will take twice as long.

MR. BAILLIE: It's not a time history matching which takes twice as much effort to do in simulator time. You are right however, the flight test does take longer.

MR. SCHUELER: It's not really significant whether you do it statically or time history. The measurement requirements that you have are such that it's--I don't see a huge difference between doing it either way.

MR. BOOTHE: What I think I'm hearing is what Stewart [Baillie] is saying has merit, I think, I think it has more merit for modeling than it does validation. And it would increase the validation requirements over what are now required.

MR. BAILLIE: The maneuver ties in a bunch of things, no. You need that level trim, anyway, so you are there. Then you pull an engine back, zero up the heading and you got the second data point. Then you clean up the aircraft, go to your next trim point anyway. It's not like you are adding tests here, you are just combining the longitudinal trim with a lateral trim.

MR. SCHUELER: I think it's a valid approach. I think it makes more sense to trim once, slow down to a speed, stabilize that, slow down some more, stabilize that. You know, hit several speeds in that manner, record your required inputs, your attitudes at each of those points and you have accomplished the same thing.

I'm not sure what retrimming at new air speeds accomplishes for you. It actually increases your variables.

MR. RAY: Depends on what you mean by retrimming. To get back to the definition where you talk about retrimming, as Gerry [Baker] indicates, zero trim, using that term, as opposed to configuration of controls being in trim.

MR. BAKER: That's a better definition.

MR. STOCKING: In my comments I meant a static trim, not--

MR. WILLMOTT: The purpose of the check is to check the V_{MCA} in the simulator is the same as the airplane at a very critical speed. That's really what it is we need to check. If you do a trim check that's away from that speed, you don't know whether you are going to meet that speed. Particularly with the turbo prop aircraft where everything is so dependent on slip stream and a few knots down a low speed is going to significantly affect control forces, control effectiveness and everything else.

I think we need to set up the test and do it like the airplane, which is the way we currently do it.

MR. BAILLIE: I know that's the way we currently do it. I would suggest the majority of the time in the simulator is not spent at V_{MCA}, it's a pilot trying to avoid getting to V_{MCA}. He is pitting forces and inputs to stay away from that. Being at V_{MCA} matching it isn't as relevant as being close to matching it.

MR. WILLMOTT: Ground rule one, we want to stick with the requirements of [Level] B if we can.

MR. DAVIS: Either which way it's double asterisks, right? If somebody wants to do it differently, they can go to the FAA and pose it differently. For now it's double asterisks.

MR. RAY: The critical point from a training viewpoint, is that there is the potential, the potential, I think Stu [Willmott] would agree, with the critical impact of V_{MC}. If you don't get close, how close is close enough? I don't have the answer to that.

In the simulation if the pilot does something wherein he should fail, fail due to controls, that simulator should fail as the aircraft should. I think there is more comfort factor, if that's the right word, with the classic approach to that, to ensure that does in fact happen.

MR. BOOTHE: Okay. I think moving right along here that we are right where we started from, if not having invented a more severe test, which we don't want to do, I appreciate Stuart's [Willmott] approach. I think it's a good one. But for our purposes here, if I think if we were to attempt validation by that method, in fact I think that would give quite valid modeling numbers, too, if we were to attempt validation by a method we are actually increasing the requirements that we currently have across the board. And if we want to do that, then by all means let's speak up. But I don't think that was one of our objectives, for sure.

MR. STOCKING: Many of this category of aircraft have min control speed below stall speed, in which case you have to back up to something that points to the right speed.

MR. RAY: Right.

MR. STOCKING: It's only an alternative.

MR. BOOTHE: Is stall not a valid--

MR. BAKER: That varies.

MR. BOOTHE: V_{MC} if it stalls before it gets there.

MR. BAKER: It varies the way it's done by manufacturers.

MR. NEVILLE: It's one of the tests that was originally included because it's a cert test, it's one that's already done anyway. To call it V_{MCA} maybe isn't appropriate. What's needed, perhaps, is a low speed engine out trim. And as Gerry [Baker] pointed out, you have got to get the airplane very light, to even be able to fly a V_{MCA} test the way it's defined, which includes five degrees bank angle.

But if you can't get there without stalling the airplane you could perform it at three degrees or two degrees and still have very low speed maximum thrust asymmetry trim. I think that's the point Stewart [Baillie] is trying to make.

MR. BAKER: If you can find the control required to get to the lowest point you could. The thing I failed to mention, I assumed everybody realized it, you are in a prop, you are at an aft CG, you are at light weight, whatever configuration it's going to windmill again, whether autofeather or NTS or just a plain old windmill, if you don't have either one of these devices, it's in the takeoff configuration, you are up.

MR. BOOTHE: Well, if we were to do what you suggest, which I think is a good idea, we would have to do that for all levels of simulators. I don't think we could--well, we wouldn't have to.

Do you want to change this so we don't actually do a V_{MC} or we do a low speed asymmetric thrust test?

MR. NEVILLE: We run into the same problem at any level. I know my experience with Boeing airplanes with a flight test airplane, because of all the flight test equipment that's fixed weight you can't get light enough to perform a true V_{MCA}, and we have had questions from the simulator operators and manufacturers complaining that our V_{MCA} test is not really a V_{MCA} because it's not five degrees bank angle. We have had to say it's four degrees, but it satisfies the intent. But people get hung up on the name V_{MCA} where it's really just a low speed engine out trim with maximum thrust.

MR. BOOTHE: I have to defer this one to you. Do you want to invent a new test for Level B?

MR. RAY: Stewart's [Baillie] approach is reasonable if you are down at that point where you are close to V_{MCA}. I'm not talking 15 or 25 knots above, I'm talking on the edge of it. It's a reasonable approach we have accepted before. Rather than invent another case for the alternative of tests like that, which may be supportive of V_{MCA}, I think is a more realistic approach to point to the existence of TIR data. If someone has it, they can match it, then it's truly a V_{MCA} test. I believe it goes back to Stu [Willmott] and the Dallas approach, if you want to call it that, where we invented the terms, in one case low speed engine out ground handling characteristics, in the other case it was engine out in the air.

MR. WILLMOTT: Low speed engine inoperative handling characteristics in the air. It's already in the [AC120-]40B.

MR. RAY: That alternative has been there for many, many years. I don't think we are reinventing anything. But to delete it could mislead someone.

MR. BOOTHE: Okay. Another test left where it is, is that the conclusion? Is that also stick a double asterisk in the right-hand column?

MR. SMITH: A couple of times you said 40B and sometimes you say double asterisk. Do you mean the same thing?

MR. BOOTHE: No. Double asterisk means we need inertial platform to measure stuff.

MR. RAY: Including controls.

MR. SMITH: That doesn't mean you are not going to measure anything else. You are going to do normally what you would do in 40B.

MR. BOOTHE: Whatever 40B required.

MR. RAY: Except for surface.

MR. BOOTHE: Moving on to roll response, again I have tried to, while I would prefer to have a roll response, in the interest of simplification I have digressed, I guess, to the old measurement of bank angle from some predetermined initial condition in one direction to some bank angle in the other direction.

A question is, then, is that good enough? We see things done both ways these days, roll response measuring roll rate, but we also still see these full wheel roll rates, which I don't think really tell us much except full wheel roll rates. I have attempted to simplify to that extent. The question is, is that good enough for Level B?

MR. WILLMOTT: The one area where you have the problem is the amount of wheel that you are putting in, and for Level B I would suggest that what could be done is that you put aileron trim of a given magnitude holding the wheel so that it isn't rolling, and when you are ready to time it, you let the wheel go and time it to 30 degrees of bank. Do the same thing [in] the other direction so you have got consistency in doing the test.

MR. BOOTHE: To get anything meaningful out of that response you have got to have a time history because you have the initial roll. What I have suggested and we just measure steady state roll rate.

MR. WILLMOTT: But that's the way of--well, I don't know how you can measure steady state roll rate. In all the time histories I see these days there is a lot of yawing that goes on which gives you from the slip roll from the slip and there is no such thing as steady state roll rate.

MR. DAVIS: How accurately can you measure with a stopwatch? You see a start plus 30, putting your wheel any time from [plus] to minus 30, however I'm a little worried how accurately you can get that with a stopwatch. You could do it with a video better.

MR. KOHLMAN: I would suggest you have the video on this. As a matter of fact, it's spelled out there. Then you can--the way we do it, we always have a digital stopwatch in the frame and you can stop it anywhere you want, read the time, read roll angle and plot it out. Maybe a little scatter but I think you get reasonable tolerances.

MR. HEFFLEY: Yes, I mean all you are really looking for here is a time to roll to a given angle. And if you do it where, for example, you put into the limit aileron that establishes the amount of control, then it seems to me it would be quite simple to get a validation point while still avoiding an explicit time for a single event. Is that what you are describing in this, Ed [Boothe]?

MR. BOOTHE: Yes, maybe I didn't do a very good job. When I say stopwatch I don't mean necessarily going clickity, clickity, but something in a video, a time recorder I should have said. I guess my brain is fixed to the old days or something. But a time measurement.

Certainly you couldn't be clicking a stopwatch in this maneuver and get anything worth getting, but with the video clock in it you could.

MR. KOHLMAN: To answer another point that Stu [Willmott] raised, you are going to get some yaw, and I forgot the other point, but you never do get a pure roll about longitudinal axis but still you try to fix things. I would say you hold the rudders neutral, put in a step and you record it, and whatever the airplane does the simulator should do. There will be some adverse yaw in there, yaw due to roll rate, but they should all be the same within reasonable tolerances.

MR. BOOTHE: To do that, Dave [Kohlman], we need to record more than just bank angle, don't we?

MR. KOHLMAN: You need to know the input.

MR. BOOTHE: You need to know the input and the bank angle change, but if I'm going to take this as an overall response, which obviously is going to involve yaw rate, generation of sideslip, which means I'm rolling from things other than aileron and not rolling because of other things than aileron, I don't know anything about those if I just measure roll rate.

MR. KOHLMAN: Well, except the assumption is if the roll rate, which is the primary match, matches over a number of inputs at several speeds.

MR. BOOTHE: We can assume the other stuff is modeled correctly.

MR. KOHLMAN: That's correct, we want to minimize the number of parameters.

MR. BOOTHE: That's what I was hoping you would say.

MR. SMITH: I disagree with that. Well, I mean this is a validation test, it's to validate the model in the lateral axis. What you want to know, you want to know if a particular airplane has a yaw characteristic, when it rolls you want to verify that, you want to verify the roll, you want to know the aileron effectiveness, you want to know if roll damping is right, you validate all that with one test if you have these parameters.

MR. RAY: Doesn't rudder response cover that to a large degree?

MR. LEISTER: That's roll. If you go roll response--Ray?

MR. KOHLMAN: This is a test primarily to measure aileron roll power. And roll response.

We will get all the other parameters with cross control tests, with V_{MC} tests, we have so many others that will find out if there is another, C_{L_β}.

MR. BOOTHE: Right. If I could address that. I agree with what Dave [Kohlman] is saying, if the response in roll is not correct, then you don't know what's causing it, but if the response in roll is correct and you do have the other measurements, then I think you are in pretty good shape.

MR. RAY: If you isolate the others.

MR. SMITH: The initial yaw due to aileron, are you going to pick up the roll--

MR. BAILLIE: You pick it up in steady state slips.

MR. SMITH: You get a static. If--well--

MR. BOOTHE: We don't measure that now as an independent parameter, yaw due to aileron.

MR. SMITH: It's built into this test.

MR. BOOTHE: What Dave [Kohlman] is saying, if you have yaw due to aileron that generates sideslip which generates rolling moment which may oppose the aileron, if you get the right roll rate then you have accounted for it.

MR. SMITH: With a time history we get the time history data, we before have gotten sideslip, we wouldn't here, we wouldn't ask for it. We may ask for yaw rate.

MR. BOOTHE: We are trying to simplify.

MR. SMITH: I know but you want the same fidelity. You want to validate the model.

MR. BOOTHE: I'm not even sure we want the same fidelity. We want a simulator that supports--we want a simulator that stimulates a pilot response that is correct. I don't know what fidelity that takes, quite honestly, and I don't think any of us do, really. I still make--if you make an aileron input of known size and you measure roll rate and it is correct, you are halfway convinced those other variables are also correct, and then we have other tests which will confirm that. Like Dutch roll and so on. So I think for a Level B we don't need to do all that. I think a simple roll rate will suffice.

MR. RAY: Eliminate the rudder parameter.

MR. KOHLMAN: Yes, eliminate the parameter, the rudder response.

MR. HEFFLEY: The other extreme is if you start breaking these model characteristics into so many components you really are checking every stability control derivative in your model, then you really increase scope. The idea of making a check that takes into account several effects all at once, you know, it's consistent with what you all have been doing for a long time.

MR. BAILLIE: That would be fine if we could say okay, we are going to do a roll step response, we are going to match yaw rate, roll rate all the accelerations, but then we are throwing out this maneuver, this maneuver, this maneuver and we are not, so at least minimizing the effort to match each maneuver does reduce some cost. You are still going to be measuring yaw rate because you need it for Dutch roll and pedal response. But let's not put it onto the roll response, let's check it.

MR. BOOTHE: So if we do a full wheel deflection roll rate, then we can eliminate this need for measuring the control wheel deflection because we are on the stop as soon as somebody has done a confirmation check on the airplane and stops in the right place which should be done anyway. And we just have a full wheel roll response.

MR. SCHUELER: There are ways to do partial.

MR. WILLMOTT: You want the wheel deflection typical of what a pilot is going to use, you are trying to check the simulator to see if it is like the airplane as far as the pilot is concerned.

MR. BOOTHE: In that case I have to go back to something to measure wheel deflection.

MR. HEFFLEY: Control system.

MR. BOOTHE: I couldn't hear you.

MR. HEFFLEY: The use of a control stop fixture allows you to intermediate without going to a full throw.

MR. BOOTHE: I agree, I'm trying to figure out what to write.

MR. LONGRIDGE: We have to stop. She is running out of tape, the sandwiches are set up as yesterday.

MR. BAKER: I hate to bring this up, there are hard roll requirements for commuter airplanes. Right now the Beech 1900 has a single engine roll rate requirement at 1.2 V_S.

MR. BOOTHE: That's more critical than this.

MR. BAKER: That's not all airplanes, I am telling you that. But Part 25 is getting the roll rate requirement. It is coming. They are critical in landing flap configuration. In fact their V_{MC} is a whole new ball game. With V_{MC} you can have a V_{MCL} which we didn't touch on. Some airplanes do have V_{MCL} already. They are actually defining V_{MCL} as the ability to do certain roll rates, so there is all kind of stuff coming.

MR. BOOTHE: Okay. Maybe we can pick it up there after lunch.

MR. BAKER: I wanted you to be aware of that.

MR. BOOTHE: Paul [Ray] needs to really be aware it sounds like some of the requirements that are already here may be addressed.

MR. BAKER: The Europeans may be ahead of you.

MR. BOOTHE: I like Tom's [Longridge] suggestion.

MR. LONGRIDGE: Reconvene at 1:00.

(Lunch break taken.)

MR. BOOTHE: Did we agree on roll response pretty much? We didn't quite have a concluding remark. My memory is that we would do known wheel or aileron controller input deflections using some sort of a stop mechanism to define the wheel deflection. And measure a bank angle to bank angle roll response assuring that that's a steady state response so we have got the transient and that would satisfy this requirement?

MR. RAY: Is it reasonable to add at that point to limit, maybe I shouldn't say limit. Perhaps less than half wheel deflection?

MR. WILLMOTT: My suggestion would be to make sure that the test is repetitive, is to put in a specified amount of wheel trim and then to release the wheel and that would normally be no more than if you used maximum trim, probably no more than halfway.

MR. SCHUELER: [AC120-]40B says about 30 percent.

MR. RAY: Right. You know where I'm leaning, isn't that a better validation as opposed to an absolute full wheel throw?

MR. BAILLIE: Yes.

MR. DAVIS: Yes.

MR. RAY: You want something to roll for 2.5 seconds, what does it prove? I understand it proves something.

MR. BOOTHE: That's important. Full wheel deflection is not a frequently used thing, although I've landed in crosswinds where I wish I had more. But Gerry [Baker] has brought up an important point, that maybe isn't something we write in here today, but commuter category airplanes in particular have roll, minimal roll requirements in some specified configurations, particularly with an engine inoperative. Did I say that correctly?

MR. BAKER: *(Nodding head.)*

MR. BOOTHE: While we aren't here to revise the simulator qualification standards in general today, I think that's something that I would recommend that Paul [Ray] take under consideration for the future, because if that's deemed necessary for airplane certification and roll is, we all know roll is limited in asymmetric low speed conditions, that that seems to me a critical point we would want to make sure the simulator did correctly. So I would like to recommend that for a--

MR. RAY: I agree.

MR. BOOTHE: --future consideration for the overall simulation requirement. Okay.

