DOT/FAA/TC-15/44

Federal Aviation Administration
William J. Hughes Technical Center
Aviation Research Division
Atlantic City International Airport
New Jersey 08405

Estimation of the Probability of Not Detecting Airplane Structure Fatigue Damage

February 2017

Final Report

U.S. Department of Transportation
Federal Aviation Administration

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/TC-15/44		

4. Title and Subtitle	5. Report Date
ESTIMATION OF THE PROBABILITY OF NOT DETECTING AIRPLANE STRUCTURE FATIGUE DAMAGE	February 2017
	6. Performing Organization Code
7. Authors	8. Performing Organization Report No.
Andrea M Dorado and Michel D Bode	
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Sandia National Laboratories PO Box 5800 Mail Stop 0615 Albuquerque, NM 87185-0615	
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
U.S. Department of Transportation Federal Aviation Administration Northwest Mountain Region Transport Airplane Directorate, Safety Management Branch 1601 Lind Ave., SW Renton, WA 98057	
	14. Sponsoring Agency Code ANM-117

15. Supplementary Notes

The Federal Aviation Administration William J. Hughes Technical Center Aviation Research Division COR was Sohrob Mottaghi.

16. Abstract

The goal for the first year of a multi-year data mining project seeking to use fatigue crack findings from operators' maintenance experiences as a source of data to estimate the risk associated with not detecting the fatigue damage was completed. The goal for this phase of the project was achieved when the Sandia National Laboratories staff members completed the foundation for the data gathering tools, validated the data source to be the Federal Aviation Administration (FAA) Service Difficulty Reports (SDR) database, and gathered all cracks located on fatigue critical baseline structures (FCBS) for one Boeing 737-300 airplane. This project is driven by FAA Order 8110.107 Monitor Safety–Analyze Data (MSAD) requirements and is using SDR data to obtain the counts of the number of cracks found in FCBS for each model of transport airplane. The MSAD process requires the use of data-driven, risk-based decision making. Combined with information from known structural failures caused by fatigue cracks, a proportion can be calculated that is a conservative estimate of Not Detected (ND), a conditional probability. Current ND estimates are based on engineering best judgment; the added use of operational experience is expected to refine and improve the overall Transport Airplane Risk Assessment Methodology process.

17. Key Words	18. Distribution Statement
Probability of not detecting; Fatigue critical baseline structures; Service difficulty reports; Transport airplane risk assessment methodology	This document is available to the U.S. public through the National Technical Information Service (NTIS), Springfield, Virginia 22161. This document is also available from the Federal Aviation Administration William J. Hughes Technical Center at actlibrary.tc.faa.gov.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	21	

ACKNOWLEDGEMENTS

The authors and the Federal Aviation Administration (FAA) would like to thank the sponsoring agency, domestic air carriers, and everyone who supported this project. Without the cooperation and kind support from these organizations and people, this work would not have been possible.

The following are the Transport Airplane Risk Assessment Methodology (TARAM) Not Detected (ND) team members:

- FAA Transport Airplane Directorate–Dr. John Craycraft
- FAA William J. Hughes Technical Center–Dr. John Bakuckas, Dr. Sohrob Mottaghi
- Sandia National Laboratories–Mr. Michel Bode, Mrs. Andrea Dorado

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AD	Airworthiness Directive
AIR	Aircraft Certification Service
ATA	Air Transport Association of America
COS	Continued Operational Safety
DOM	Date of manufacture
FAA	Federal Aviation Administration
FCBS	Fatigue critical baseline structure
MSAD	Monitor Safety – Analyze Data
ND	Not Detected
RAS	Risk Analysis Specification
SDR	Service Difficulty Reports
SMS	Safety Management System
SNL	Sandia National Laboratories
SRM	Structural repair manual
TARAM	Transport Airplane Risk Assessment Methodology

EXECUTIVE SUMMARY

In support of Safety Management System (SMS) development within the Federal Aviation Administration and other international organizations, the Aircraft Certification Service (AIR) is revising existing processes to embrace the concepts of an SMS. One of the most important efforts is the implementation of a Continued Operational Safety (COS) management process based on SMS concepts. AIR SMS Order 8110.107A was first issued on March 12, 2010 and became effective on September 15, 2010. The Monitor Safety–Analyze Data (MSAD) is a standardized COS process based on SMS principles. The MSAD process is used throughout AIR for the resolution of aircraft safety issues.

As defined in Order 8110.107A, one step in the MSAD involves the determination of the risk associated with suspected unsafe conditions. The development of methodologies to determine risk within all AIR SMS processes is governed by the AIR SMS Risk Analysis Specification (RAS). A basic requirement contained in the RAS is that AIR SMS risk analysis methodologies be as quantitative as possible (based on actual, measurable data) or be developed so that the methodology can evolve to become quantitative as sufficient data are obtained.

Order 8110.107A also directs each AIR directorate to develop an RAS compliant, risk analysis methodology within risk-level guidelines. The Transport Airplane Directorate has developed a risk analysis methodology—Transport Airplane Risk Assessment Methodology (TARAM)—that is fully compliant with the RAS and Order 8110.107A.

Sufficient transport airplane historical operational data, in a form amenable to the TARAM, is necessary to ensure compliance with the risk analysis requirements of the RAS and Order 8110.107A. This research requirement is for the development of quantitative data to support the estimation of the risk analysis parameter Not Detected (ND). ND is the conditional probability that the occurrence of a fatigue crack will not be detected before it leads to critical airplane damage. Critical airplane damage is defined as structural damage to an airplane that may result in a fatal accident (e.g., runway lateral departure, in-flight breakup, etc.). The requirement goals will be achieved through a review and analysis of existing historical and ongoing transport airplane operational and design data; research, identification, and collection of new transport airplane data; compilation of the data into the form and format best suited for efficient use in transport airplane risk analysis; directed research to develop data-driven risk analysis; and the statistical and probabilistic analysis of such data to determine the probability of ND.

1. INTRODUCTION

The risk analysis process for transport category airplanes is called the Transport Airplane Risk Assessment Methodology (TARAM). TARAM defines a process for calculating the risk of transport airplane type design safety issues. It applies to all aspects of an aircraft (e.g., flight controls, structures, etc.).

One parameter used in the TARAM analysis of an airplane structure fatigue issue is Not Detected (ND), which is the conditional probability that an occurrence of a defect (fatigue crack) will not be detected before it leads to an unsafe outcome (airplane accident). There is a tendency for analysts to be extremely conservative in their estimates of ND. Because the calculated risk is directly proportional to ND, large errors in estimating ND will result in large errors in the calculated risk. The calculated risk values are used to make safety decisions and to determine acceptable compliance times. Airworthiness Directives (ADs) are legally enforceable regulations issued by the Federal Aviation Administration (FAA) to correct an unsafe product. Excessively conservative ND values could result in unnecessary ADs or ADs with unnecessarily aggressive compliance times. This is contrary to the intent of a TARAM risk analysis, which is to provide the best estimate of the risk and then base the safety decisions and risk management on the actual risk. The scope of this project is limited to obtaining data that can be used in the estimation and development of guidance material for ND for airplane structure fatigue problems in metallic fatigue critical baseline structure (FCBS) components of transport category airplanes. The identification of FCBS components is defined in Advisory Circular 25.571D paragraph 6.c, except the information on control surfaces is limited to their major attach fittings and immediately adjacent structures. Control surface mechanical systems are also excluded. Secondary structure is specifically excluded from this research.

Cracks can be found by a directed inspection looking for a crack in a particular location or incidentally discovered during normal operation and routine maintenance. These incidental discoveries are an important source of safety estimates, which should be recognized in the risk analysis by the numerical value assigned to ND.

The objective of this work is to conduct research that results in data that will enable the FAA to generate guidance material to support engineers as they make estimates of an important conditional probability of not detecting airplane structural fatigue damage that is used in the risk analysis for airplane structural fatigue failure.

2. SURVEY OF AVIATION SAFETY DATABASES AND AIR CARRIER PARTICIPATION

Scoping efforts in the first phase of the project were focused on obtaining fatigue crack-finding data directly from operator maintenance information; this led to the conclusion that the best source of this information is the FAA Service Difficulty Reports (SDR) database. The reasons that support this conclusion are:

1. Researchers were experiencing long and convoluted legal issues concerning non-disclosure agreements with individual carriers to allow use of their proprietary maintenance data.

2. The complex data management systems used for storing and retrieving maintenance data by each carrier required a significant investment of time, travel, and manpower to conduct successful research.

3. The SDR database is collected from operator’s maintenance organization’s submittals to the SDR database as required by regulation. Once submitted, the data are publicly available via the internet. Therefore, there are no proprietary information issues that could hinder publication and use of the information.

Additionally, using the SDR database for industry-wide safety programs provides justification for the regulatory drivers.

2.1 DATA GATHERING TOOLS

Regardless of the source of data, development of a useful database requires the development of tools to acquire, manage, and use the gathered information. Sandia National Laboratories (SNL) Airworthiness Assurance Nondestructive Inspection Validation Center staff spent significant time building Microsoft® Excel® spreadsheet templates for each airplane model that are considered for TARAM ND estimates. Based on common makes and models of transport aircraft currently in service, a total of 10 airplane model tools (listed in table 1) were developed, which encompass most Boeing models (including MD-80), all Airbus models, and one Embraer model. These tools provide standard templates for data gathering that will support rapid and insightful use by FAA risk analysis staff in estimating the ND of fatigue cracking on FCBS items.

Table 1. Data gathering templates by airplane make and model

Aircraft Make	Aircraft Model Series	Aircraft Model
Boeing	MD-	80
Boeing	737-	300, 400, 500
Boeing	737-	600, 700, 800, 900
Boeing	747	
Boeing	757	
Boeing	767-	200, 300
Boeing	777	
Airbus	Single Aisle	300, 318, 319, 320, 321, 330
Airbus	Long Range	340
Embraer	-	145

2.2 COMPARISON AND VALIDATION OF FAA SDR SUBMITTALS AND COMMERCIAL AIRLINE SDR SUBMITTALS

The FAA SDR database was once considered of limited value, but improvements in industry reporting over the past 20 years and more recent improvements by the FAA in managing the information have provided a data-rich source for this project. To verify the completeness of current SDR data against actual operator submittals, a sample of SDR data submissions from two operators was compared with the publicly available FAA SDR data. The purpose of this comparison was to validate the consistency of the incorporated operator SDR submittals into the FAA SDR database. Once the SDR submittals were confirmed to be consistent between the operator and the FAA, it was determined that the FAA SDR submittals would be the primary source for collecting data to estimate the conditional probability of ND airplane structural fatigue damage.