So we will move on, I have added the word stop, and wheel deflection stop here to be left to the ingenuity of the person developing the test procedure. But you have to have some defined way, or you could do it Stu's [Willmott] way, except you have got to--you have got to go a little past the bank you want to measure so you are out of the transient by the time you cross some point. Unless you can measure roll rate, then we would like to see the transient, so leave that to the testers, I guess.

MR. STOCKING: You'd better pass it.

MR. KOHLMAN: Don't we get the transient in the next one?

MR. BOOTHE: Yes, we do. Which brings up the next question, do we need to do both of those for Level B?

MR. KOHLMAN: Right. I think in one maneuver we do a step input like Stu [Willmott] is suggesting, you get the transient and steady state both.

MR. BOOTHE: Which means would we prefer then to retain 2.d.(3) and throw out 2.d.(2)? 2.d.(3) requires more instrumentation, but it gives you a much better result.

MR. HEFFLEY: Yes.

MR. BOOTHE: I spent 15 minutes before lunch for nothing?

MR. HEFFLEY: Yes.

MR. WILLMOTT: I never knew why 2.d.(3) became to be that. It used to always be the rollover, for [Level] B it was changed and I was never sure why, what really is the difference between 2 and 3?

MR. BOOTHE: A lot. Let me just say I did it and we will talk about it later because it's too much to add to this meeting. I really think 2.d.(3) is a more informative response and I would certainly choose that any day over 2.d.(2). If we think we can make money on a Level B by eliminating one I would go for eliminating 2.d.(2).

I see positive head shakes; are there any negative head shakes?

MR. HEFFLEY: I guess I wondered way back when whether the reason for these things, one was basically a maximum roll control power and the other was simply the roll transient response, roll trim, $L_{\delta a}$ and L_p.

MR. BOOTHE: That's what I envision 2.d.(3) to be, the latter thing that you mentioned, and the other one was pretty much a maximum roll rate.

MR. STOCKING: It's origin was in the TIR.

MR. BOOTHE: The question is, do we need them both? If we do the roll response to a reasonable size wheel input will we get a steady state of roll rate for the wheel input? That's not the maximum roll rate necessarily, so do we need that?

MR. DAVIS: Just keep in mind the roll response test calls for two configurations where the d., 2.d.(3) does not, so we have to cover that somehow. 2.d.(2) calls for approach and/or landing.

MR. RAY: 2.d.(3) is only one case. The recommendation would be to eliminate 2.d.(2), but add a cruise case. Right now we are running three cases, one for 2.d.(2) two for 2.d.(3). Eliminate one of those.

MR. BOOTHE: Okay. We will do that.

As far as instrumentation for the roll response to a stepped input, you have to have a time history to make any sense out of it, so I think we are stuck with an instrumentation requirement.

So we can move on to spiral stability. I've never liked the way we do spiral stability, but I won't tell you why until we discuss it. How important is it to you?

MR. HEFFLEY: Do you need to say how you should measure it? As Stu [Willmott] just mentioned here, it's something that can be altered depending on how you perform the maneuver. Spiral time constant is difficult to back out.

MR. WILLMOTT: I think its real purpose is to tell, to find out, whether the airplane has a tendency to roll further into a bank or to come out of a bank when a pilot is flying a bank in a simulator and that was its original purpose. But it's hard to set everything up symmetrically, so when you roll into the bank what you are measuring is how accurate you got it in trim in level flight, so it's usually good to do it in both directions.

MR. BOOTHE: Well, I think it needs to be convergent or divergent as the airplane is convergent or divergent. There is no arguments on that, and reasonably the same rate. But, to roll over 30 degrees and see what it does is not very meaningful to me. I've never been able to get that changed, but I would really rather see what the airplane does on its own when disturbed from level flight. But getting it disturbed sometimes--

MR. WILLMOTT: Thirty degrees is a typical bank angle that the transport category aircraft use when they are turning with passengers. So it's seeing what tendency the airplane has in that condition.

MR. BAILLIE: The test is probably more repeatable and less sensitive if you go to a lesser bank angle. Less sensitive.

MR. LEISTER: You need to do it in both directions, too.

MR. BAILLIE: Yes.

MR. SCHUELER: Particularly for a slip stream airplane.

MR. BOOTHE: Well, what I have suggested here is from a simplistic test point of view, in this case we could use a real watch that goes tick tick tick, this ought to be a slow response, ships calibrated instruments, some sort of crude resolution on attitude indicator which a person can really make up a scale and perhaps a video, and I think we ought to be able to get adequate results that way on spiral if we do it carefully.

Is there any objection to that technique?

MR. WILLMOTT: No. Not really.

MR. BOOTHE: Okay, gee.

It should be or--that's something a person could really measure by watching attitude, so--or engine inoperative trim. Again I just looked at adding some scales to the trim controls and doing a ground calibration of the surfaces, but we have already decided not to measure surfaces, so that's sort of redundant at this point.

It's a steady state condition that we are simply measuring what trim inputs are required to maintain the condition, so I think if we, if we add whatever scales are necessary and calibrate them for the trim controls, it's hard to make a general rule because airplanes vary a lot, but I think that could give adequate data for trim conditions.

Stewart [Baillie], you had some thoughts on that earlier.

MR. BAILLIE: Yes. You do a lot of trade-offs in OEI trims, we all know to get a zero heading rate state. And my suggestion originally was to acquire inertial measures and to match the accelerations and control inputs. That's a lot more detailed test than here.

MR. BOOTHE: Okay. You have to, if you don't mind, elaborate a little bit. I'm not with you.

MR. BAILLIE: Well, for a given steady state condition, asymmetric thrust, given that it is steady state matching the lateral acceleration and matching the control inputs. You are not measuring beta, but at least this way you have beta is implicitly then being matched.

MR. SMITH: You are verifying the trim. Verifying the steady state condition.

MR. BAILLIE: Yes. Well, it's an accelerated trim condition in that the lateral force is not zero, so you should probably be measuring those acceleration forces.

MR. WILLMOTT: The way that it would normally be run is that for this class of airplane you would zero the ball with the engine symmetric, which means it needs both rudder and aileron trim to do that, then you do the asymmetric engine, pull the engine back, zero the ball doing that. That means you have zero acceleration, so you are suggesting that you use an accelerometer laterally to give you a better ball centering capability.

MR. BAILLIE: Or accepting the fact in most cases the pilot may trim with a non-zero ball or may accept steady state flight with a non-zero ball. It doesn't matter if you have zero a_y or a measured a_y, so long as you matched a_y and a little bit of ball deflection can make a fairly big impact in where your rudder has to be. So measure it lateral acceleration rather than just zero.

MR. WILLMOTT: Is that the way you would normally fly, zeroing the ball?

MR. BAKER: Depends on where you are doing it at. What speed. What speed you are doing this at.

MR. WILLMOTT: Unspecified, I guess.

MR. STOCKING: Second segment and approach and landing low speed.

MR. BAKER: There is no certification requirement in trim the second segment.

MR. LEISTER: If you combine it with engine out climbs--

MR. BAKER: Something--heck, most airplanes will not trim at second segment. A Part 25 airplane has the same requirement to trim as a Part 23 airplane. Clean configuration. Second segment is not a requirement to trim to, most airplanes won't trim to it.

MR. BOOTHE: What should be there is measuring the required control forces rather than trim.

MR. BAKER: That's very well what it could be. You could have an airplane that you will not trim there.

MR. BAILLIE: So it becomes measuring controlled inputs to forces and lateral acceleration if you can't get the ball setting.

MR. BOOTHE: I guess--

MR. BAKER: We require climb performance to be demonstrated at first and second segments, beyond that it's--

MR. BAILLIE: There are lots of variables.

MR. BAKER: There are lots of variables.

MR. BAILLIE: What I was suggesting is a minor change in any variables can make a big difference in dynamics, so the trick is just rather than specifying that you must be exactly level, which is always difficult to achieve, specify that you must measure these things and just match all the measurements and you have done the same dynamic validation.

MR. BOOTHE: So what you are suggesting really is that we have an inertial system and a control, cockpit controller position, and force measures which drives this requirement up considerably. So let's see if we can get--

MR. BAILLIE: That's my role here.

MR. SMITH: Thank you.

MR. BOOTHE: But since only two guys are applauding each other, let's see what the rest of us think here.

MR. WILLMOTT: Engine out trim and engine out capability in the simulator in my experience is somewhat of a problem. In the Lear jet, for instance, with takeoff power and V_2 speed you need full rudder trim and you need pedal force, quite a lot of pedal force at lower speeds, and the pilots know about 170 knots they can do it all with just rudder trim. So it's a check for that type of characteristic. And I think the engine out trims that most of our simulator tests perform, we don't use full power, we use a condition where the pilot does not need force, so it's checking out the full trim capability.

MR. BOOTHE: Do we need to go to the instrumentation level that Stewart [Baillie] is suggesting, though, or do--or are we content to measure just the trim positions and not measure the acceleration?

MR. WILLMOTT: Well, bearing in mind that we are trying to make this simpler to do, I would suggest that we do it where you can basically use the cockpit instrumentation. You use the trim controls and you use the ball. And you do it at a speed whereby the trim capability will be able to give you zero ball. Which, you know, is very easy to set up in the airplane.

MR. BOOTHE: I think by silence you are outvoted, Stewart [Baillie].

MR. BAILLIE: Okay. I don't mind being outvoted, I'm just raising the questions.

MR. RAY: I think it's probably more repeatable.

MR. WILLMOTT: I keep thinking back to our basic purpose. We definitely need really good instrumentation for [Level] C and D devices, but again there are lots and lots of tests that the pilot can perform at a Level 3, 4, 5, 6 device, we are talking about a Level B that is somewhere in between in sophistication and I think doing a simple test like that is adequate for this level of simulation.

MR. LEISTER: Which is this test in the ATG, then?

MR. WILLMOTT: I'm sorry?

MR. LEISTER: Why is a simulator required to do this?

MR. RAY: It's a validation really of what the pilot would need for training. What's a better validation? I tend to agree with Stewart [Baillie].

MR. LEISTER: Well, yes.

MR. RAY: The force, position of controls is a much better validation I think. You can get too many, I shouldn't say too many, other variables in it, such as the accuracy of the slip indicator and the control assembly. We all know the difficulties of the accuracy of the trim indicator in the cockpit. Measuring the force and the controls in the airplane, matching that in a sim, I believe is considerably more valid.

MR. LEISTER: The pilot is not going to be flying at a speed where he doesn't need any additional input, on some airplanes he is going to be flying at speeds where he is trying to climb out and get away, he is trying to trim an engine out at best climb speed probably, that's probably going to require additional input.

MR. WILLMOTT: We are also doing circuits with engine out as part of the training engine failure at takeoff, leveling off, circling and, coming back and doing the landing. This is a check that you can use for the trimming required in the circuit. And we are already doing, as you said, an engine out rate of climb, although I guess we are doing that from the flight manual, so I better be careful.

But you are checking the capability of the simulated airplane to be able to trim out, you know, full engine power condition in your climbs.

MR. BOOTHE: Keeping in mind the objectives that you acknowledged as well, I'm content to leave that like it is, while I totally agree with Stewart [Baillie], if we wanted to get a better measurement he has certainly outlined a way that's certainly an improvement over what's here. But keeping in mind we are trying to find a way to validate something at a lower cost, which is as I said earlier, Dave Kohlman reminded me it may not be the same fidelity as a Level C simulator.

So I think I will leave that one and move on to the next two, which are rudder response and Dutch roll, both of which require rather significant instrumentation to get any reasonable result from them. On the rudder response I would say that we should measure the cockpit or the rudder pedal position or the rudder pedal input. We have to know that, otherwise we don't know what we are measuring.

And on the Dutch roll, I don't see that we do anything differently, I don't know that we need to measure--if we measure rudder response and measure the rudder pedal input, the Dutch roll then is an open loop response and we don't need to know the input if we are only interested in the Dutch roll response.

MR. NEVILLE: Is there any reason those two tests couldn't be combined? You excite the Dutch roll with rudder input anyway, so you get rudder response in a Dutch roll test.

MR. BOOTHE: I see no reason why you can't. You could still cull them out separately if you needed to, but in fact I don't see why you couldn't do one test and get both outputs.

MR. SMITH: Typically they are done differently, rudder response and the Dutch roll--the rudder response you put the rudder in and hold it, whereas the Dutch roll you do it with a doublet, typically. If it's a free response here again--

MR. BOOTHE: True.

MR. SMITH: --you need the rudder positioning.

MR. BOOTHE: But the first half of the doublet input when I push the rudder and I see the response I can continue the doublet and get a free response. I'm only interested in the initial response for the rudder after a brief transient there is other stuff going on.

MR. KOHLMAN: I think you are measuring the same things two different ways. You do a pure rudder response to hold the step in and you will get both the yaw and the $C_{L\beta}$ pretty clearly. And if you do--sometimes we will do the Dutch roll with a cross control and get it out there to a nice big sideslip, then release and that will get your Dutch roll, which gets the dynamics plus a number of other derivatives.

MR. BOOTHE: In which case you would not combine them.

MR. KOHLMAN: That's right.

MR. NEVILLE: For the response to a steady rudder input you get that in the sideslip.

MR. KOHLMAN: You do get a lot of overlap here, if you do cross control steady sideslip then you are getting $C_{L\beta}$, aileron power, rudder power. All of those.

MR. BOOTHE: Okay. I think the answer is yes. We can leave them as separate responses. But I have seen on a number of occasions where people have used the same test to demonstrate both effects. And I don't think there is a problem with that. To me the rudder response, if I'm just interested in rudder response, and it's a real short period, if I'm interested in the subsequent effects that Dave [Kohlman] described, then I definitely need a rudder step input to get that. So what are we interested in, I guess is the question?

And if it's just the initial response to rudder, you can combine them. But for our purpose I would just leave them as they are because in either case we need to instrument the airplane or we get nothing.

MR. WILLMOTT: Right.

MR. BOOTHE: That's really the cost driver.

MR. KOHLMAN: I can certainly see somebody taking the first second or two of Dutch roll initiation saying let's match the rates and accelerations, that will satisfy that condition.

MR. BOOTHE: I have seen that done. For better or worse.

MR. ELLIS: You can also excite it with an aileron, too. Look at some other.

MR. RAY: Could that comment on the Dutch roll for larger airplanes "it might be possible to," et cetera, could that be misleading? Do you leave that in there? Under Dutch roll it says "strap-down inertial system," the latter part of that first sentence, because we know what that means.

MR. BOOTHE: That's stretching it a bit, I guess. Keep in mind I was trying to pull out every thought I could to see how could I do this cheaper?

MR. RAY: Agreed. I just recommend striking that part.

MR. BOOTHE: Okay.

MR. SMITH: I'm not sure we don't need the rudder position, because like the phugoid with a reversible control system, the response can be different.

MR. RAY: That's true, it can. We talked about that earlier. I think the fidelity of that maneuver is based upon the premise to all this that we would not have rudder position for any of this.

MR. SMITH: Control. I mean rudder control pedal.

MR. RAY: I think that's embedded in this.

MR. SMITH: Okay.

MR. BOOTHE: Could be, but it's not showing other than verification of the flight condition and test, it's not something that is mentioned in the Advisory Circular. And I don't think the rudder is--well, to do this you ought to have a rudder deflection, what's going to be important about rudder on most airplanes other than the float.

MR. LEISTER: I will tell you this, to build a solid model you need the rudder pedal input position. But this is modeled.

MR. BOOTHE: For rudder response definitely the input, but for Dutch roll?

MR. LEISTER: For Dutch roll you need it. You literally can derive seven derivatives from a Dutch roll test alone.

MR. DAVIS: Those are validation, though.

MR. LEISTER: No, for a model.

MR. BOOTHE: We are going to--

MR. LEISTER: The response you are going to get are about the same with any kind of rudder.

MR. SMITH: I think you need it, though. Especially since we backed off on roll response, I think we need it.

MR. WILLMOTT: Suggestion, Ed [Boothe], for consideration for simplicity. Where you can combine the Dutch roll and the rudder instead of input you trim the airplane up for level flight zero ball, you then do a test similar to what I was suggesting for the wheel. In other words, you hold the rudder pedals where they are, you put in an amount of rudder trim. Then when you are ready, take your feet off the pedal, that gives you the step input of rudder and also excites the Dutch roll.

I guess you are not quite sure how much banking that you are going to get when you do that, you have to select a rudder trim input that would give you a satisfactory bank.

MR. BOOTHE: Well, it excites an asymmetric Dutch roll, which you can deal with.

MR. SMITH: But you are not going to save anything, I don't think.

MR. LEISTER: In a prop airplane I recently worked on we had a pretty large input of rudder, it rolled over very smoothly, no Dutch roll that you could tell. That may not be applicable to all planes, I don't know.

MR. STOCKING: We need stabilizing gyros.

MR. BOOTHE: I tell you, gentlemen, in the interest of time what I would like to do, if we could come back to steady state sideslip, if we can. Normal landing, cross landing, inoperative landing, all are fully instrumented events. I don't know how to make that any simpler or cheaper, except to remove angle of attack and sideslip, which we have already done, and say we will measure cockpit controllers instead of surfaces, which gets us to, I think, probably an important area of ground effect.

I would like to spend a little time on ground effect, then I would like to spend some time on this broader issue of predicted data and see if we can't also discuss costs a little bit. So could we just skip to ground effect for now and I guess there is lots of ways to do ground effect, but what is a recommended, a recommended alternative for us? For this application? And how can we minimize instrumentation? Again, remember now we have already said angle of attack is out, and with angle of attack out of the picture, we have to do something neat here. I don't quite know what it is.

MR. SMITH: If these are level flybys, I think it would be acceptable to compute it from data, pitch angle.

MR. BOOTHE: That takes--that would be acceptable, but that's a Level D technique and--it's not a Level D technique, it's a Level D requirement. But is there an easier and simpler and cheaper way?

MR. HEFFLEY: Ed [Boothe], I guess the most effective thing I've seen for this sort of an airplane or something where you really have a lot of power lift effect, are these constant attitude approaches all the way down, the very shallow approach, all the way down to the point of nosewheel contact, but you need, you need precise h and h-dot measurement to really make sense out of it. And given that you know you--I guess radar altimeter--

MR. BOOTHE: Is that high enough resolution to get what we need?

MR. ELLIS: We have one, it was really good.

MR. BOOTHE: Was it high enough resolution?

MR. ELLIS: Yes.

MR. BOOTHE: Is the standard installation on an airplane these days high enough resolution--you had a special one, didn't you?

MR. ELLIS: No, it was pretty standard. There was a Honeywell which had been around for some years, it was a standard on P-3s, I think. But we got convinced that it was very accurate down to just a matter of a few feet.

MR. BOOTHE: You could extract rate from it?

MR. ELLIS: Yes.

MR. HEFFLEY: Are you suggesting a baro-altimeter?

MR. BOOTHE: I don't think we could get much with a baro-altimeter.

MR. HEFFLEY: I was just wondering.

MR. WILLMOTT: There are changes in the pitot static errors going into ground effect and you can't rely on the pressure altimeter. I was going to suggest essentially the same thing that we did in the original landing maneuver approval, which is to fly an approach with as low a rate of descent as you can, so you give as long a time as possible to see what the ground effect does to the airplane.

MR. LEISTER: Hands-on.

MR. WILLMOTT: It was called hands-off and I think because it was called hands-off that scared everybody off that test, but it's a real low rate of descent approach, so you get into ground effect and you are giving the ground effect time to do something to the airplane that you can see.

MR. LEISTER: Right.

MR. WILLMOTT: In the case of the 727, when we first did that when it got into ground effect, we came in at 250 feet per minute, it pitched down very strongly and it would rise out of the ground effect and it continually did a phugoid and it never touched the ground.

MR. BOOTHE: Most of them I saw suffered from pilot intervention, that there wasn't much there. Probably with good reason.

MR. HEFFLEY: The one effective one I saw was from the Bréguet 941. It was flown with attitude-hold autopilot on. The pilot in effect was out of the loop except for being close to the controls, and it was flown at a very, very shallow pitch attitude. You got very good resolution of what was happening with the pitch controls (the elevator) as well as what was happening to the flight path. Therefore you measured both pitching moment and lift ground effect with good resolution.

MR. BOOTHE: The ground effect can be so subtle, and we have already thrown out elevator measurements here, it seems to me we need a measurement of control deflection somehow.

MR. HEFFLEY: If you want pitching moment, yes.

MR. BAILLIE: I think you are going to have to measure the inertial parameters plus perhaps a radio altimeter plus column as a minimum, to get any description of the ground effect. And the idea of a reduced rate approach you are already at some level validating ground effect in each of your approaches. Already having a markedly different descent rate gives you another point to validate ground effect, not the only point but another point.

MR. WILLMOTT: Of course if you do what Bob [Heffley] is saying, you have to measure the elevator surface anyway.

MR. HEFFLEY: Yes.

MR. BOOTHE: Okay. So we need a radio altitude, a radio altitude rate. You say we need inertial measurements so we have a full blown, fully instrumented test.

MR. BAILLIE: It's another landing, just a reduced rate landing.

MR. SCHUELER: Then it doesn't matter if you do flybys or shallow approaches, whichever technique.

MR. KOHLMAN: It really doesn't. The problem with constant attitude approach is you are changing ground effect during the ground effect event. The way we derive ground effect is do a constant angle of attack approach. The pilot is monitoring angle of attack.

MR. HEFFLEY: Pilot tracking angle of attack?

MR. KOHLMAN: Yes.

MR. BAILLIE: I wasn't suggesting constant pitch attitude or angle of attack, I was saying set up and do an approach. A pilot control intervention is part of it. But you are going to go through ground effect at a different rate than you do in a normal three degree approach, and to match the control inputs and angular rates of both that maneuver and a standard approach maneuver means you need a ground effect model. Because you have got a different onset--

MR. HEFFLEY: Aren't all these techniques more or less equivalent from the standpoint they all expose ground effect, they all pretty much require these basic measurements?

MR. SCHUELER: You can look at the changes in the airplane trim or whatever you want to call it, through that transition with any of the approaches. But you need the instrumentation.

MR. KOHLMAN: If we have one test really looking at ground effect rather than landing and takeoffs it would be better to limit the number of variables as much as possible. You are not going to have angle of attack, but I like Bob's [Heffley] suggestion, constant attitude.

Because as you were saying, Ed [Boothe], the effects are very subtle, if you put some controls in there we just may blank out or at least overwhelm the small changes we are looking for. If you hold constant attitude ground effect is going to--

MR. HEFFLEY: Let me add that by holding constant pitch attitude you have something that's inherently a bit easier to be flown manually.

MR. KOHLMAN: You should hold constant elevator, keep the wings level.

MR. HEFFLEY: Of course you can do that, too. Again, all of these are essentially equivalent if in fact you are matching the states.

MR. NEVILLE: Ed [Boothe], you mentioned the level flight flybys are a Level D requirement. But there is no reason they couldn't be used for Level B.

MR. BOOTHE: Absolutely not.

MR. NEVILLE: The way it's described in the AC it says "a test." You can show an acceptable ground-effect test, including flybys. There has to be more than one test, one near the ground, one at an intermediate height, and one in free air. You don't need angle of attack. If you get rid of the flare problem--

MR. BOOTHE: You still need the instrumentation?

MR. HEFFLEY: Yes.

MR. NEVILLE: Do you need as much?

MR. SCHUELER: Whichever technique you use you need instrumentation.

MR. BOOTHE: We've eliminated angle of attack.

MR. KOHLMAN: Still it's our most instrumented low cost Level B, which is inertial and control and control forces.

MR. BOOTHE: We need those. That's more or less a conclusion, not necessarily the one I was looking for, but the kind of conclusion I'm looking for, we can't cheapen this test, because it's--I mean, that's the very reason we are talking about Level B for Tom's [Longridge] application and we have to land and we have got to do in ground effect maneuvers. And I think it's important to do that right. So I think we arrive at Dave's [Kohlman] conclusion, we have to instrument pretty much completely with the exception of angle of attack, which if you did level flybys of course you've got that involved. All right?

So we will just leave that technique as you want the instrumentation will be required, write it up that way. Back to [AC120-]40B.

MR. WILLMOTT: A test to demonstrate longitudinal ground effect. The words in 40B.

MR. BOOTHE: We skipped a couple of things kind of lightly here. I would like to leave them for the moment. One of the considerations for Level B to present a lower cost simulator from the point of the aeromodel was to consider the use of predicted data by whatever means, but to me that means any data short of being like validated.

You know where you get predicted data better than I know where you get it. Couldn't we take the approach to a Level B simulator which we could do the aerodynamic program with predictive data and eliminate some of the cost associated with the flight tests? When I say validation, I have to watch my words, put simulator validation aside for a moment, couldn't we get a good enough simulator in Level B for doing a pilot recurrency check without doing initial training in it, programmed with predicted data, with validations of the kind that we have been talking about, or could we not, I guess is the first question?

MR. LEISTER: I would just like to say that 20 years ago or 15 years ago that's exactly what happened, people took predicted aircraft data and put it in a simulator and the simulator didn't fly like the airplane for some reason.

MR. BOOTHE: Like some reason?

MR. LEISTER: For a lot of reasons. Making a model work in a simulator is a game with very, very small numbers. And predicted data just is not that good. I wish it were. I could build models at home with my PC and then take them outside and make them work, but they don't work that well. So I don't think you can, but Mr. Stocking is going to tell us.

MR. STOCKING: What I said yesterday about the change that we have in computer capacity now. I can now implement DATCOM and turn it into a simulator program which has about ten times the number of variables, the complexity as the models that we had 20 years ago. As long as you take advantage of that change in 20 years, there is no question in my mind whatsoever that we can meet that objective. It's just how much time is going to be allocated to the particular device to do it?

The only way I can see to do that is to spread the cost of development of these larger models over a number of devices. And you can do that by making programs more generic, then populating it with the type of data that you need to do that. So regulating that or guaranteeing that you have that type of model in place really is the question. And I don't know how to do that.

MR. RAY: If I could interject, Ed [Boothe], the question is potentially not can it be done, but who can do it?

MR. SMITH: And has it been done?

MR. STOCKING: I have done the concept on a lower device. I have not done this with a higher device.

MR. BOOTHE: But the device you did, did it require validation to some set of validation parameters?

MR. STOCKING: Absolutely, yes. I had to go out--as a matter of fact, I did far more than what's required under the regulation as a proof of concept.

MR. NEVILLE: So was it altered based on flight data? I mean you started out with a DATCOM derived model.

MR. STOCKING: But the DATCOM got me within one and a half degrees of elevated trim tab, for example, I tweaked it the rest of the way.

MR. NEVILLE: It wasn't--the end result was not purely predicted data, it was--

MR. STOCKING: No. The end result was a validated model. I started with a predicted.

MR. RAY: But it's a subset of what we just went through.

MR. LEISTER: You still had to tweak, though.

MR. STOCKING: Yes.

MR. KOHLMAN: I agree with Chuck [Stocking]. With the sophistication that we have now and the computer programs plus the increasing database that we have, with a great many Level C and D packages of various airplanes, whatever configuration we want to simulate, I think you can get reasonably close with a predictive model. Then we are going to have to do a flight test for the validation data, and with a great many of these validation tests I can extract stability derivatives and aerodynamic coefficients to help me fine tune that predictive model to the point where then a program of fine tuning will get me within the Level B requirements.

MR. LEISTER: That's not different from what we are doing right now. What I do, anyhow.

MR. BOOTHE: In that process have we eliminated cost factor?

MR. KOHLMAN: What we eliminated is 30, 40, 50 hours of flight testing to get parameter identification data and all of the heavily instrumented data we are using to build Level C models now. We eliminated flight testing as well as a substantial amount of instrumentation.

MR. BOOTHE: Not to put you on the spot, which I seem to often do, what sort of cost increment in the overall data package would you guess we are eliminating by this?

MR. KOHLMAN: This is just a very broad guess, but I would say you are eliminating 50 percent of your flight test time to begin with. You're eliminating a pretty large amount of your analysis time that is spent doing a very detailed parameter identification matching program, and extracting a lot of data from flight test that you would instead do with a predictive program. And you replace some flight test analysis with predicted analysis.

But you are looking at not trivial savings in your initial costs getting a model ready for validation.

MR. DAVIS: I would ballpark it at about a half million dollars. A half million is a ballpark figure.

MR. KOHLMAN: That's certainly a reasonable order of magnitude, in my estimation.

MR. BOOTHE: I see Stewart [Baillie] wincing and grinning.

MR. BAILLIE: The only danger I see--I agree with Dave [Kohlman] and Tom [Davis] that you could save based on the instrumentation that we have discussed for these tests and a reduction in the extent of flight test you could save that order of magnitude. The danger is, not that Chuck [Stocking] would do it, but someone else will, they will come up to developing a model that the only real data that they have used are those tests. And the question has to be is how is the FAA going to determine whether that is sufficient?

MR. RAY: I appreciate you saying that. It goes back to what we are attempting to do in the case of the Boeing 737-6[00], -7[00], -800 family of airplanes. In a reduced set of data for the 6[00] and 800 we hope we can, at least we are going to try. The international community has gotten together under the auspices of the Royal Aeronautical Society and put together a fence. I call it a fence for lack of a better term, which says if you do this then you may be able to do that. I think that's what I hear Stewart [Baillie] saying.

And the feeling I'm getting from Dave [Kohlman] and also from Chuck [Stocking] is that, is it reasonable for someone to come to a regulator, whether us or the MoT or CAA or JAA, for that matter, and present your case, that based on this process that we have agreed upon to get to the point that Dave [Kohlman] is with his program with Stewart's [Baillie] approach and meet acceptable standards. I believe you will be able to do this. Is that a reasonable approach?

MR. HEFFLEY: Are you suggesting that that mitigates or that takes the place or that removes the requirement for some of this validation data?

MR. RAY: No. We are saying it may succeed in eliminating what Dave [Kohlman] mentioned as far as all the additional flight tests that they would need to do to acquire sufficient data to build their model from scratch.

MR. HEFFLEY: So you are suggesting some sort of a requirement for a credible modeling approach. You want to know, you all want to know what the basis is for this math model along with the validation test points.

MR. RAY: I believe that's what I said.

MR. KOHLMAN: That is what is done today for Level C and D or do you, rather, even though you know how we get the data, come in and look at the simulator, make sure the test guide data was obtained in the proper manner from the proper airplane and if those all come together, then the stamp of approval is given without sitting in on the model data analysis gathering process or analysis process. Are we doing something that isn't done for C and D at this point?

MR. BAILLIE: I would say what you have done, though, is you have brought down the cost of flight test, so whereas before people that got in this game had the capital invested so they would do the well-founded development, now you brought it down to a cost level where maybe the guys that aren't going to do the well-founded development can get in the ball game.

I think the--I like the concept of if this is the only aircraft data involved, which it could be in a lot of cases, I think either having a description of how the model was developed or making sure that the guys don't tweak the model to this until you are involved. Like if you--it's the classic case of a seventh order curve with seven test points. And both of those are an increase in the requirement, I'm aware of that. But I think if you are going to deal with an unknown model that just comes and meets these, you are going to have a problem unless you somehow understand how the model was built.

MR. DAVIS: I think that's a fair compromise. All that's being said, we will let you get away with doing all this testing but tell us how the model came about. Versus Level D, they don't ask for that but you go a hell of a lot farther in terms of proving objectively it meets the level of the airplane. It's a fair compromise.

MR. LEISTER: You are speaking as though the approval test guide, those tests are the whole story.

MR. DAVIS: It may be, though.

MR. LEISTER: The subjective part is a very big part.

MR. RAY: That's true.

MR. LEISTER: You can't make the simulator fly well if you don't do your job up front. I've actually wondered why you guys haven't asked in the past just what model you are using in the simulators, I have seen some crude simulators that doesn't re--

MR. RAY: We have too.

MR. KOHLMAN: This is not the sole source of in-flight data. We have talked about the flight manual, certification testing, TIR; if we have access to those, certainly I'm going to use those as part of my predictive model. It's not as if this is a skimpy amount of data.

MR. LEISTER: I think it would be difficult to build a model based on those tests. I don't know how you could do that.

MR. DAVIS: Well, with something like that DATCOM you can get pretty close. Those tools, AAA, DATCOM, whatever you want.

MR. STOCKING: I bet a poor model wouldn't get certified.

MR. BOOTHE: Let me see if we understand this. Are you suggesting that you would develop a model based on DATCOM and other predictive techniques, whatever that might be?

MR. KOHLMAN: Data from whatever source you are going to get it.

MR. BOOTHE: Then having developed the model you would do flight testing to acquire the types of validation data that we need for validation and you might also collect--not everybody can collect parameter identification data and do something with it. Did you indicate that you would also collect parameter identification data with this qualification data?

MR. KOHLMAN: No. What I'm saying is each one of these tests that are test guide type points have enough data in them that I can extract some derivatives, for instance steady state cross controls. You can extract quite a bit of information. The trim points, you can extract a lot of information. And I don't want to get the cart before the horse, if I'm doing this job I'm going to do these flight tests very early in the game and I will probably add some additional points with this minimally instrumented airplane. That gives me other isolated data points and derivatives that help me fine tune a DATCOM type model much closer to the final product.

MR. BOOTHE: Okay. So what is the danger or the risk of winding up with a predicted model that is kludged to fit the validation points and maybe erroneous in other parts of the envelope if you do this any more than we have now?

MR. KOHLMAN: The danger is you will match all the data points and the pilot who comes in to evaluate says yes, it trims fine right here but ten knots higher it's not anything like the airplane; or you do a maneuver and the pilot says this doesn't fly like the airplane. That's the danger.