SDR submittals covering a 1-year period were provided by each of the two commercial airline companies. The SDR submittals from the operators were then compared with the corresponding year's SDR submittals found in the FAA SDR database. The categories used to compare the SDR submittal data included Air Transport Association of America (ATA) code, aircraft make, aircraft model, aircraft serial number, difficulty date, operator designation, operator type, aircraft N number, stage of flight, discrepancy description, part name, manufacture part number, part condition, part location, date when submittal was sent (for commercial airlines), or date when submittal was received (for FAA).

The SNL staff determined that the degree of congruency between the commercial airline operator's SDR submittals and the FAA's SDR submittal entries is very high (approximately 95% or higher). The reason for such a small incongruity is the differences in the ATA codes/part locations. The primary difference in congruency was due to the ATA code because the ATA code in the FAA SDR submittal entry tended to be more specific than the ATA code submitted by the commercial airlines. An example of the comparison between the operator and FAA SDR submittals is shown in table 2.

Table 2. Comparison of SDR submittals

SDR Database	Database Row #	ATA_ CODE	AIRCRAFT _MAKE	AIRCRAFT _MODEL	AIRCRAFT_ SERIAL_NO	DIFFICULTY _DATE	OPER_ DESIGN	OPER _TYPE	ACFT _N_NO	STAGE_ OF_FLIGHT	Discrepancy	PART_ NAME	MFG_PART_N UMBER	PART_ CONDITION	PART_ LOCATION	SUB_ CODE	Sent (Operator)/Received (FAA)
Operator	8	5310	Boeing	7373H4	26574	20140502	Operator	01	363SW	IN	Main wheel well pressure deck craced at BS. 664+1, LBL 24.5+7.5. Rapaired Deck IAW EO.	Deck	65-45409	Cracked	Fuselage	A	6/2/2014
FAA	1818	5312	Boeing	7373H4	26574	20140502	Operator	1	363SW	IN	Main WW press deck craced at BS 664+1, LBL 24.5+7.5. Repaired Deck IAW EO.	Pressure Deck	6545409	Cracked	LT MLG WW	A	20140731
Operator	9	5310	Boeing	7373H4	26574	20140502	Operator	01	363SW	IN	Crack on main wheel well pressure deck located at BS. 664+1.5, LBL 24.5+8. Repaired Deck IAW EA.	Deck	65-45409-30	Cracked	Fuselage	A	6/2/2014
FAA	2003	5312	Boeing	7373H4	26574	20140502	Operator	1	363SW	IN	Crack on main WW press deck located at BS 664+1.5, LBL 24.5+8. Repaired deck IAW EA.	Pressure Deck	6545409306	Cracked	Fuselage	A	20140731
Operator	10	5310	Boeing	7373H4	26574	20140502	Operator	01	363SW	IN	Main wheel well pressure deck cracked at BS. 664+1, LBL 24.5+14.5. Repaired deck IAW EO and EA.	Deck	65-45409	Cracked	Fuselage	A	6/2/2014
FAA	1819	5312	Boeing	7373H4	26574	20140502	Operator	1	363SW	IN	Main WW press deck cracked at BS 664+1, LBL 24.5+14.5. Repaired deck IAW EO and EA.	Pressure Deck	6545409	Cracked	LT MLG WW	A	20140731
Operator	14	5320	Boeing	7373H4	26574	20140513	Operator	01	363SW	IN	Floor structure angle cracked at BS. 270, BL 0. Repaired angle IAW EO and EA	Angle	65-45833-44	Cracked	Fuselage	A	6/2/2014
FAA	2007	5320	Boeing	7373H4	26574	20140513	Operator	1	363SW	IN	Floor structure angle cracked at BS 270, BL 0. Repaired angle IAW EO and EA.	Angle	6545833449	Cracked	Fuselage	A	20140731
Operator	17	5715	Boeing	7373H4	26601	20140513	Operator	01	386SW	IN	R/H wing trailing edge bracket cracked at stabilizer beam outboard position WBL 114.00. R&R brackedt IAW SRM and DWG.	Bracket	65-50821	Cracked	R/H Wing	A	6/2/2014
FAA	1823	5720	Boeing	7373H4	26601	20140513	Operator	1	386SW	IN	Right wing TE bracket cracked at stabilizer beam OTBD position WBL 114.00. R&R bracket IAW SRM & DWG.	Bracket	6550821	Cracked	RT Wing	A	20140731

3. TARAM ND CRACK FINDING

The purpose of the current phase is to collect and document all the historical and ongoing fatigue cracking that occurs on FCBS for a certain number of aircraft of a certain make and model. The TARAM Crack Finding Database will be created for each individual aircraft starting with the oldest date of manufacture (DOM) and will eventually work up to the most recent DOM of a make and model. The first make and model of aircraft to be studied is from the Boeing 737-300 series. The first Boeing 737-3H4 studied has a DOM of 1984. The cracks located on FCBS will be gathered from the publically available FAA SDR database. The gathered data require a search protocol to allow for a systematic use of data when estimating the probability of ND.

3.1 SDR SEARCH PROTOCOL DEVELOPMENT TO IDENTIFY TARAM ND CRACK FINDINGS

A protocol was developed to collect data efficiently and consistently while populating the TARAM Crack Finding Database. This protocol ensures that the sorting and entering of the required data will be consistent and independent of the personnel conducting the research. The required data are gathered and sorted from the publicly available FAA SDR database for each year of the airplane's life. The protocol provides instructions for:

- Downloading the FAA SDR document.
- Sorting the SDR document by individual airplane serial numbers.
- Sorting maintenance entries to identify crack findings located on FCBS components based on the Joint Aircraft System/Component codes.

The protocol provides specific instructions for entering each crack finding into the TARAM Crack Finding Database, including:

- Entering general airplane information into the "MASTER" worksheet.
- Entering information about each crack specified in the Detailed Work Plan into a worksheet designated for each crack.
- Checking the "Summary" worksheet of the TARAM Database to ensure all of the information is entered correctly.

The protocol can be found in appendix A.

3.2 PERFORMING DATA GATHERING–TARAM ND CRACK FINDING DATABASE

Data mining using task-specific data gathering tools has begun and is expected to provide long-term support to the Transport Airplane Directorate as it continues to apply the Monitor Safety–Analyze Data process in the future. Using tools developed from common spreadsheet software, FAA engineers who are experienced in transport airplane structures (including damage tolerance concepts), maintenance, and inspection are identifying and evaluating crack finding reports from SDR data and assigning crack counts to appropriate FCBS for various models of transport airplanes. Early efforts were focused on the Boeing 737-300, one of the most common transport models.

A TARAM Crack Finding Database was created for the first Boeing 737-3H4 with a serial number of 22940 and a DOM of 1984. Airplane 22940 had 247 cracks entered into the TARAM Crack Finding Database.

For FAA staff to easily locate each crack, a picture is taken from the structural repair manual (SRM) for that airplane and inserted into the corresponding crack-finding worksheet. At the time of this report, only a few pictures had been incorporated into the crack-finding database, because of a lack of location description in the SDR submittal and the time required to sort through the extensive information in the relevant SRM. Figures 1 and 2 are the “MASTER” and “SUMMARY” worksheets, respectively, in the TARAM Crack Finding Database for airplane 22940. Figure 3 is an example of one of the 247 crack-finding entry worksheets in the TARAM Crack Finding Database for airplane 22940.