MR. BOOTHE: So we are really placing then a greater reliance on some subjective evaluations instead of we are now relying on them, or are we?

MR. KOHLMAN: I don't think so. I don't see how you can build a model that doesn't use standard equations and aerodynamic components. I don't see how you can do that. That's why it may be a misplaced faith that I have, but I think if you are able to match this many test guide points with a model that has all of the standard mathematical components that we are using today, that it's going to fly in the rest of the envelope in a proper manner. Even when we have these $500,000 flight test programs and then we deliver them to SimuFlite or Flight Safety there is fine tuning that goes on; they still have to adjust and tweak the model. So the process is no different.

MR. BOOTHE: Except we have skipped some portion of the flight testing that seems to be a high dollar.

MR. BAILLIE: We skipped all the tricky installations, we no longer have oleo, you no longer have string test, you no longer have all the things that make the last increment on the fidelity.

MR. BOOTHE: Bob [Heffley] was trying to say something for 15 minutes.

MR. HEFFLEY: It's been changing from minute to minute. The one thing, Ed [Boothe], I don't see what the increased risk is here over how it's been done in the past. And some of these things that Stewart [Baillie] just mentioned in terms of the little finishing touches are things that I guess I really believe are pretty much invisible, or at least very difficult to see from the standpoint of a pilot in the simulator unless you are using the same basic list of validation requirements. And I think in all the discussion we have had, we kept coming back around to the point where there we really didn't make any real compromises in the quality of the data that are being gathered here. In the final analysis really I don't see where there have been real compromises in the quality of the data.

MR. BOOTHE: You mean the validation data?

MR. HEFFLEY: The validation data.

MR. BOOTHE: I don't either, we didn't simplify a lot.

MR. HEFFLEY: Yes. So you wind up really where you were except for the fact that now we are talking about maybe some additional offerings of words on approach used for the math modeling to make the FAA feel better about the quality of the basic math model, which is something that apparently has not really been subject to much question.

MR. BOOTHE: The math model has not been subject to question. In fact I often used the expression when I was there we really didn't look behind the curtain. I still, in terms of what kind of instruments were behind the instrument panel, I never really cared as long as they looked right and worked right. And I never looked behind the curtain of modeling as long as the validation and the test guide demonstrated what we asked. I mean, that was really all we asked. So I don't see that difference, either.

But I think there was always some comfort factor in having some idea that people were doing a considerable amount of flight testing and were adjusting their models to meet that flight testing over and above the validation tests that the FAA asked for. But when looking at this from a perspective now of a regional airline who is training in the airplane, while I don't think we should make an impulsive step here, I think we need to find out how to do this, maybe even figure out how to do a trial run somewhere.

I cut you off Hilton [Smith], I'm sorry.

MR. SMITH: That's okay.

MR. BOOTHE: You had something you wanted to say?

MR. SMITH: It seems like we came up with a whole other question. I believe what Paul [Ray] was saying, yes, we might do this if. My opinion is that if we, you know, now we don't really look at the model, like you say, but the advice is to use flight test data to program a simulator. However, we take that away and just don't say what is used to program the simulator. I think we [have] got to have validation data according to [AC120-]40B requirements.

MR. BOOTHE: We have almost wound up at that point, not quite.

MR. SMITH: I mean, I admit that we struck out alpha and beta, which we can do, but then everything else has to be rigorous because you are then relying on all the other measurements to derive those. And there is no question about it. I have seen the quality of data go all the way from aircraft manufacturer data down to--I remember questioning an operator about some questionable buffet data for a Level D machine, he finally admitted they went out and obtained it in a thunder storm.

MR. BOOTHE: Warped buffet data.

MR. SMITH: It was that. There is data and there is data and there is data.

MR. BOOTHE: No, I don't think anybody here is suggesting any degradation in data integrity, now we all know there are people out there who would.

MR. SMITH: No.

MR. BOOTHE: That's just real world. But I think--I mean, I'm also--I think we have been aware that at least in my experience I never saw much work without a lot of inputs from the artist of their dynamics. And I think it's still at that state. You can do all the drilling of the coefficients in your equations that you want the first time, but the aerodynamic artist has to operate with those to meet the conditions.

If you know better than that, I want to patent it, maybe we can get a co-agreement here. But if this has an opportunity to or this presents an opportunity to lower the cost of the simulator from the aerodynamic program perspective by as much as I thought I don't know if you meant Canadian dollars or American dollars, but in either case it's a bunch of money. It's a lot of money. And shouldn't we somehow try this out? And so then how do we do that? I don't know how we do that. But somehow it seems to me we should be able to get our heads together and come up with a definitive plan on paper, here is how we are going to program the simulator, here is how we adjust the parameters, here is how we validate it, here is the validation data we are going to collect and we are going to try it out on this device. That's what I would like to see happen. And that's a test concept, that doesn't mean that it couldn't be abused, but we have to work with that.

MR. LEISTER: I just don't think there are good predictive models for a lot of things. These little prop jobs I'm working on, there is no method, it wouldn't do any good at all to sit for hours and try to come up with a predicted model for a prop type airplane because we just don't know the prop that well. I can take a 747 model and start and build any kind of model you want out of it. It just doesn't matter what you start with, really.

MR. SCHUELER: What prevents me from going out and taking a predictive approach today? There is nothing that prevents me from doing that other than my engineering judgment or someone's engineering judgment that that's not the best or the safest approach.

MR. STOCKING: That has been done. McDonnell-Douglas on the DC series aircraft uses an all predictive model.

MR. SCHUELER: There is nothing here that says I can't do that today for a Level D device.

MR. SMITH: Well, I think it--you are encouraged to use flight test data, it's indicated that you can use some predicted but I think you are encouraged to use flight test data.

MR. SCHUELER: Not for modeling.

MR. RAY: Not for modeling.

MR. SCHUELER: As long as I provide flight test data to fulfill the validation tests--

MR. RAY: Correct.

MR. SCHUELER: --for a Level D device, I can come up with a model any way I want to.

MR. RAY: Very true.

MR. KOHLMAN: If we get into the situation of the FAA wanting to somehow approve, and I'm not sure how you write the specifications for that, how the model was developed, where it came from, how you came across all this nice data, then you are faced with the situation of somebody, just as a hypothetical case, inviting you in to approve a simulator. And they show you all of the flight test data, maybe invite you to participate in the test guide flight test data and it meets all of the requirements within the tolerances and the FAA sends its best pilot to evaluate the simulator and it flies great.

But then you say, just for my comfort I want to know how you got this model, where did it come from? And the guy says you can't see behind the curtain, it's proprietary, I don't want you to know how I got it. You say well, if you are not going to show me, I'm not going to approve your simulator. I think that puts the FAA in a very difficult position.

MR. RAY: As far as the sequence, it would never occur that way. It's backwards. Before anybody came in--

MR. BOOTHE: I don't work there anymore.

MR. RAY: It would be in the initial application that you come up with your approach had you never done this before. That gets back to the B-737 process we developed. You have to have been there before you can get there now, really. In a nutshell. But it's a front end, you come in and make your case for presenting this simulator based upon something. Explain how you got from the conceptual idea to where you want to go with it.

MR. BOOTHE: Stewart [Baillie]?

MR. BAILLIE: We have spent two days in detailed discussions about particular minimum sensors for a given test. Perhaps one thing that should be done by this group is to take an existing simulator that's out there, approach the company that owns it, and with them get the minimum Level B data package so even though you have got a tremendous wealth of information, only give, for instance, the period and damping of the phugoid, only develop this minimum ATG case. And then regardless of this, go through it page by page and say is this enough? As a second look at this. Because we have gone back and forth through a lot of the tests but until you pull it all together I might not really understand the depth that you validate. I think we have probably validated more than I personally think we have. If that makes sense.

MR. BOOTHE: Maybe. But it's break time, so let me just--if we were to follow the scheme that Dave Kohlman outlined, you yourself have said we could save an awful lot on instrumentation and flight time, it seems to be the major area of cost reduction. And if we can get to the same end by doing that, then I don't have a means to try this out, but I think somebody ought--we ought to figure out how to do that. Because while I know we have discomfort right now, I can see the discomfort on Hilton's [Smith] face. And doubts in the room. I think that that's not unusual. I think we need to really consider this, and if there are those kinds of savings that you are describing, that can go a long way towards getting these folks out of airplanes and into simulators if it works. I'd be really thrilled to see something like that happen. I don't know what the next step is, but I think having that conclusion is really something I'm happy about right at the moment.

MR. KOHLMAN: I want to say, just to make it clear, I don't question or disagree with the policy or the desire of the FAA to have a comfort level about what this model is built of. Because that's reasonable. I have trouble understanding how we are going to define how you get the comfort level you need and how you define that you are at that comfort level.

But I have had the experience myself of going into a simulator of a prominent manufacturer of lower level simulators. I think it was a Seneca, and it flew really great, it was nice. But then I did the Kohlman test on it, I rolled it 90 degrees and I was able to hold altitude and air speed just fine. That told me there is something wrong with that model or the equations of motion.

MR. SMITH: I'd like to ask Dave [Kohlman] one thing that really, I've heard some numbers like, when you do a flight test program a certain percentage is for modeling data and a certain percentage is for validation data. What would be the effect on the half million dollars cost savings we talked about here if you just got 40B validation data and like you said, no modeling data, but just say 40B validation data as opposed to what we discussed here?

MR. KOHLMAN: I'm going to kick that over to Daryl [Schueler]. I think he has a better handle on it in recent tests than I do.

MR. SCHUELER: Test guide maneuvers are probably on the order of a third of the testing that would be accomplished. You could typically accomplish, if you are reasonably aggressive, the full set of data for Level D in no more than three calendar weeks. Two calendar weeks for instrumentation. For Level D.

MR. KOHLMAN: Right. But that's of course after you already have a fully instrumented airplane.

MR. SCHUELER: No, two weeks instrument, two, two and a half weeks is doable. It's aggressive but it's doable. So maybe you cut airplane time down to three weeks from five weeks, I don't know.

MR. DAVIS: You go back to Stewart's [Baillie] original slide from the first day.

MR. BAILLIE: The IQTG for a simulator company that will remain nameless took six weeks of aircraft time. Nine days was flying, the rest was instrumentation.

MR. SMITH: That was validation data.

MR. BAILLIE: That's all that was. The addition of modeling is usually seven hundred 3211 inputs. [That] is the only difference. [That] is basically what we have been doing; that's a week of flying.

MR. SCHUELER: You can come up with it [in] different ways, you know different sets of maneuvers, a little bit different time for instrumentation. I don't agree completely on which ones are difficult parameters, which ones are easy ones, but the numbers are in the right ballpark. So if you pull out--if you reduce five to six weeks of airplane time down to three weeks, you know, maybe.

MR. BAILLIE: I think the saving here has been that the modeling, the flight test for modeling per se, a lot of it doesn't add much more flight time. But it--it's the instrumentation of the subtleties in the aircraft and the instrumentation to meet the requirements of the [AC120-]40B test maneuvers that add the biggest chunk of time to a flight test program.

MR. SMITH: Isn't the quality of the data directly proportional to the quality of the instrumentation?

MR. BAILLIE: I am saying that--no. I am saying that if you need oleo displacement it's going to take time. If you don't need it, it's not a quality issue, it's just either you have it or you don't.

MR. BOOTHE: Can we--that's something I want to mention, anyway. Can we pick that up after a ten-minute break?

MR. LONGRIDGE: Let's just take ten minutes. We are going to break at 3:30, so we need to get started again in about ten minutes.

(Break taken.)

MR. BOOTHE: Sorry to rudely yank you back to your seats, but unfortunately time comes marching in and we promised you would be out of here by 3:30 so you could connect with your flights back to California and places like that.

I think that last discussion that led us up to an approach to modeling and validation that promises significant cost reduction is a very important result of our being here for these two days. I know that's not what we spent most of the time on, but we, in deciding what to discuss first, thought that the FAA has a much larger influence over the validation than they do modeling and we ought to get through the validation stuff.

But I think the big payoff might be in what we just discussed the last hour. And I'd like to extend that a little bit. One thing I would like to ask, would all the discussion we did on the validation, do any of you see any significant cost reduction there? Have we really accomplished anything or are we, when you really put your validation hat on and you have got to go flight test, are we really saving anything or are we really just sort of looking at Level B as it exists in the current Advisory Circular?

MR. DAVIS: You are saving in terms of instrumentation, I think that's clear. I mean, if not you have to fly, we haven't removed any tests.

MR. BOOTHE: Is there an increment that you would care to guess at there?

MR. DAVIS: Myself, maybe Stewart [Baillie] is in a position to guess at that, but in terms of time--

MR. BAILLIE: In the test of just gathering that data, you probably saved two weeks.

MR. BOOTHE: Are you talking just validation data?

MR. BAILLIE: That's all I'm talking, yes. The gathering validation data, I think that takes me six weeks.

MR. BOOTHE: What takes you six weeks now is both validation and modeling or just validation data?

MR. BAILLIE: Compared to a Level D version data set I think I could do a Level B in two weeks less.

MR. BOOTHE: That's really a third reduction in time. Does that equate to a third reduction in cost, approximately, then?

MR. BAILLIE: That depends on the size of the aircraft. And how much it costs to fly per hour versus how much it costs to sit in a hangar for an hour. But in manpower it's a saving.

MR. SCHUELER: Manpower during the flight test phase, but you haven't significantly changed data reduction time or any of that time, which can be--those are cheaper hours but there is a lot of hours there. So--

MR. DAVIS: Your data reduction costs would be reduced some, you are measuring a lot less parameters, the pain in the ass ones, I'm not sure how significant it is, but it has to be some reduction.

MR. BAILLIE: You don't have to do angle of attack calibration, that saves time.

MR. SCHUELER: You still have to do air speed.

MR. KOHLMAN: However, we are making some data gathering less efficient, because if we have all that stuff instrumented, we would run through a computerized flight test analysis program, print out engineering units. Whereas now somebody has to sit and read points off of videotape or other knee board type data.

MR. BAILLIE: When I suggested two weeks reduction, I would approach this by having the column and force control inceptor and control force and inertial package on all tests and do it all that way. I don't think--if you are going to instrument for the takeoff you do all of them that way.

MR. SCHUELER: If you are going to collect a whole data set, video doesn't save you anything because the reduction is so much more labor intensive.

MR. BAILLIE: If after you have put all this to bed the aircraft is gone and then you realize you need a data point, the video, the minimum stuff that we have defined, is of great importance.

MR. HEFFLEY: Right.

MR. BOOTHE: So that's really the only place it would really pay off, is what I hear you say. If you are going to do a data collection and you need the instrumentation for some test, if I were doing it, using the instrumentation for all tests, I think that's what you are feeding back to us anyway. So that really says if there is a cost increment it's that two weeks you mentioned. And that's preparation time and that could be, that could be on the order of 20 percent, though, couldn't it?

MR. BAILLIE: Two out of six, 30 percent.

MR. BOOTHE: I'm being conservative.

MR. BAILLIE: Fine.

MR. BOOTHE: So there is a potential, then, for some, because of the some of the changes we did make, namely instrumentation, I think primarily angle of attack and sideslip, where that comes in for something on the order I say 20 and you say 30, so 25 percent. And but then there is this big cost savings in the approach that we covered before the break. So does this mean that we could probably do all this work, which I assume it will, we could do a Level B aerodynamic modeling and validation for half of what we are doing it now?

MR. BAILLIE: I've never done a predictive model, so I don't know what the cost would be of doing that.

MR. WILLMOTT: When you are talking about validation, too, you are talking about what's required for the Level B validation plus all of the other validation data that you need to verify the predictive model; is that correct?

MR. BAILLIE: No. I think the only data you are required is the stuff we have discussed.

MR. DAVIS: That's it. You have AFM--

MR. WILLMOTT: I'm not sure Chuck [Stocking] was thinking the same thought.

MR. BAILLIE: You might do, rather than just one V_{MCA} case, you might do two or three.

MR. WILLMOTT: Normally you know if you are collecting validation data and you want to do every single flap transient, you want to do a phugoid at each of the five configurations, you want to do Dutch rolls, probably at each of the configurations, so those things are not included in what you are talking about.

MR. DAVIS: I don't think so. If you want to look at the model you want the minimum amount of data and rely on predictive techniques.

MR. WILLMOTT: If Gerry [Baker] comes along to the simulator after we have done the predicted package and modified it appropriately to what is in the Level B validation tests, and then says Dutch roll isn't right, in some configuration or the airplane pitches the other direction when I move the flap from here to here, that's not in that.

MR. BAILLIE: You have trouble.

MR. WILLMOTT: What do we do?

MR. HEFFLEY: But then you have the ability to come back and more cheaply get additional flight test points. I mean, you are still better off, it seems to me.

MR. KOHLMAN: If you need one more flight test data point to solve a problem, then that's where video--

MR. HEFFLEY: Pays off.