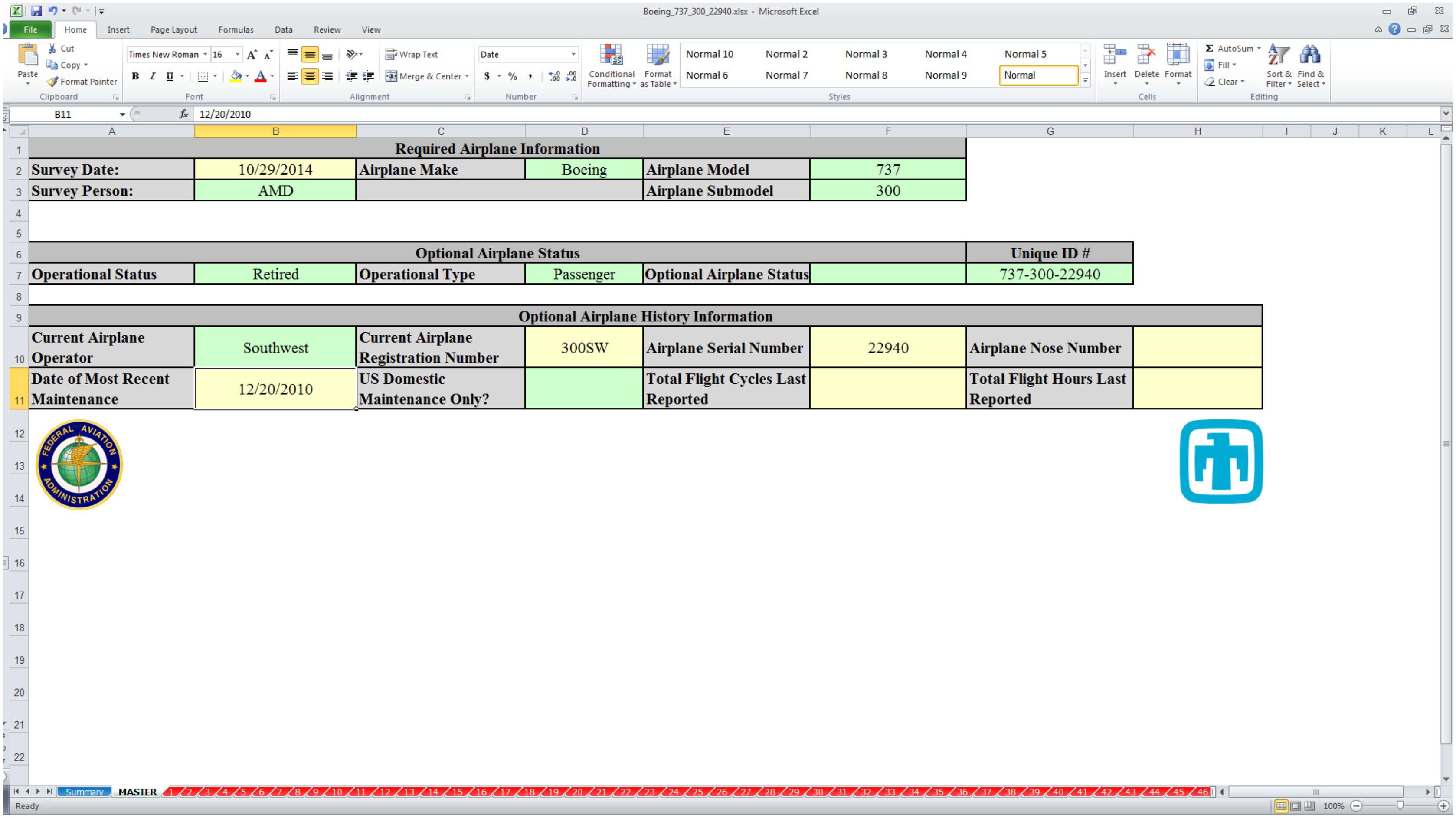
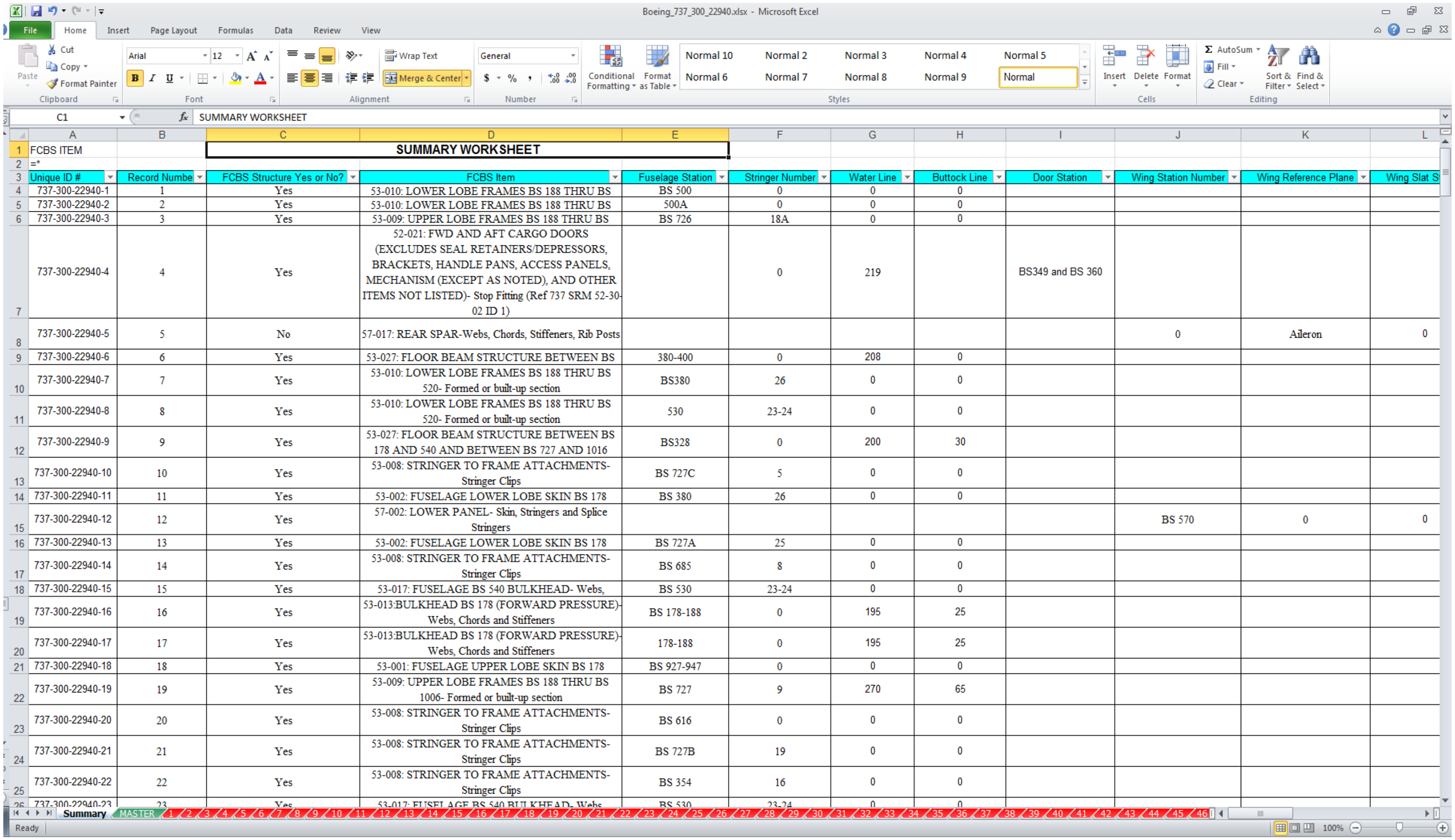