MR. KOHLMAN: And fish scale comes into--

MR. WILLMOTT: I think Chuck [Stocking] was thinking to validate the model he was talking about that there are additional validation things that aren't covered by what we were talking about here. I just wanted to check what you were talking about as far as validation data is concerned. It's Level B only.

MR. BAILLIE: The one premise that I have probably implicitly at the moment is to really look at this you expect, or considering the guy that has the Level 5 standard turbo prop model who thinks it flies like a given type and you can just gather this amount of data and prove that it does fly like that type. Subjectively everybody already, in some cases everybody already says that flies like the real aircraft. So it's just to get over the documentation hurdle. There is where you save the money.

If you are starting from scratch, you probably want to take more data.

MR. SCHUELER: Part of the fallacy of saying hey, if I need one more data point I can do it cheaply, it depends on what that data point is. Dutch roll being the example, we have said it needs inertial data. Didn't save me anything.

MR. BOOTHE: That's true.

MR. SCHUELER: If it's a climb point, okay, yes, I can--I can run out with a stopwatch, but realistically today if I ran into that situation I'd call Paul [Ray] and say hey, I need one more data point. And it's this one and how about if we go do it this way? And work out some reasonable approach to fill in that piece of data. And more than likely--and if it was that kind of data point, that would be acceptable today for a Level D device.

MR. RAY: In most cases that's, as we talked about outside, that's with the foreknowledge that you required all of this other data, you just happened not to have a particular case that's spelled out. It's not that you can't pull a test from somewhere to validate performance in a different configuration, it's to fill in the configuration requirements.

MR. SCHUELER: Right.

MR. BOOTHE: Okay. I don't know where else we can go with that subject today. I personally am delighted at the outcome. I think it offers some real opportunities for exploration, I guess is the way to put it. But I do think a demonstration program of some kind would be very informative on it. I would like to see that happen. I don't know how if it can be, but we need to figure out if this can significantly reduce this particular cost and add it to other possible cost reductions in other parts of simulator construction. It could go a long way towards the goal of getting people who now say they can't afford simulation out of airplanes and training in simulators.

I think everybody here would agree that is an honorable goal. So if something contributes to that, Stewart [Baillie] was mentioning before we broke about modeling an oleo, and I've often questioned why we bother. Why don't we have a model that goes from wheel in the pilot seat one big transfer function, if you will, if I can describe it that way, instead of having to model? Is it important to model each of these little components of landing gear and structure or could all that be lumped parameter system, say here you go, here is what you feel when this happens, and I know I'm overly simplifying, but something I've thought about.

MR. SCHUELER: You get into robustness and ability to handle failure modes and some of those kinds of questions. Some things it might be reasonable to model as a black box, if you will, [an] input-output model, but other things may--that approach may drive you into a corner.

MR. BOOTHE: Well, let's go back to Level B for a minute, and maybe we would have to review as Stewart [Baillie] has so often reminded us, what are we going to do with this thing? Are we going to do tire and landing gear failures or is that part of it done somewhere else? I think that's an important consideration. But it seems to me we use the same ground reaction model on everything, of course if you've got one that's fine. And you can fill in the numbers.

MR. STOCKING: The place where we model ground reactions where we are concerned with, it is in the air to ground, ground to air transition, it needs to push back on the airplane. Just like it does in the airplane. And so we want that spring curve in there just like it was in the airplane. It goes away and it comes in like it does on the aircraft. And we have made enough generic models that we can estimate that data real close at minimum cost by using our models.

MR. BOOTHE: So you already have models that you can use, but--

MR. STOCKING: That's correct.

MR. BOOTHE: --suppose he doesn't.

MR. WILLMOTT: The oleo itself is a very simple model because it's a pressurized system, it's adiabatic when you compress it, it's a very simple model, knowing the cross-sectional area of the oleo and the pressure it's precharged to. Usually everything in the airplane that we know of is simulated, so we are simulating the aircraft.

As far as the struts are concerned, when sometimes people like landing on one gear and getting the right effects, if they were to do that we even have to represent a one gear up landing malfunction sometimes. We have tire burst malfunctions and we have to represent banking due to this.

MR. BOOTHE: That's more Level C and D stuff.

MR. RAY: As far as failure it doesn't preclude--

MR. BAILLIE: Perhaps we forgot one thing, with a Level C and D you want to know exactly when the nosewheel leaves the ground and the best way to do that is oleo deflection. You want to know exactly where the wheels first touch, the best way to do is oleo deflection. In a crosswind you want to know where when the tires touch, again oleo deflection. That's the reason why, not to model but to know what wheel touches first.

MR. STOCKING: You need to know the forces before you leave the ground. That's the other part of it.

MR. WILLMOTT: And also, the model normally works out the deflection of the bottom of the tire and you have a tire spring rate and you don't start deflecting the oleo until you get the preload at the oleo, it's part of the model.

MR. STOCKING: You also model the tire so you get the slalom handling characteristics--

MR. BOOTHE: I think you all have a good reason why it's needed.

MR. KOHLMAN: How much of this applies to Level B?

MR. WILLMOTT: Also there is normally a hydraulic damping mechanism within the oleo with a metering pin in there that gives you different flow rates depending on the deflection of the oleo, so the damping actually varies.

MR. BOOTHE: My thought was it seems like there is lots of components there to model. If we can bypass any of them for somebody developing a model it might be worth consideration. But I hear that it isn't.

MR. RAY: It could be an issue between an A and a B though, because of the credit you can receive in a B, but then if you had a B would you really go and pull that piece out just to create an A? Probably not.

MR. DAVIS: Again, this parameter we drop in a Level D if we want to, it's just something when we build a high fidelity simulator we want the information for our own insight. We don't need to know it for a Level D so we don't need it for a Level B. It doesn't go into development, it goes into the validation process. There isn't savings to be had there, we are making the choice to get it.

MR. BOOTHE: Okay, thank you.

MR. LONGRIDGE: I would like to return to an issue that was raised earlier, that was the question of whether or not there is an adequate model for the predictive data purposes for this class of aircraft. It seems to me the cost savings that we hope to achieve is very much dependent on whether or not we can use predictive modeling. Because if there isn't, the FAA may want to consider paying for the development of such a model and making it available to everybody.

What is your feeling with regard to the availability of a sufficiently sophisticated model to do what we are trying to do?

MR. HEFFLEY: I think there is the availability of models for this class of aircraft that have been around for a while that can be used as a basis if you don't have a basis already. And you need something that structurally contains the right things. Namely propellers, slip stream, airfoils and the rest of the usual things.

MR. NEVILLE: So this really brings up the possibility of a generic aerodynamic model for a class. I mean it could even be as specific as a high wing T tail twin turbo prop, for example, that would cover all airplanes in that category.

MR. HEFFLEY: There have been models built for this class of aircraft in the past not in use right now necessarily.

MR. LONGRIDGE: The question is, are they good enough to talk about what we have been talking about doing? Dave [Leister] is shaking his head.

MR. LEISTER: They are absolutely not.

MR. STOCKING: I agree.

MR. LEISTER: Stocks, you and I have disagreed for a long time.

MR. BAILLIE: About the case where you have a simulator for a similar type which now has three feet added on the wings and a plug, but in the fuselage we can certainly make the adaptations to the stability derivatives, et cetera, using classical techniques to probably make that model fit the test maneuvers for the type and all the ATG data does is say make sure you have made those extrapolations reasonably well. That's a good example where you could save a big amount of money.

MR. DAVIS: I think that's fair. To do a 100 from a blank page and DATCOM, I am a little more skeptical about that.

MR. STOCKING: If you would like I will read you the effects that are in the current model that we derived from DATCOM or a textbook, they are--

MR. DAVIS: I acknowledge there could be a million terms, that's not really what's relevant. What's relevant is how accurate the terms are.

MR. STOCKING: They are quite accurate.

MR. LEISTER: Do they drive the simulation to fly like the airplane?

MR. STOCKING: The problem is not all the effects have ever been put in a simulator. People have grabbed bits and pieces to get what they want. They have not gone a back and done a full-up stretch of how the propeller affects the surfaces on the aircraft.

MR. LEISTER: On the ratings we haven't had the computing power up to just now to do that.

MR. STOCKING: That's my point. When I was sitting down doing this model I modeled practically the rest of the airplane and then I sat down and modeled the prop effects. It was almost an equal test. It was extensive. But it was available, and the reason why it's not been used in the past is because of how extensive it is.

MR. BOOTHE: That's just propeller effects, you said?

MR. STOCKING: Just prop effects.

MR. HEFFLEY: On an airfoil.

MR. STOCKING: Yes. Any place it impinges on the airframe itself.

MR. HEFFLEY: If we go back 30, 40 years people were doing that. It's a matter of going back in the literature. Models of this class of aircraft have been handled, successfully, and there are fairly good theoretical models for effects of power lift on airfoils.

MR. STOCKING: The tables I'm using came off a Bearcat.

MR. LEISTER: World War II.

MR. BOOTHE: What about the power lift that was done at NASA-Ames?

MR. HEFFLEY: We mentioned Bréguet 941, it's a rather extreme power lift aircraft, you simply back off on the extremity of that. But models of propellers and powered-lift effects on airfoils exist, and can be included in the sort of system that Chuck [Stocking] has been--is talking about.

MR. STOCKING: They are extensive, they look at what the wing is doing, then modify what the wing is doing accordingly.

MR. LEISTER: Have you taken this model and flown it against the flight test or tried to make it--

MR. STOCKING: No.

MR. LEISTER: That's--

MR. STOCKING: Well, yes, but with qualifications. The proof of concept that I did it was only partially in there, I used this portion of it, an estimate, everything went in the right direction, there is nothing that makes me believe that it isn't a good accurate model.

MR. LEISTER: Someone should let you cook up a model like that for one of the known--well, a Dash 8 or something like that, and see how it rides in a sim. You may have something.

MR. STOCKING: It's not me, I'm just rolling over what's been there for a long time that we haven't used because of our limited computation problems.

MR. HEFFLEY: That's right. And further you know there is a body of existing wind tunnel data that has been gathered on aircraft such as light twins.

MR. BOOTHE: So is this existing data that's lying in the archives that current modelers are not taking advantage of? Or--

MR. HEFFLEY: It's there. And I think it would be the logical basis, if one really were starting from scratch. At the same time contemporary commuter aircraft, as a class of aircraft, is not terribly extreme in terms of powered-lift effects. The effects of propellers are significant. But there are existing data and models to draw from.

MR. LEISTER: Those effects are modeled but I guess what Stu--I'm sorry, what Chuck [Stocking] is saying, is that perhaps using predictive methods you can come up with a model that would play in a simulator. Is that what you are saying?

MR. STOCKING: You have to realize when I take stuff from DATCOM it's more than predictive, this has been contributed to by the experiences of researchers.

MR. HEFFLEY: You do not have to go to the extreme of just starting from DATCOM, you don't have to start with totally analytic functions.

MR. STOCKING: No.

MR. HEFFLEY: You start with whatever you can find. And some of that is existing wind tunnel.

MR. STOCKING: The air frame manufacturers have gone far beyond what's available to me in DATCOM or another source, a public source, I have to rely on public sources.

MR. HEFFLEY: Same here.

MR. STOCKING: The volume of data.

MR. LEISTER: Hilton [Smith] and I worked on a C-130 derivation years ago, the prop effects--Hilton Smith? He is gone.

MR. HEFFLEY: That's another example where there is some decent NASA test results on powered lift (on the NC-130).

MR. WILLMOTT: A thought that occurred to me, Ed [Boothe], that maybe you have thought of, too. Is it reasonable to consider taking what Chuck [Stocking] has done, which is the process that we are talking about, to reduce the costs, and try and put that into a simulator somewhere, additionally do the flight testing that is necessary, we have come up with the validation tests for B, and to use it as a proof of concept? You are asking if there is something that you could do like come up with models or something like that, maybe something like that is beneficial.

MR. LONGRIDGE: There is no question, I think we are moving in the direction of a demonstration program for this particular effort. And I think it's quite feasible that we might as part of that program do something like that.

MR. WILLMOTT: I mean, the proof of the pudding is in the eating, they say across the way.

MR. BOOTHE: I think that it is feasible and I think it's more than feasible, I think it's quite desirable, and I even would go so far as to say it's necessary to at least gain the confidence that's needed to say yes, this is a viable method and we can do this.

I just want to spend a couple of minutes on the Level B issue, and Tom [Longridge] has some concluding remarks. But a couple of things we never got to the steady state sideslip, I will let you read that yourself and you can shoot me through CompuServe or something, but these other tables we never got to talk about and I guess the conclusion was we didn't want to talk about them.

But I tell you that Microsoft Word does a nice job doing it, so I guess we just leave them to be and those are just as I said, yesterday's is pretty much a redo of the IATA tables and use them or throw them out or whatever you find them useful for.

But this Level B issue, there is intention beyond just the data, we know we can't reduce the cost of the simulator just on the data as a start. So we are going to be looking at, at motion systems and visual systems, and I don't think that necessarily means we are going to be looking at can we use cheaper, smaller visual systems, I think we are going to be looking at what kind of visual system does one need to accomplish what we need to accomplish and what needs to be in it. I mean, do we need photo texture and pretty clouds and waves? I don't know. Those are some things that I'm sure we will be addressing.

And the old question of motion goes on and on and probably we could split this room fifty-fifty and half of us believe in motion and the other half don't. And it's something that's going to be unresolved until the community decides to do some work to find out how needed it really is and if it's needed and--which I think it is, but that's all right, I've got an open mind, I'll be convinced it isn't if you show me the data.

But what motion is needed? I think that's important. Can that cost be reduced? Do we need a one degree of freedom sidekick error, do we need a six degree [of] freedom 72 stroke system, and those questions need to be answered, and I think that's all part of the equation of lower cost simulation.

But I think that needs to be done in such a way that we still accomplish the goal and that's not--that is to not degrade the pilot certification function. So that has to be kept firmly in mind as we do all this. We recertify pilots periodically, if we can recertify them periodically in a Level B they still go out and fly in air transportation service perhaps with you riding in back. So the simulation still has to be of high integrity and it has to support that task.

So I think as we continue, that's really what happens. As we continue we have to keep that thought in mind. Even with the modeling. So if we can do it cheaper we ought to. But we still have to keep in mind that the idea is to certify pilots, and I think we all have a concept of what that means. So I think that's the important aspect and I don't want to lose those in the process of cutting costs here and cutting costs there. But I certainly don't want to do more than is necessary to accomplish that task, accomplish it properly, and accomplish it with integrity.

So I want to thank you all for your contributions. I think this has been one of the best discussions on simulation I have ever been involved with. And it's just been so open and all of you have contributed beyond my best hopes. And I'm just really pleased with what you brought with you and what you have given us. And thank you all very much. Tom [Longridge]?

MR. LONGRIDGE: I certainly second those comments.

There is one other issue I would like some further clarification on. It was brought up at one point that it might be fruitful to the extent we are going to rely more heavily on predictive modeling for the FAA to require some type of description of the model development process. And is it the recommendation of this group that the FAA come up with some type of criteria for such a description? Or do you feel that that's probably not necessary?

MR. STOCKING: I really feel you can do it through training requirements. If you have a training requirement to fly forward CG, that implies the simulator is going to have a fair representation of forward and aft CG.

MR. LONGRIDGE: Let me ask by show of hands how many people would recommend that we not require, not establish criteria for such a description of model development.

MR. RAY: And a model development would be something in the order of what we were talking about earlier. How did you get from point A to point B, not a full description of your model development, something along the lines we are working with now.

MR. KOHLMAN: Rephrase that again, Tom [Longridge].

MR. WILLMOTT: Not get involved, right?

MR. LONGRIDGE: The question is, do you recommend that the FAA establish criteria for description of model development?

MR. KOHLMAN: Okay.

MR. LONGRIDGE: Yes or no, raise your hand if you recommend.

MR. RAY: Can I ask a follow-up question?

MR. BOOTHE: Let's answer this one.

MR. RAY: That's right. Answer this one first. It passed, your question was no, don't fool with it.

MR. LONGRIDGE: Don't fool with it. I'm not surprised.

MR. RAY: I'm not surprised either.

MR. LONGRIDGE: Yes.

MR. BAILLIE: Rather than putting forward a criteria which somebody is going to figure a way to get around anyway, requesting some level of explanation is a different approach.

MR. LONGRIDGE: The point is, if you are going to require a description we need to specify the nature of that description. What I mean by criteria. What would be a satisfactory description to the FAA? If we don't specify that, we might as well not ask for it.

MR. WILLMOTT: Your subjective evaluation of the simulator covers the things that aren't really specifically spelled out in those validation tests. The purpose of the subjective evaluation is that you can fly it wherever you want, do other things and you are effectively checking the simulation, you are checking all of the models, you are checking aerodynamics, checking the controls, checking weight and balance, checking the engine, all of that is being done by your subjective evaluation.

MR. LONGRIDGE: I understand that. I also understand that we don't presently require any such description but it's also understood that the people that are doing this model development are in fact doing those tests and the FAA knows that and we are talking about going perhaps to a regime where that's no longer the case. You may have new people doing this who may not have the integrity of the present group.

MR. RAY: That's where I was coming from with my follow-up question. Where I thought we were going earlier when I saw a head or two nod saying yes, to what’s reasonable.

In answer to Tom's [Longridge] question, I would have answered the same way that you did. Within this room with the way everyone in this room I believe perceives the way simulators should be built, have been built in the past, will continue to be built hopefully tomorrow. There is no need for that. Hopefully the industry opens up to other people, assuming the computer simulation market opens up. I see a lot more folks, as I referred to earlier, who we don't know, haven’t the foggiest idea what their capabilities are, will come in and ask us to qualify a simulator. Putting yourself in the same position, is it reasonable to ask at least what process, that's the wrong word, what approaches did you take in development, whether it's of a model or the data, whatever the case may be, similar to what we do today with the Level 2, Level 3 and Level 5 devices as far as the generic aero behind it. They come in and present their case, this is how we develop our generic aeromodel and our validation set or data that confirms it is representative. When they come in and present that, it's a rather a straightforward process.

The only question is, is that reasonable to ask for those who haven't done this before particularly getting into the idea of the issue of expanded--is it a reasonable thing to ask? If it's not, I'll stop.

MR. HEFFLEY: What would you use to rule out an approach that somebody says “Hey, this is the way I'm going to do it.” You have got to be prepared to say “Well, I sure don't like that for such and such a reason.”

MR. RAY: Exactly what we ask to put together a similar group of what's sitting here right now. The exact same way we did it with the international scene with Boeing, Boeing participating in the process on what was reasonable. What would be reasonable to the experts in the room if they were to come to you. They built a process and it seems to work. We hope it works, anyway.

MR. WILLMOTT: One of the things about this, Paul [Ray], is you are right now addressing presumably the six aerodynamic coefficients.

MR. RAY: Presumably.

MR. WILLMOTT: The next step with this class of aircraft are the three control hinge moment coefficients, the next thing the downspring, the bob weight, the whole control system itself. The next thing is the engine, and how you model it, and as I was saying to Tom [Longridge] last night, sometimes somebody gets in a simulator and it flies badly, it's got nothing to do with any of that. It's the flight director.

So now you want to see all of the laws and the logic of the flight director? It's very difficult to pick out one thing of all of the simulation and say that this is what really matters as far as the flying qualities are concerned. And you know if you start down the path--

MR. RAY: We certainly don't want to get into that chart. The other chart we didn't talk about. We would not want that at all. It's not a reasonable question. You want us to try to work it out the way we typically have, that's fine. I just think there is some--gut instinct tells me, particularly with some of the inquiries we have had recently, that it's reasonable to ask someone to sit down and explain how you are doing what you are doing, not at this detail level, but do they seem to have a reasonable grasp about what they are doing? Have they addressed some of the simplistic pieces of putting their simulation together, whether it's motion, visual, the aero, whatever?

MR. WILLMOTT: Maybe one of the long-term solutions and suggestions is to get the regional aircraft, commuter aircraft manufacturers to do what the major airline manufacturers do, and that's produce the packages and then, you know, they are available for you to see.

MR. RAY: That's one of Tom's [Longridge] points I think he is going to be making or wanted to ask that question before we adjourn.

MR. WILLMOTT: They really are the best qualified people to do that. But it means that they have got to do things perhaps that they didn't do before even with the sort of class of aircraft you might have to develop aeroelastics which they may not do right now.

MR. RAY: It's a good time to ask the question.

MR. WILLMOTT: And all sorts of other things.

MR. RAY: Sorry.

MR. WILLMOTT: Go ahead.

MR. RAY: It's a good time to perhaps ask that question. Is it reasonable, would it be the recommendation of this group that we take from this meeting the idea that the FAA should somehow mandate the incorporation of data for simulation in the initial certification of an airplane?

MR. WILLMOTT: Well, if I were to say yes, I'm putting various people out of work.

MR. RAY: Actually you may--

MR. WILLMOTT: The answer is yes, really.

MR. RAY: If you look at it pragmatically perhaps you are increasing business.

MR. BAILLIE: In general we are working with a lot of companies to get that data to them.

MR. SCHUELER: I don't think the FAA has to regulate or demand that. The market can cause that to happen.

MR. RAY: True.

MR. ELLIS: That would be the best case if the customers for the airplane said manufacturer, we want simulators and we want you to provide the data package, otherwise we won't buy your airplane.

MR. SCHUELER: If the market forces aren't strong enough to force it then is the need great enough--

MR. LONGRIDGE: They haven't been strong enough to force it in the commuter market. We do have an NTSB recommendation in so many words.

MR. RAY: Everyone is aware of the '94 NTSB recommendation which essentially said it should be a requirement. We recommended, when that came out, the alternative should be that simulator training is required. And airplane training is an alternative. If you require simulator training, then the market forces come to bear where you are not going to buy the airplane unless the manufacturer produces the data. I think the end result may be the same, but it may not. I don't know all the answers to it, that's your recommendation. If you require the simulator training to the manufacturers obviously that will have some impact. They will be forced somehow, to provide data.

MR. SCHUELER: I think the FAA would be very hard pressed to regulate into existence the kind of package developed today for the regulatory agency. To define and regulate what that package is I think would be an enormous task and I don't think we could do a very good job of getting it right, at least not for quite a while.

MR. STOCKING: And the cost?

MR. SCHUELER: But the marketplace can do that, it can bring the forces to bear to say, you know, to cause someone even like Boeing to change and modify and update what they develop because we have learned and found new ways and whatever.

MR. BAILLIE: Can I revisit an issue which I feel compelled to talk about? I was probably one of the people who first said you should look at how people build the model. And as we discussed it I agreed with all the can of worms that come up from making it a requirement. But similarly in AC120-40B right now there is a requirement that either you use aircraft manufacturers' flight test data or data from a source that you have approved. Something of that level might get you over that comfort hump that you want to have in terms of aeromodel time where you take a look at the person not based on the architecture of the given model but based on his or her own personal competence; has this person got the competence to model an aircraft? That might be an out that doesn't bother the majority of people who are in the industry right now but allows the door to be opened with a gate on it so you can watch who is walking in.

MR. LONGRIDGE: There again you have criteria.

MR. BAILLIE: What's the criteria for the data?

MR. KOHLMAN: That's broad enough to allow the sort of thing that I have been thinking could come along and I have asked myself how would the FAA handle that. I have been reading about new ways of modeling, such as neural networks. I don't pretend to understand, but what I do know about it, it's a new way of modeling complex systems in which we don't have the traditional C_{L_α}, C_{L_β}, all those terms. Instead it's a rather complex transfer function.

What if somebody says here is how I'm going to model the airplane? What do we do then? Then we fall back on the competence and experience question. And the source of the data.

MR. SCHUELER: There are also some things that come in from the certification side where the FAA as a regulatory agency applies control: data collection, data process, data analysis--[all that] has to be documented. Validated, if you will. Or shown to be sound. In some manner. Calibration of the instrumentation has to be documented. There isn't currently any requirement on data for simulators. From that--in that same way. There is a requirement that the data come from an improved source. But in certification there is actually a regulation that specifies that that data collection will be documented and approved by the agency.

So there is some--there is some tools and methods that, some avenues, that might apply without.

MR. BOOTHE: Maybe we ought to get simulators mentioned in Part 21, which is where I think that information is.

MR. BAKER: Yes, it's 21.

MR. BOOTHE: That would be a big step in the right direction if we could just get them recognized in that concept that you have just outlined.

MR. BAILLIE: We aren't trying to make it more difficult to gather data, we are trying to look at people who build the models.

MR. SCHUELER: I guess part of what I'm trying to say, is that some of those concepts without--without regulating how it's done or who can do it or whatever, there is some examples again in other areas of how that might be done, how you might open the door to allow you the insight that I think you are looking for, and that's appropriate in certain cases, but without saying you have to show me all of your equations or something.

MR. RAY: Don't say that.

MR. SCHUELER: Right. That's not what you want.

MR. ELLIS: Just I hate to see us get into a rigid "this is how we do it now, this is how it's going to ever be." Dave [Kohlman] mentioned earlier something coming along called object oriented programming. Chuck [Stocking] is into, we are into it. It's very, very promising for this simulation field. We need to give it a chance.

MR. BAKER: One thing to me maybe that's what the NTSB was saying, I don't recall the recommendation but it would seem logical, I think it's what forces Boeing to support simulators as you said earlier, that the customers that the airplane hits the street on for training. If you could somehow try simulation to any of these airplanes in scheduled passenger carrying service I think you have to look at it from that direction. Schedules aside, if somehow you could tie that together that there is--there should be simulation provided at the time of delivery of the airplane.

MR. LONGRIDGE: That was exactly the NTSB recommendation. Yes.

MR. RAY: The way they phrased it--

MR. BAKER: The only way it's going to happen is if the manufacturer provides it. That's a fact.

MR. LONGRIDGE: It's just my impression it's going to take a bit of a push to make that happen. I'm not so confident the market forces are going to be adequate, at least in the near term.

We are out of time, I would like to thank all of you. I think from my perspective we have definitely accomplished the objectives the FAA had in calling this meeting. I appreciate your input, it's clear the input streams to maintain the quality of flight simulators, I can tell you we will act on this input, we are moving towards a demonstration program in this area.

Thank you all.

(Time Noted: 3:30 p.m.)

Transcript of the

Joint FAA/Industry Symposium

on

Level B Airplane Simulator Aeromodel Validation Requirements

To the Memory of Daryl Schueler

Part 7 of 7

Appendix:

Longridge, T., Ray, P., Boothe, E., & Bürki-Cohen, J. (1996). Initiative towards more affordable flight simulators for U.S. commuter airline training. *Royal Aeronautical Society Conference on Training - Lowering the Cost, Maintaining the Fidelity* (pp. 2.1-2.17), London, UK

Washington Dulles Airport Hilton
March 13 - 14, 1996

INITIATIVE TOWARDS MORE AFFORDABLE FLIGHT SIMULATORS FOR U.S. COMMUTER AIRLINE TRAINING

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Abstract

Recent regulatory action, coupled to a policy of encouraging commuter airlines to conduct all pilot training and checking activities in ground based equipment, has created an impetus to consider how best to ameliorate the conditions which have discouraged the use of such equipment for pilot recurrent training by commuter airlines in the United States. This paper compares the relative merits of permitting additional recurrent training credit for enhanced flight training devices versus revising the qualification standards for Level B full flight simulators to achieve enhanced affordability. The current status of an ongoing Level B flight simulator qualification standards review, results to date, and future plans, including plans for the development of a comprehensive applied research program, are discussed.

Background

The use of flight simulators for initial and recurrent pilot training by U.S. major airlines is universal, and its effectiveness is well recognized. However, the use of such equipment by smaller U.S. commuter airlines is mixed. While many commuter airlines use approved simulator resources available from aircraft manufacturers and training centers for initial pilot certification, smaller airlines frequently do not make use of such equipment for recurrent pilot training, due to various considerations, such as cost, convenience, and flight simulator availability. For airlines employing small aircraft, the per hour cost of operating an aircraft for training may compare favorably with the cost of contracting for simulator time. For some commuter aircraft, simulator resources may be very limited in availability, and they may be inconveniently located geographically for U.S. operators.

On 20 December 1995, the Federal Aviation Administration (FAA) issued a new regulation (Ref 1) applicable to all airlines that operate scheduled air carrier service in airplanes having ten or more passenger seats. This new regulation, Part 119 of Title 14, Code of Federal Regulations (14 CFR), encompasses all scheduled commuter airlines that operate airplanes of 10 or more seats under 14 CFR, Part 135. Among its provisions, it requires all such airlines to conduct pilot training and evaluation in accordance with the same provisions of the Federal Aviation Regulations (FAR) that apply to major airlines, namely 14 CFR, Part 121. These changes are intended to encourage one standard of safety for all air carriers, regardless of the size of their aircraft or the range of their flight operations. In concert with these new rules, the FAA has adopted a policy of encouraging commuter airlines to transition their pilot training programs out of the aircraft and into ground-based training equipment. However, it is likely the effective realization of this policy will not occur until the major obstacles which have historically restricted access of commuter airlines to such equipment, namely cost, convenience, and availability, are removed. If this is to occur on a timely basis, the FAA must act proactively in meeting the needs of the commuter airlines for affordable training equipment. The FAA has also concluded that for any such effort to be successful without compromising safety, it must be accomplished without degradation in the qualification standards for such equipment.

The FAA qualification requirements for a flight training device (FTD) are defined by Advisory Circular (AC) 120-45A (Ref 2), which defines seven levels of such equipment. The credit permitted for a corresponding FTD level is proscribed as an appendix to the FAA Practical Test Standards, as revised (Ref 3). Within the U.S., the Regional Airline Association has proposed that the FAA consider expanded options for the use of FTDs, a proposal which has also been enthusiastically endorsed by those equipment manufacturers for whom FTDs constitute a principle product line. The proposed strategy would entail an upgraded Level 5 or Level 6 FTD, consisting of an enhanced aeromodeling package and the addition of some type of visual image generation and display system. In some proposals, the addition of a low cost, small throw, three or four degree-of-freedom motion platform has also been discussed, although design specifications and associated capabilities have yet to be clearly defined. This enhanced FTD alternative is considered appealing by its proponents, because, provided the FAA were to agree to allow full credit for the use of such equipment in recurrent training and checking, it appears that this proposal would have the potential of addressing all of the major obstacles discussed above.

From a regulatory perspective, however, there are certain drawbacks to this proposed approach. The first such drawback concerns the need for standardization in equipment qualification, in order to maintain acceptable standards of safety for pilot training and checking. As the purposes for which the FAA established the category of equipment called FTD did not incorporate an intent to address the full spectrum of pilot training needs, the existing FTD qualifications standards are not applicable to the use of these devices for such broad purposes. FTDs were established for use within an overall air carrier pilot training curriculum, which must either employ a full flight simulator (FFS), or the aircraft itself, as an essential component. The FFS provides an FAA-qualified vehicle for training and testing the skill integration required for the full range of flight operations. The FTD provides an FAA-qualified vehicle for mastering the skills associated with individual flight tasks, particularly procedural skills. Use of an FTD better enables matching training objectives to training equipment, by virtue of permitting training on lower level enabling objectives to occur on lower level equipment.

This practice clearly permits more efficient use of FFS time, by concentrating use of the latter on those skills for which the FTD is not a suitable vehicle - namely, flight operations training and evaluation, in which the training equipment must be capable of presenting a full representive range of operational tasks, conditions, and contingencies. While the FAA has authorized training and checking credit for certain individual flight maneuvers to be accomplished in an FTD, the FAR also require that the demonstration of pilot proficiency for certain other tasks be completed in an appropriately qualified FFS, or in an aircraft, as part of the air carrier's approved overall training program. For recurrent pilot training proficiency checks, unless the landing maneuvers are accomplished in a Level B or higher FFS, evaluation of proficiency on these maneuvers must be conducted in the aircraft, typically accomplished by the satisfactory completion of at least two landings during the required operational (line) evaluation. In addition, 14 CFR Part 121 requires that recurrent windshear training be accomplished annually in a FFS.

In 1990 the FAA issued Special Federal Aviation Regulation (SFAR) 58, Advanced Qualification Program (AQP), which created a voluntary alternative to the traditional 14 CFR Part 121 requirements for pilot training and checking (Ref 4). SFAR 58 provides a regulatory mechanism on which basis the FAA may approve significant departures from traditional requirements, including the authorized use of equipment for training. It has been argued by some in the training development community that "..... qualification of ground-based devices for training needs to be based on their effectiveness for that purpose, not solely on their verisimilitude to an airplane" (Ref 5), and that ".....what an effective simulation requires is as many of the psychophysical, cockpit management and communications demands as possible, rather than technical, physical, or aerodynamic fidelity to a particular aircraft type. Suitable simulation devices thus need "functional" fidelity and the simulation scenario must ensure appropriate "operational" and "embodied" fidelity." (Ref 6). Under AQP it is possible to conduct pilot training which is fully consistent with this philosophy, and to obtain FAA approval for the use in an AQP curriculum of equipment based upon such functional considerations, rather than on engineering criteria. It is not possible, however, to conduct the evaluation of end-level pilot proficiency in such equipment.

In the U.S., as in many other countries today, regulations permit pilot training, qualification, and certification to be conducted entirely in ground-based equipment. Pilots qualified on such a basis are permitted to perform immediately as cockpit crewmembers in aircraft which fly passengers in revenue operations, albeit under the supervision of a check airman during the initial operating experience which follows upgrade or transition training. Recurrent training for continuing qualification of pilots can be accomplished entirely in ground-based equipment. Consequently, it is critical to safety that the ground-based equipment employed to evaluate end level proficiency for such purposes be qualified as replicating the aircraft over the full range of operational tasks, conditions, and contingencies.