Figure 1. "MASTER" worksheet of TARAM ND Crack Finding Database

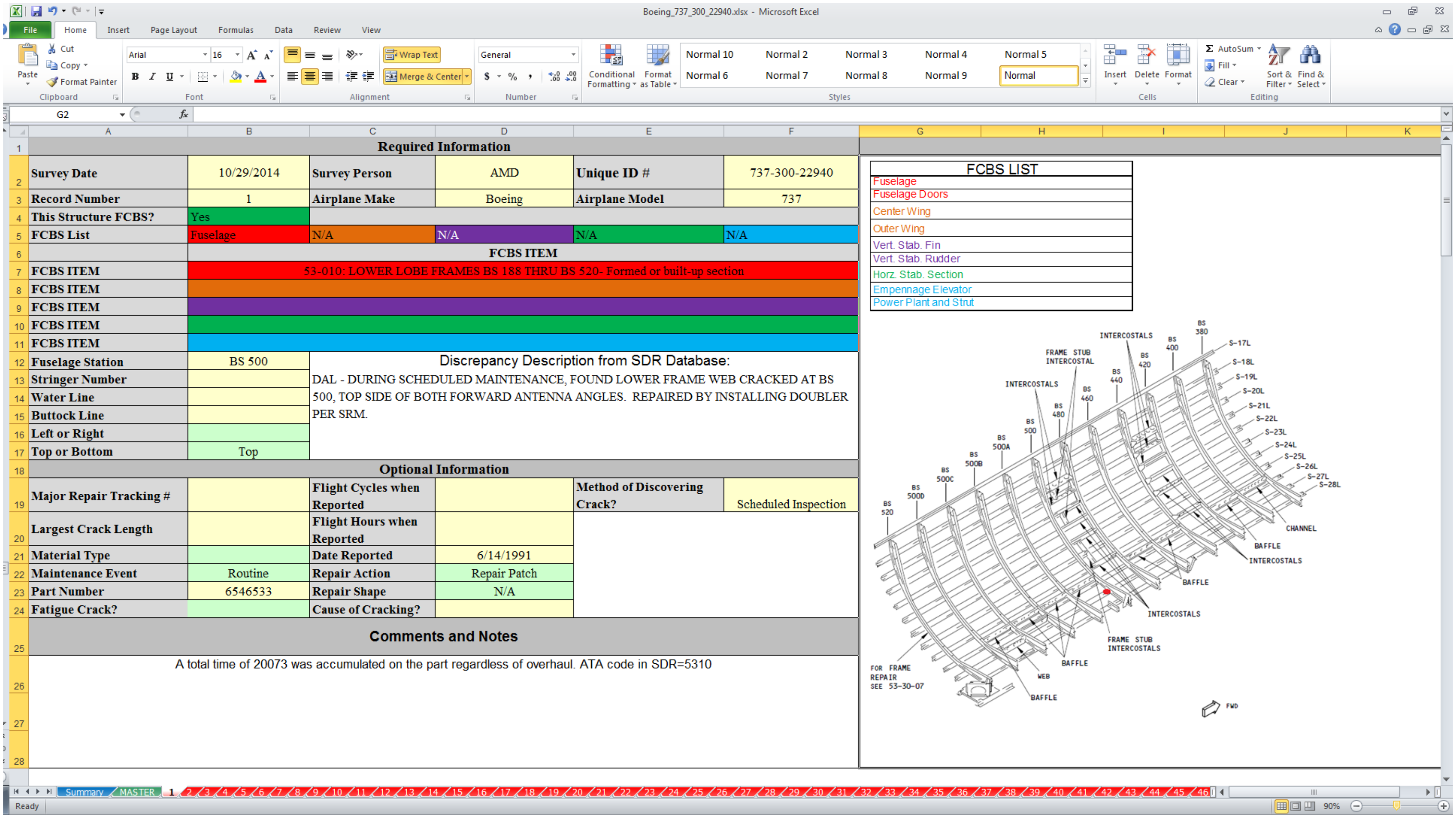


FCBS ITEM

SUMMARY WORKSHEET

Unique ID #	Record Numbe	FCBS Structure Yes or No?	FCBS Item	Fuselage Station	Stringer Number	Water Line	Buttock Line	Door Station	Wing Station Number	Wing Reference Plane	Wing Slat S
737-300-22940-1	1	Yes	53-010: LOWER LOBE FRAMES BS 188 THRU BS	BS 500	0	0	0				
737-300-22940-2	2	Yes	53-010: LOWER LOBE FRAMES BS 188 THRU BS	500A	0	0	0				
737-300-22940-3	3	Yes	53-009: UPPER LOBE FRAMES BS 188 THRU BS	BS 726	18A	0	0				
737-300-22940-4	4	Yes	52-021: FWD AND AFT CARGO DOORS (EXCLUDES SEAL RETAINERS/DEPRESSORS, BRACKETS, HANDLE PANS, ACCESS PANELS, MECHANISM (EXCEPT AS NOTED), AND OTHER ITEMS NOT LISTED)- Stop Fitting (Ref 737 SRM 52-30-02 ID 1)		0	219		BS349 and BS 360			
737-300-22940-5	5	No	57-017: REAR SPAR-Webs, Chords, Stiffeners, Rib Posts						0	Aileron	0
737-300-22940-6	6	Yes	53-027: FLOOR BEAM STRUCTURE BETWEEN BS	380-400	0	208	0				
737-300-22940-7	7	Yes	53-010: LOWER LOBE FRAMES BS 188 THRU BS 520- Formed or built-up section	BS380	26	0	0				
737-300-22940-8	8	Yes	53-010: LOWER LOBE FRAMES BS 188 THRU BS 520- Formed or built-up section	530	23-24	0	0				
737-300-22940-9	9	Yes	53-027: FLOOR BEAM STRUCTURE BETWEEN BS 178 AND 540 AND BETWEEN BS 727 AND 1016	BS328	0	200	30				
737-300-22940-10	10	Yes	53-008: STRINGER TO FRAME ATTACHMENTS- Stringer Clips	BS 727C	5	0	0				
737-300-22940-11	11	Yes	53-002: FUSELAGE LOWER LOBE SKIN BS 178	BS 380	26	0	0				
737-300-22940-12	12	Yes	57-002: LOWER PANEL- Skin, Stringers and Splice Stringers						BS 570	0	0
737-300-22940-13	13	Yes	53-002: FUSELAGE LOWER LOBE SKIN BS 178	BS 727A	25	0	0				
737-300-22940-14	14	Yes	53-008: STRINGER TO FRAME ATTACHMENTS- Stringer Clips	BS 685	8	0	0				
737-300-22940-15	15	Yes	53-017: FUSELAGE BS 540 BULKHEAD- Webs,	BS 530	23-24	0	0				
737-300-22940-16	16	Yes	53-013:BULKHEAD BS 178 (FORWARD PRESSURE)- Webs, Chords and Stiffeners	BS 178-188	0	195	25				
737-300-22940-17	17	Yes	53-013:BULKHEAD BS 178 (FORWARD PRESSURE)- Webs, Chords and Stiffeners	178-188	0	195	25				
737-300-22940-18	18	Yes	53-001: FUSELAGE UPPER LOBE SKIN BS 178	BS 927-947	0	0	0				
737-300-22940-19	19	Yes	53-009: UPPER LOBE FRAMES BS 188 THRU BS 1006- Formed or built-up section	BS 727	9	270	65				
737-300-22940-20	20	Yes	53-008: STRINGER TO FRAME ATTACHMENTS- Stringer Clips	BS 616	0	0	0				
737-300-22940-21	21	Yes	53-008: STRINGER TO FRAME ATTACHMENTS- Stringer Clips	BS 727B	19	0	0				
737-300-22940-22	22	Yes	53-008: STRINGER TO FRAME ATTACHMENTS- Stringer Clips	BS 354	16	0	0				
737-300-22940-23	23	Yes	53-017: FUSELAGE BS 540 BULKHEAD- Webs	BS 530	23-24	0	0				

Figure 2. "SUMMARY" worksheet of TARAM ND Crack Finding Database



Required Information					
Survey Date	10/29/2014	**Survey Person**	AMD	**Unique ID #**	737-300-22940
Record Number	1	**Airplane Make**	Boeing	**Airplane Model**	737
This Structure FCBS?	Yes				
FCBS List	Fuselage	N/A	N/A	N/A	N/A
	FCBS ITEM				
FCBS ITEM	53-010: LOWER LOBE FRAMES BS 188 THRU BS 520- Formed or built-up section				
FCBS ITEM					
FCBS ITEM					
FCBS ITEM					
FCBS ITEM					
Fuselage Station	BS 500	Discrepancy Description from SDR Database:			
Stringer Number		DAL - DURING SCHEDULED MAINTENANCE, FOUND LOWER FRAME WEB CRACKED AT BS 500, TOP SIDE OF BOTH FORWARD ANTENNA ANGLES. REPAIRED BY INSTALLING DOUBLER PER SRM.			
Water Line					
Buttock Line					
Left or Right					
Top or Bottom	Top				
Optional Information					
Major Repair Tracking #		**Flight Cycles when Reported**		**Method of Discovering Crack?**	Scheduled Inspection
Largest Crack Length		**Flight Hours when Reported**			
Material Type		**Date Reported**	6/14/1991		
Maintenance Event	Routine	**Repair Action**	Repair Patch		
Part Number	6546533	**Repair Shape**	N/A		
Fatigue Crack?		**Cause of Cracking?**			
Comments and Notes					
A total time of 20073 was accumulated on the part regardless of overhaul. ATA code in SDR=5310					

Figure 3. Crack entry #1 worksheet of TARAM ND Crack Finding Database

Though data gathering has been slow in the initial scoping phase of this project, it is expected to increase significantly in the next phase, which is exclusively focused on data collection now that the ground work has been completed.