Even in AQP, therefore, there are clear restraints on the use of equipment for assessing terminal proficiency. Such equipment must be qualified by the FAA, and it must be approved for its intended use as AQP proficiency evaluation media. AQP does offer considerably flexibility with respect to the use of FTDs for the progressive sign-off of proficiency on individual objectives, including training to proficiency on technical and/or cognitively oriented objectives. However, the final criterion for successful completion of an AQP curriculum is the formal evaluation of proficiency in realistic operational scenarios that test a diagnostic sample of technical and cognitive skills in a systematically developed Line Operational Evaluation (LOE), which is designed to test both sets of skills together. The FAA has determined that only a qualified FFS is an acceptable media for LOE.

Authorization of an "enhanced" FTD to accomplish recurrent training and checking, whether for credit on specific maneuvers under a traditional 14 CFR Part 121 program or under SFAR 58 with respect to evaluation on specific proficiency objectives, would require the development of appropriate equipment qualification standards for the modified configuration of devices to be employed for those purposes. Alternatively, it would necessitate the application of existing FFS qualification standards to the enhanced components of that equipment. It would also require modification to, or exemption from, the existing FAR pertaining to the requirements for FAA approval of an air carrier's pilot training program under Part 121. Since the enhancements to an FTD necessary to justify these actions would in effect be identical to those required to upgrade the device to a FFS, it is highly questionable whether this proposed course of action is warranted.

From an FAA perspective, a more rationale course of action would be to take the existing qualification standards for a Level B simulator as a starting point, and determine (a) whether more affordable means of meeting those equipment standards can be achieved, and (b) if certain revisions to those qualification standards can be accomplished which would enhance affordability without degrading the quality of equipment performance. AC 120-40B (Ref 7) defines four FFS levels - A, B, C, and D. Of these, Level B appears to be the most logical target for this endeavor, because it can be used for 100% of recurrent training, equipment for recurrent training use is among the most significant cost considerations for U.S. commuter airlines, and the engineering requirements for a Level B simulator are such that the likelihood of a successful outcome for this review is higher than would be the case for a Level C or D simulator. Most U.S. regional airlines are already using a Level C or D FFS for initial and transition pilot training. Their use for that purpose is recognized as cost effective, but the cost of purchasing or leasing access to that level of equipment for pilot recurrent training is not considered to be acceptable by many commuter airlines, which continue to find it financially advantageous to conduct recurrent training and checking in the aircraft. Few, if any, Level B (or Level A) simulators are presently available for use with commuter class aircraft in the U.S..

The choice of a Level B simulator as a target system is driven by the stated policy of the FAA to encourage commuter airlines to conduct all of their training in ground-based equipment, rather than in the aircraft. While a Level A simulator can be employed under 14 CFR Part 121 to accomplish most of the requirements for aircraft specific recurrent pilot training and checking, the regulations require that if limited to that level of equipment, then two landings under the observation of a check airman must also be accomplished in the aircraft within the due period of the proficiency check for a given pilot. As previously noted, the two landings are typically observed during the required operational (line) evaluation, thereby necessitating at least two flight segments. If a Level B simulator is utilized for the proficiency check, the line checking requirement may be satisfied with a single flight segment, thereby potentially reducing the workload on check airmen by 50%. Another consideration for choice of Level B as the starting point concerns the feasibility of generalizing between equipment levels. Downward extension from Level B to Level A would appear to be more practical than attempting to extrapolate in the opposite direction..

Accordingly, the FAA is undertaking a comprehensive review of the equipment qualification standards for Level B FFS. This effort constitutes the initial phase of a systematic, multi-year program of FAA-sponsored flight simulator applied research, intended to provide empirical data on the relationships between training equipment engineering characteristics, pilot cueing requirements, equipment cueing effectiveness, and equipment pilot training and evaluation effectiveness. As results become available, they will be presented by the FAA for discussion and potential application internationally.

FAA efforts regarding this issue are supportive of ongoing international initiatives to improve the quality of simulation and its use. The FAA actively supports the recently adopted international standards for Level I and II simulators, as exemplified by their incorporation into FAA Level C and D simulator qualification standards. This paper will describe the current status of the Level B flight simulator qualification standards review, progress to date, and future plans, including plans for the development of a comprehensive applied research program. The paper constitutes a description of work in progress.

Review of Level B Simulator Qualification Standards

The baseline for this review is AC120-40B and the simulator validation tables therein. The review is being conducted on a progressive basis, beginning with the data requirements for validation of the aeromodel for a Level B flight simulator, since this consideration is fundamental to the fidelity of the simulator's handling characteristics, and is crucial for pilot acceptance of such equipment as a substitute for the aircraft. The second priority for this review is Level B flight simulator motion cueing. The third priority is Level B flight simulator visual display technology. Although there are other considerations to simulator validation, the FAA has determined that these three priorities have the biggest potential for success relative to achieving increased flight simulator affordability. To date, however, only the aeromodel review has been initiated.

Aeromodel Validation

In initiating a review of those portions of AC120-40B pertaining to the validation of the aeromodeling for a Level B simulator, each test was examined with regard to the following questions: Given a commuter class aircraft with wing mounted turboprop engines, (a) what is the objective of this test? (b) is the test important to simulator fidelity from the perspective of what the pilot actually sees and feels in the cockpit? (c) are there modifications to the test that would reduce costs without seriously impacting simulator handling characteristics? and (d) are there modifications to the flight data instrumentation requirements that would reduce costs without seriously impacting the reliability and validity of the aeromodel verification process? A meeting of selected subject matter experts from industry, academia, and government in the disciplines of aerodynamic modeling, aircraft flight test instrumentation, simulator qualification, aircraft certification, and air carrier pilot training was convened to examine the tests in light of the above questions. The results of this review are summarized in Table I, and the verbatim transcript of the proceedings from this meeting has been documented (Ref 8).

As Table I indicates, changes were proposed to more than half of the existing tests. Of 48 total tests, 27 were changed, including two which were deleted entirely - (2.d.(2): Roll Response Rate, and 2.e.(4): Rudder Effectiveness with Reverse Thrust. The most significant change was the elimination of angle-of-attack and control-surface-position measurements from all flights tests. While these recommendations do not depart dramatically from the existing requirements of AC120-40B, it is estimated that the net effect of adopting these proposed changes would be a savings of at least 25% in the cost of flight simulator validation, by virtue of reduced requirements for certain flight test instrumentation. For example, for Crosswind Landing - 2.e.(2), and Engine Inoperative-2.e.(3), the replacement of angle-of-attack and sideslip measures with normal and lateral acceleration measures would result in a significant instrumentation savings. While all these proposed changes would simplify flight testing and thereby reduce costs, it was the consensus of the review team that the quality of Level B simulator performance would not be adversely affected for pilot recurrent training purposes.

In addition to a review of FAA simulator qualification requirements as embodied in the AC120-40B validation tables, consideration was given to the feasibility of using predictive modeling as a substitute for the flight test data typically required by the simulator manufacturer in order to tune an aeromodel to better match aircraft handling characteristics throughout the maneuver envelope. The use of flight data for this purpose is not a requirement of the objective tests specified in the FAA validation tables, which tend to reflect the acquisition of data taken from the middle of the flight envelope during steady state conditions. Nevertheless, simulator manufacturers have historically required flight data beyond that required for FAA objective tests, in order to refine the equations of motion so that simulation of aircraft dynamics is acceptable for the purposes of FAA-required subjective tests, and ultimately, for pilot acceptance. This requirement can add to the overall cost of the data package for a given flight simulator.

Considerable progress has been made in recent years in the use of predictive modeling techniques to generate estimated flight data. In conjunction with increased accessibility to very high-powered computer technology, these techniques have become quite sophisticated. Moreover, it has been possible to refine the precision of such models by comparisons of their output with actual flight data on an iterative basis over a period of years. Indeed, the use of such techniques has become standard practice for simulator manufacturers, as a means of establishing new simulator configurations pending the availability of actual flight test data. These techniques are also gaining acceptance as a means for transport category aircraft manufacturers to reduce the amount of actual flight testing required for certification of variants from a previously flight-tested aircraft make and model.

If predictive modeling can be successfully used to significantly reduce the requirement for flight data needed for aerodynamic model programming, it is estimated that an additional reduction of 25% in the cost of a simulator data package could be achieved. It was the consensus of the review team that this proposal has merit, and warrants further exploration, though it remains to be satisfactorily demonstrated that this approach would produce sufficiently accurate results for commuter class turboprop aircraft. The net cost savings for the flight test data package, which would result from the proposed validation table changes, and the use of predictive modeling as the primary source for supplemental flight data, is estimated to be 50%.

Motion Cueing

There is probably no topic in the domain of flight simulation in more dire need of a unified approach to the quantitative analysis of flight simulator cueing requirements than that of motion cueing. In the absence of tools for that purpose, the continuing controversy over motion extends to diametrically opposing arguments (Ref 9, 10, 11, and 12), resolution of which is unlikely to ever occur unless a systematic program of properly designed research is undertaken to develop the requisite methodologies and to conduct the necessary critical studies. Surprisingly little satisfactory progress has occurred toward that end in recent years.

The presently described FAA program is committed to the application of resources to address this need, but this effort is only in an early planning stage, and it remains to be determined whether such a program will be more successful than previous endeavors in this arena. In the meantime, the FAA must move forward to address the motion cueing considerations that would be applicable to updating the qualification requirements for a Level B flight simulator. Pending the availability of new scientific data, decisions in this regard must be based on the existing literature, and on best expert judgment.

In light of the current state of knowledge (Refs 13, 14, 15, 16, and 17), the FAA has determined that both Level A and B full flight flight simulators must continue to be equipped with full-body-motion capability. Remaining at issue is whether the existing standards for motion platform performance for a Level B simulator should be left unchanged, or whether, in the interest of equal or better fidelity at reduced cost, modifications may be warranted. The objective tests in AC120-40B only directly address motion platform hardware performance, not motion drive software, which is only indirectly assessed by virtue of subjective acceptance testing. Consequently, there is presently no defined standard which validates that the motion system *per se* provides appropriate cueing. Nor is there a requirement for objective tests which specifically address acceptable phase lag relationships between flight simulator visual and motion systems, though there is ample data that the lack of simulator fidelity for onset cueing therein can not only impact motion perception (Refs 14, 15, and 17), but it can be a contributor to simulator sickness (Ref 18). While consideration of additional standards or guidelines along these lines might on the surface appear to risk increasing rather than reducing the costs for a Level B simulator, it is entirely possible that the establishment of such standards could enable increased regulatory flexibility with respect to approval criteria for alternative full-body-motion simulator system configurations. For this reason, these issues will be addressed as part of the FAA's comprehensive Level B simulator qualifications standards review.

Visual Image Generation & Display Technology

The existing requirements in AC120-40B for simulator visual image generation systems could be considered to be minimal, given the progress that has occurred in the capabilities of commercial off-the-shelf technology (COT), and the associated significant drop in the cost of such systems during the past decade. Not only are relatively inexpensive full-color, photo-texture-capable image generation systems suitable for Level B simulator use available in the marketplace, but user friendly, relatively inexpensive data base modeling systems are also available, as a result of which there does not appear to be any requirement to address image generation from either the perspective of the FAA Level B qualification standards review, or planned research. On the other hand, progress in the development of affordable visual system display technology, though evident, has been less dramatic. Until recently, there have been few alternatives to calligraphic displays, or to hybrid rastergraphic/calligraphic displays, suitable for meeting FAA Level B qualification standards for approach and runway lights. Similarly, although Level B standards do not explicitly call out a requirement for collimated optics, it is unlikely that a display system without such optics could qualify with respect to simultaneous field-of-view, sink rate cueing, and depth perception. Although Level B qualification standards only specify a requirement for a 45 H by 30 V degree field-of-view for each pilot, the provision of such displays systems can be relatively expensive. No change in the existing standards for Level B simulator display systems is contemplated. However, it is planned to seek the recommendations of subject matter experts concerning alternatives for more affordable display technology capable of meeting existing Level B standards.

Future Plans

Practical Applications

Plans for the immediate future include convening groups of recognized subject matter experts in the areas of simulator motion cueing, as well as simulator visual display technology, respectively, for the purposes of reviewing the existing AC120-40B qualification standards for Level B flight simulators in light of the considerations discussed above, and formulating recommendations to the FAA that could enhance simulator affordability without degrading quality of performance.

Following FAA review, collation, and integration of expert input on aeromodeling, motion systems, and visual display systems, the FAA will publish an addendum to AC120-40, as revised, which will incorporate any appropriate revisions to qualification standards for Level A and B full flight simulators.

Planned Research Program

Planning for an FAA-sponsored comprehensive simulator research program is still in development. The research plan will not be finalized until the recommendations from the remaining subject matter expert groups discussed above are available, and a presently ongoing review of the pertinent scientific literature in these areas has been completed. However, certain research priorities have already emerged for the immediate future. First, with regard to the use of predictive modeling as a substitute for the supplementary flight data used to tune the math model, the FAA will sponsor research to compare the results of predictive modeling with actual flight data for commuter class turboprop aircraft. Provided the results of that endeavor are positive, the characteristics of effective strategies for the use of predictive models to generate valid data estimates, and the properties of effective models for that purpose, will be documented. This information will be disseminated to industry. Concommitantly, the FAA will seek recommendations on whether guidelines for the application of such models to flight data estimation should be incorporated into agency advisory materials.

Secondly, a research program to address the key unanswered issues in flight simulator motion cueing for transport category aircraft will be designed and initiated. Such a program must advance our state of knowledge regarding the critical interactions between the human visual/somatosensory/vestibular senses relating to motion, simulator hardware characteristics, simulator software-drive algorithms, and the transfer of pilot performance to the aircraft. As a minimum, this research must resolve the question of whether whole-body cueing information is needed for performance of particular flight tasks in the simulator, and if so, whether its presence or absence impacts transfer of pilot performance on those tasks from the simulator to the aircraft. If simulator motion is needed for particular maneuvers, then research must establish the nature of the translational, linear acceleration, and angular acceleration motion cueing required for those maneuvers. Since it is known that there exists a powerful interaction between visual perception and motion perception (Ref 9), if motion cueing is needed, then research must address the requirements for the synchronization between visual and motion cueing systems. Given that a Level B simulator only requires a 45 H by 30 V degree field-of-view per pilot eye point, the research must include consideration of field-of-view size effects on visually induced motion perception, and the associated interaction of visual field size with whole-body motion cueing. And in particular, since a flight simulator is restricted in its physical capacity to provide translational and acceleration motion cues, if motion cueing is warranted, research is needed on to how to optimize motion system design, so as to most effectively provide the essential cues, while minimizing false cues.

Though none of these questions are new, all of them remain controversial, despite the existing body of research literature. It is therefore appropriate that they should be reexamined in light of the most recent improvements in simulator visual and motion system technology, with a focus on better quantifying the relationships between the pertinent engineering and behavioral variables.

Conclusions

The FAA is undertaking a proactive effort to increase the accessibility of flight simulators to commuter airlines for use in recurrent pilot training in the United States. This strategy entails examining the qualification standards for a Level B simulator, to determine whether revisions which enhance affordability without degrading fidelity may be feasible. The most immediate product of this ongoing effort will be an update to AC120-40, as revised, addressing modified qualification standards for Level A and B flight simulators. It is hoped that this will serve as an enabling initiative for industry, by virtue of providing advance notice of FAA acceptance of more streamlined qualification criteria for such equipment. Whether such equipment will in fact ever be built must be determined by the marketplace. While the FAA encourages the use of FTDs as a means of increasing training efficiency, the FAA does not anticipate any change in the requirement to utilize an approved FFS for accomplishing certain pilot evaluation requirements. The FAA has no plans to authorize the use of an enhanced FTD to substitute for use of a FFS to accomplish those requirements.

In conjunction with its review of Level B qualification standards, the FAA is in the process of initiating a comprehensive program of flight simulator research. The short term goals for this program entail the acquisition of data needed to support the Level B initiative, such as the feasibility of using predictive modeling to generate estimated flight data suitable for use in tuning the simulator aeromodel. On a more long term basis, the research will address certain fundamental issues in flight simulation, such as the contribution of whole-body motion cueing to effective flight simulation training in transport category aircraft. Although still in an early planning stage, the FAA has elected to announce its intentions for such a program in the interest of soliciting suggestions on how it should best be formulated, and for the purpose of seeking partnerships in its execution. The FAA welcomes the recommendations and participation of interested parties to this endeavor.