4. CONCLUSION

The first year of a multiyear data mining project that has sought to use fatigue crack findings from operator's maintenance experiences as a source of data to estimate not detecting fatigue damage was completed. Within this first year, Sandia National Laboratories staff members partnered with air carriers and identified the data source, developed the foundation for the data gathering tools, validated the use of the Federal Aviation Administration (FAA) Service Difficulty Reports (SDR) database, and gathered the details of all cracks located on fatigue critical baseline structures (FCBSs) for one Boeing 737-300 airplane. Some additional data and observations from this project include:

1. The majority of cracks were found in the fuselage section of the airplane, most of which (55 crack entries) were found on stringer clips. Based on prior studies, this is a likely cracking scenario for most transport aircraft [1].
2. More specificity is required in the SDR discrepancy descriptions to determine the exact location of the crack and if the location is on a FCBS structure. Lack of specificity in discrepancy descriptions also makes finding pictures of the crack's exact location difficult and time-consuming.
3. Having considered the budget and manpower available for this project, the SDR database was identified as the best available resource for gathering data to derive more accurate Not Detected (ND) risk analysis parameter estimates than the current estimate to support the FAA Order 8110.107 Monitor Safety–Analyze Data.

The amount of data gathered in one year can be estimated either by the cost per airplane or the amount of time per crack finding. Because the number of cracks found for the life of each airplane varies, it would be more accurate to use the time per crack-finding estimate. Because the groundwork has been completed, the time needed to find and enter each crack into the Transport Airplane Risk Assessment Methodology (TARAM) ND Crack Finding Database will be reduced. The time per crack finding is estimated to be 15 minutes per crack. Therefore, for an airplane with 247 cracks, it will take approximately 61.75 hours to enter all of the cracks into the TARAM ND Crack Finding Database.

5. REFERENCES

1. Bode, M. and Sippel, W., "Survey of Transport Airplane Structural Repairs and Alterations," FAA report DOT/FAA/TC-14/14, February 2015.

APPENDIX A—SERVICE DIFFICULTY REPORTS SEARCH PROTOCOL

A.1 SERVICE DIFFICULTY REPORTS SORTING STEPS

1. Download Tab Delimited Data Service Difficulty Reports (SDR) submittals from the FAA database at: http://av-info.faa.gov/dd_sublevel.asp?Folder=%5CSDRS
2. Save the text file using the downloaded name.
3. Import the text file into a spreadsheet and save using the same name as the text file.
4. Filter by Model=Column c140 and then Submodel=Column c150
5. Using the cross-reference document titled "AIRCRAFT SERIAL NUMBER.xlsx," find the serial number of the oldest manufactured airplane with the desired model/submodel (from step 4).
6. In the SDR spreadsheet, filter column C440 (plane serial number) using the serial number found in step 5.
7. Filter column C40 (the ATA=JASC) code for the 5000 series codes.
8. Read the "s" in the columns with C510 in the title and highlight the rows containing a description where a crack was found.
9. Create one crack finding entry for each highlighted row.
10. Repeat steps 1–9 for the same airplane's serial number from date of manufacture (DOM) to retirement.

A.2 ENTERING CRACK FINDING INTO DATA COLLECTION FORM FOR ONE PLANE'S SERIAL NUMBER

1. Each airplane serial number will have its own data collection form. Work on the same airplane (one serial number) from DOM to retirement.
2. Save the data collection form template as a new file, then name it using the following format:

    a. Make_Model_Submodel_Serial Number.xlsx

3. In the "MASTER" worksheet enter:

    a. The survey date, airplane submodel (if empty or not correct)
    b. Current Airplane Operator
    c. Current Airplane Registration Number
    d. Airplane Serial Number
    e. Airplane Nose Number
    f. Airplane DOM-Survey (age of aircraft in months and years)
    g. (optional) Total Flight Cycles Last Reported for the Last Year the Serial Number was Entered into the SDR
    h. (optional) Total Flight Hours Last Reported for the Last Year the Serial Number was Entered into the SDR

4. Using the numbered worksheets to the right of the “MASTER” worksheet, enter crack-finding entries into worksheet 1 for recording the first and oldest crack finding. Enter the next oldest crack finding in worksheet 2, and continue entering the cracks, in the order they were found, in the subsequent worksheets. The most recent crack-finding entry should appear in the highest numbered worksheet. For each numbered worksheet, fill in the following boxes using the crack-finding entry from the SDR spreadsheet:

   a. Is this structure an FCBS? (yes/no)
   b. FCBS List: Using the column c40 in the SDR file, choose the corresponding location from the dropdown menu in the Data Collection Form.
   c. FCBS Item: Only enter information (from the SDR spreadsheet) in the FCBS Item row that matches the color of the FCBS List.
   d. Enter all additional information (as available) in the rows below the FCBS Item rows.
   e. Copy the Discrepancy Description from the SDR spreadsheet into the discrepancy description area in the Data Collection Form.
   f. Copy a picture from the plane’s corresponding SRM showing the FCBS location of the crack indicated by a dot or line drawn on the image.

5. Check the “Summary” page to ensure the entered information is indicated in the “Summary” sheet correctly.