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Table 1

PROPOSED
VALIDATION TEST DATA SOURCES
AND TEST TECHNIQUES
FOR LEVEL **B** FLIGHT SIMULATOR
(Multi-engine Turboprop Aircraft)

120-40B test No	Test Name	Existing Data Source	**Test Objective (Obj)** Proposed Test Technique and Instrumentation	Comment
PERFORMANCE				
TAXI				
1.a.(1)	Min Rad turn	AFM/Ops Manual	**Obj: Verify ground handling and required ground maneuvering surface area.** None Required	NC
1.a.(2)	Rate of Turn vs Nosewheel Steering angle		**Obj: Verify that steering is commensurate with airplane steering .** Tiller protractor and video of heading indicator during steady state turn or full rudder pedal steady state turn and video. If less than full rudder pedal is used, pedal position must be recorded. (A single test procedure may not be applicable to all airplane's steering systems, therefore appropriate measurement procedures should be devised and proposed for FAA concurrence.) If heading change rate and speed are constant, ground speed can be calculated, otherwise groundspeed must be measured by accepted methods.	Rev
TAKEOFF				
1.b.(1)	Ground Acceleration	Cert Data TIR AFM	**Obj: Confirm the simulator model ground performance during acceleration.** As currently permitted by 40B. Also, could use stop watch, calibrated A/S and rwy markers to acquire data during a takeoff with power set before brake release. Power settings hand recorded. If an inertial measurement system is installed, speed and distance may be derived from acceleration measurements.	Rev
1.b.(2)	Min Cont Spd, Grd	Cert Data TIR AFM	**Obj: Confirm the simulator on ground aerodynamic controls, thrust and control models.** Available in AFM, Required Certification Test	NC
1.b.(2)	Alternative to Min Cont Spd, Gnd	None	**Obj: Confirm the simulator on ground aerodynamic controls, thrust and control models.** Rapid throttle reductions at speeds near Vmcg recording yaw rate, control inputs etc. The nose wheel must be free to caster, or equivalently freed of sideforce generation. The applicant for simulator qualification must demonstrate that the simulator yawing moment due to asymmetric thrust and the rudder yawing moment to compensate are the same as those of the airplane. Inertial measurement system and cockpit control force and position measurement device.	** Rev

(Con't)

120-40B test No	Test Name	Existing Data Source	**Test Objective (Obj)** Proposed Test Technique and Instrumentation	Comment
1.b.(3)	Min Unstick Speed	Cert Data TIR	**Obj: Confirm low speed elevator effectiveness in ground effect and confirm lift model at high angle of attack in ground effect.** Required speed definition for Part 25, not defined for Part 23 Commuter Category. Rotate, using full elevator input, at a speed less than V_R , hold a constant attitude until lift off etc. The test and procedure are described in AC 25-7 para 10. B.(5) which should be consulted for the test procedure. An equivalent test may be used for Part 23 Commuter Category airplanes for which V_{MU} is not an airplane certification requirement. The elevator effectiveness and lift computation for the simulator must be verified by comparison to the airplane. Inertial measurement system and control input measurement devices.	** NC
1.b.(4)	Normal Takeoff	Cert - Performance Only	**Obj: Confirm the overall performance and handling of the simulator model during ground, lift off and transition through ground effect, and initial climb operations.** Calculate AOA from pitch attitude and flight path. Inertial measurement system, radio altimeter, video of calibrated aircraft instruments, Force and position measurement on cockpit controls.	** NC
1.b.(5)	Critical Engine Failure on Takeoff	Performance data available from certification	**Obj: Confirm simulator model response to a critical engine failure during the take off run, corrective control inputs, effect on takeoff distance, and initial climb with one engine inoperative.** Need is aircraft dynamic response to engine failure and control inputs required to correct flight path. Inertial measurement system and video system. Omit AOA measurement. Measure heading and lateral acceleration.	** Rev
1.b.(6)	Crosswind Takeoff	None, except limiting crosswind	**Obj: Confirm proper response of simulator model, including flight controls, to a crosswind during take off and post lift off.** Inertial measurement system, video of calibrated aircraft instruments, Control forces measurement device, Omit AOA. Measure heading and lateral acceleration. The wind profile should be specified. The 1/7 law to 10 meters is suggested as an acceptable wind profile model that is now in use.	** Rev
1.b.(7)	Rejected	None	**Obj: Confirm simulator model overall on ground performance and modeled wheel brake effectiveness during maximum wheel braking.** Use ground acceleration per 1.b.(1) and stopping per 1.d.(1) except that take off flap settings must be used which may effect the stopping distance.	Rev
CLIMB				
1.c.(1)	Normal Climb, all engines	Certification data, TIR, AFM,	**Obj: Confirm simulator model climb performance.** As now permitted by 40B, could also do with stop watch and calibrated ships airspeed system.	Rev
1.c.(2)	Second Segment Climb, One Engine Inoperative	Certification data, TIR, AFM	**Obj: Confirm simulator model climb performance in airplane take off configuration with one engine inoperative.** As now permitted by 40B, could also do with stop watch and ships calibrated airspeed system.	Rev

(Con't)

120-40B test No	Test Name	Existing Data Source	**Test Objective (Obj)** Proposed Test Technique and Instrumentation	Comment
1.c.(3)	Approach Climb, one engine inoperative	Certification data, TIR, AFM	**Obj: Confirm simulator model climb performance in airplane approach configuration with one engine inoperative.** As now permitted by 40B, could also do with stop watch and ships calibrated airspeed system.	Rev
STOPPING				
1.d.(1)	Deceleration Time and Distance, Wheel Brakes	Certification data, landing distance tests, TIR, AFM	**Obj: Confirm simulator overall lift, drag and wheel braking model on the ground.** None Required if time to stop is available in certification data.	Rev
1.d.(2)	Deceleration Time and Distance, Reverse Thrust	None	**Obj: Confirm simulator on ground overall lift, drag and thrust modeling with reverse thrust.** Landing Tests, stop watch, runway markers, video, calibrated aircraft instruments. Thrust control lever positions and engine output (pertinent parameters) must be recorded.	Rev
ENGINES				
1.e.(1)	Acceleration	None	**Obj: Demonstrate that the simulator engine model responds correctly during the specified condition.** Calibrated aircraft instruments, video with time read out.	Rev
1.e.(2)	Deceleration	None	As above	Rev
HANDLING QUALITIES				
STATIC CONTROL CHECKS				
2.a.(1)	Column Position vs Force	Maintenance Manual for surface to column calibration	**Obj: Confirm model of flight control system force, position and friction relationships.** Control force and position measurement device and x - y recorder needed. Surface position could be measured from FDR sensor or, if no FDR sensor, at selected column positions using a control surface protractor.	* Rev
2.a.(2)	Wheel Position vs Force	Maint Man as above	Same as above	* Rev
2.a.(3)	Pedal Position vs Force	Maint Man as above	Same as above	* Rev
2.a.(4)	Nosewheel Steering Force and Position	None	**Obj: Confirm important nosewheel steering metrics of the simulator model which are important to ground handling.** Use 45A. Measure breakout with hand held force gauge. Use hand held gauge to measure force after breakout for small arc. Predict remainder.	Rev
2.a.(5)	Rudder Pedal Steering Calibration	Acft Design Data	**Obj: Confirm important nosewheel steering metrics of the simulator model which are important to ground handling.** Force pads on pedals, pedal position measurement device, design data for nose wheel position. (Turn radius will be compared to AFM at full pedal, and possibly other, deflections also) [See 1.a.(2) above]	* Rev
2.a.(6)	Pitch Trim Calib. Indicate vs Compute	None	**Obj: Validate the simulator model pitch trim calculation.** Calculated	NC

(Con't)

120-40B test No	Test Name	Existing Data Source	**Test Objective (Obj)** Proposed Test Technique and Instrumentation	Comment
2.a.(7)	Power Lever and other engine control levers Angle vs Engine Indication	None	**Obj: Confirm that given engine control lever positions result in the proper engine performance indications.** Fabricate scale to use on throttle quadrant. Video camera to record steady state instrument readings or hand record steady state engine performance readings.	Rev
2.a.(8)	Brake Pedal Position vs Force	Acft Design Data	**Obj: Assure that the brake pedal produces the appropriate force feedback for a given brake pedal position.** Use design/predicted data. As for Level 6, measure only at 0 and maximum and use acft design data curve for deflections between extremes.	* Rev
LONGITUDINAL				
2.c.(1)	Power Change Dynamics	None	**Obj: Confirm the correct simulator model dynamic response to an in flight airplane power or configuration change.** Do as per AC120-40B. Inertial measurement system would then be required. Transient data is needed therefore the dynamic case must be done.	** NC
2.c.(2)	Flap/Slat Change Dyn	None	Same as above	** NC
2.c.(3)	Spoiler/ Speedbrake Change Dyn	None	Same as above	** NC
2.c.(4)	Gear Change Dynamics	None	Same as above	** NC
2.c.(5)	Gear Flap Slat Operating Time	Design Data, Certification Tests	**Obj: Assure that the simulator model configuration change time increment corresponds to that of the airplane.** Measure in conjunction with acquisition of data for 2.c.(1), (2), (3), (4) above. Statement of compliance referencing an appropriate data source. [Such as design data, production flight test schedule, maintenance test specification etc.]	Rev
2.c.(6)	Longitudinal Trim	Certification Tests (limited)	**Obj: Confirm that simulator model parameters are correct in level flight steady state conditions.** Inertial measurement system for pitch attitude, cockpit controls position measurement equipment with a calibration of cockpit controls positions and surface positions, ships engine instruments, do a number of level runs in accordance with the guidance of AC120-40B.	** Rev
2.c.(7)	Longitudinal Maneuver Stability	Certification Tests, TIR	**Obj: Confirm the simulator model longitudinal control force as a function of normal acceleration.** Ships calibrated airspeed indicator. Apply a temporary high resolution bank angle scale to attitude indicator, inertial measurement system and wheel/column force measurement device.	** NC
2.c.(8)	Longitudinal Static stability	Certification Tests TIR	**Obj: Confirm the simulator model longitudinal control force as a function of airspeed increments from trim airspeed.** Ships instruments, hand held force gauge.	NC
2.c.(9)	Stick Shaker, Airframe Buffet, Stall Speeds	TIR, AFM	**Obj: Confirm that the simulator model produces stall at the correct airspeed and incorporates the appropriate warning modeling at airspeeds approaching the stall.** Acquire using stop watch, ships calibrated airspeed, and video, hand record flight condition and configuration. The speeds are available in the TIR and AFM. Consideration should also be given to stall characteristics	NC

(Con't)

120-40B test No	Test Name	Existing Data Source	**Test Objective (Obj)** Proposed Test Technique and Instrumentation	Comment
2.c.(10)	Phugoid	None	**Obj: Confirm that the phugoid is correct as this mode is indicative of certain features of the longitudinal aerodynamic model and is very important to longitudinal trim ability.** Inertial measurement system is necessary to accurately measure this important response. Cockpit controller positions are also important, especially in cases where the dynamics of flight control system components alter the character of the response.	** NC
2.c.(11)	Short Period	None	**Obj: To assure that this primary longitudinal maneuvering mode is correctly produced by the simulator model.** Inertial measurement system, measuring primarily accelerations (normal), video.	** NC
LATERAL DIRECTIONAL				
2.d.(1)	Minimum Control Speed, Air	Certification Tests, TIR,	**Obj: Confirm the minimum airspeed at which control can be maintained with one engine inoperative. Control force and deflection, asymmetric thrust and overall handling approaching and at the minimum control speed are important and should be recorded.** Inertia measurement system, cockpit control force and position measurement device. An alternative procedure to measuring just the minimum speed at which control can be maintained is to measure the needed control deflections and other parameters at several speeds as the speed approaches the minimum control speed and as close as possible to the minimum speed in order to develop several simulator validation points at progressively lower speeds.	** NC
2.d.(2)	Roll Response (Rate)	None	Stop watch, ships calibrated instruments, high resolution scale on attitude indicator, FDR sensor for lateral control (wheel) deflection. Do roll in both directions using a number of wheel deflections and measure only the steady state rates. Video of instruments	* Delete
2.d.(3)	Roll Response to Step Input	None	**Obj: Confirm that the simulator model properly produces this primary lateral-directional dynamic response mode and produces the correct steady state roll rate.** Inertial measurement system to obtain rates. Lateral control input measurement device, video . Cruise case in addition to flight conditions specified in AC120-40B.	** Rev
2.d.(4)	Spiral Stability	None	**Obj: Confirm that the simulator model properly produces this primary lateral-directional dynamic response mode.** Stop watch, ships calibrated instruments, high resolution scale on attitude indicator or video.	NC
2.d.(5)	Engine Inoperative Trim	None	**Obj: Validate simulator trim or control deflections required to counterbalance engine inoperative asymmetric forces and moments.** Apply high resolution scales to trim controls and perform a ground calibration using protractors on the control/trim surfaces (ignores airloads). Use control scales for in-flight measurements. Very system dependent, but similar methods for other controls. Alternatively measure cockpit control force and position, especially during second segment climb where trimming is not a certification requirement and not a task to be accomplished in flight until the proper altitude and conditions are satisfied.	Rev

(Con't)

120-40B test No	Test Name	Existing Data Source	**Test Objective (Obj)** Proposed Test Technique and Instrumentation	Comment
2.d.(6)	Rudder Response	None	**Obj: Validate simulator model short term transient response to rudder inputs.** Inertial measurement system, Rudder pedal input position measurement device.	** NC
2.d.(7)	Dutch Roll	None, maybe TIR	**Obj: Confirm the lateral-directional simulator modeling as manifest by this coupled primary response mode.** Inertial measurement system. Record with and without yaw damper. Rudder pedal input position measurement device.	** NC
2.d.(8)	Steady State Sideslip	None, maybe TIR	**Obj: Confirm the relationships that exist between sideslip and rolling moment and secondarily the rudder and roll control power.** Use ground reference (a long straight path) for track and heading indicator for sideslip angle. Cockpit controller force and positions measurement device. If inertial measurement system is installed, measure lateral acceleration. Video. This test was not discussed during SME meeting. Revisions have been made based on the overall discussions.	* Rev
LANDINGS				
2.e.(1)	Normal Landing	None	**Obj: Confirm the overall performance and handling of the simulator model during descending flight near the ground, transition through ground effect, landing flair and touch down.** Inertial measurement system, cockpit control force and position measurement device.	** NC
2.e.(2)	Crosswind Landings	None	**Obj: Confirm proper response of simulator model, including flight controls, to a crosswind during descending flight near the ground, transition through ground effect, decrab and touchdown/rollout.** Inertial measurement system, cockpit controller positions and forces, record normal and lateral acceleration in lieu of AOA and sideslip.	** NC
2.e.(3)	One Engine Inoperative Landing	None	**Obj: Confirm proper response of simulator model, including flight controls, with one engine inoperative during descending flight near the ground, transition through ground effect, touchdown and rollout.** Same as above	** NC
2.e.(4)	Rudder Effectiveness with Rev Thrust	None	**Obj: Demonstrate that the rudder effectiveness during reverse thrust on landing in the simulator is representative of the airplane.** No test recommended since the test was specific to airplanes with aft fuselage mounted engines.	Delete
GROUND EFFECT				
2.f.(1)	Ground Effect Demonstrate G.E.	None	**Obj: Confirm the simulator modeling and proper aerodynamic modeling changes as a function of height and rate of change of height in ground effect.** Level fly-by trim runs. Use high resolution scale on elevator trim control. Ground calibrate Trim control with trim surface. Use ships calibrated flight instruments and engine instruments, video of trim controls and aircraft instruments. Or fly low angle constant pitch attitude approach and landing at constant power and record trim, control displacement and airspeed changes as ground is approached (not applicable to all airplanes). Inertial measurements system, cockpit controller force and positions, radio altitude and altitude rate are needed.	** Rev

Comments Legend

** tests for which an inertial data acquisition system is recommended - 20 tests
* tests for which some instrumentation less than inertial is recommended - 6 tests
Total number of tests requiring installation of instrumentation - 26
Total number of tests listed - 48

NC no change from the current AC120-40B guidance

Rev revision of the current AC120-40B guidance, usually by the use and acceptance of existing data sources or the use of more basic (less sophisticated and complex) flight test methods.

Notes:

1. Measurement of angle of attack and sideslip have been omitted for all tests. Also measurement of control surface positions is not required, however, cockpit controller positions must be measured where indicated and tolerances comparable to those for the control surfaces determined. These measurements alone result in revision to most Level B validation tests.

2. With the exception of the alternative, and in some cases relieving, techniques and instrumentation recommendations given above, all tests should be done to comply with the guidance of AC120-40B.

3. Measurements of control surface deflections/positions have been omitted in the above table, however, cockpit controller positions must be substituted and equivalent tolerances will have to be used when complying with AC120-40B Level B simulator qualification guidance.

4. To accommodate the recommended test methods and techniques, some measurements would be replaced with pilot's notes.

5. Certification/TIR data points are usually at the extremes of weight and CG, but still lie on the locus of a given parameter and are useful for model validation.

6. TIR data may be proprietary and should not be relied upon until known to be available

This paper was published in the Proceedings of the Royal Aeronautical Society Conference on Training - Lowering the Cost, Maintaining the Fidelity, 15-16 May 1996, London, UK, pages 2.1-2.17