A Proposed Benchmark for Future Air Traffic Computer Systems

Jacques Press

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16. Abstract

The study presented in this document describes how the Federal Aviation Administration (FAA) should develop simulation loads to use them collectively as a standard performance measure, called a benchmark, for the Host and Advanced Computer Systems. Conducted at the FAA Technical Center, this investigation addresses technical issues concerning workload design and provides a management plan outlining the benchmark development. A milestone schedule and a summary of required manpower for developing the benchmark are included.

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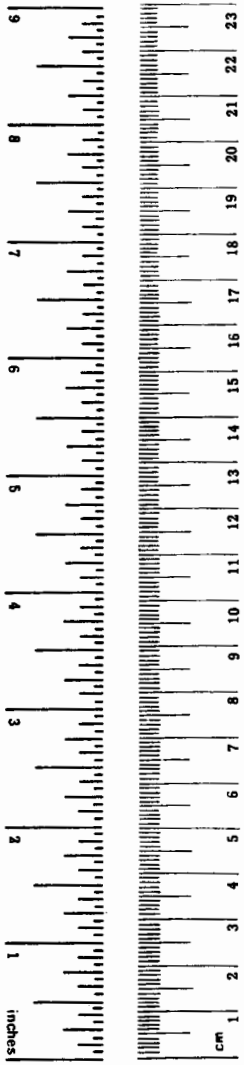
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

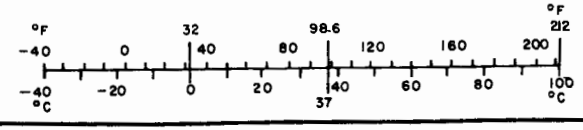
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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NATURE OF THE STUDY.

By 1985, the Federal Aviation Administration (FAA) expects to purchase computers that will eventually host throughout the country a slightly modified version of the current en route air traffic control software. With a highly expanded memory and an extensive channel capacity, this future equipment, known as the Host Computer, will process data at speeds well beyond the speed of today's field computers. Vendors plan to compete in selling their hardware as Host equipment and, consequently, the FAA will evaluate the performance of the proposed hardwares during lab tests. Specialists conducting these lab tests will impose heavy loads on the Host in a simulation mode to measure the working capacity of the equipment before it is deployed in the field. Towards this end, the study presented in this document describes how the FAA should develop simulation loads representative of field conditions so that they can be used collectively as a standard performance measure, called a benchmark, for the Host computers. Conducted at the FAA Technical Center, this investigation addresses technical issues concerning workload design and provides a management plan outlining the benchmark development.

Moreover, because the resulting benchmark will reflect traffic loads which are independent of computer systems, it will be useful in measuring the capacity of the successor to the Host: the Advanced Automation System (AAS). With ultramodern air traffic control display suites and a completely new software, this AAS will replace the current air traffic automation well beyond the Host era.

RECOMMENDATIONS.

According to a recent National Bureau of Standards investigation, benchmarking (establishing software standards to evaluate the performance of proposed computers) is an accepted methodology in the competitive selection of computer systems within both industry and the Federal Government (see reference 1). Agreeing with this thought, the following is recommended:

1. The FAA should develop a new simulation load based on a current workload known as the "600 series" simulation load, for use as the standard performance benchmark for future computer systems.

Rationale: Over the past 10 years, the FAA has applied the 600 series load with success during several development cycles. Thus, despite some limitations, the series represents a stable tool for computer evaluation within the realm of the FAA air traffic automation. Furthermore, because the FAA requirements for air traffic simulation are complex, no other existing industry benchmark can readily fit the FAA needs with respect to performance testing. Therefore, the 600 series should readily serve as a model benchmark load.

2. The Universal Data Set (UDS) environment, available at the Technical Center, should be updated and used as the standard data base from which to build the proposed benchmark.

Rationale: Field site adaptations differ so much from each other that no single site data base can be used as a standard for the others. In contrast, the UDS represents a simulation test bed containing most of the sites' characteristics and can, therefore, be used as the benchmark's adaptation. This eliminates the need to represent all the different air traffic control centers in the laboratory.

INTRODUCTION

BACKGROUND.

An extensive review of government practice concerning computer benchmarking ("Findings of the Standard Benchmark Library Study Group," National Bureau of Standards, NBS SP 500-38, January 1979) provided the following conclusions:

1. "Producing high quality benchmarks is usually a very expensive process for an agency."

2. The technical foundation is not yet established on "how to" benchmark.

In the light of these remarks, the Federal Aviation Administration (FAA) can save time by developing a workload based on an existing air traffic simulation load which was used successfully during the development and maintenance of the en route automation system. This existing workload, also known as the 600 series, contains a complex mix of simulated controller messages, radar targets, and interfacility communications. Six separate subsets make up the series. Each subset is labeled 601, 602, 603, 604, 605, or 606 to indicate whether it simulates the equivalent of a 111, 222, 333, 444, 555, or 666 aircraft track load, respectively.

During current lab performance measurements, simulation tapes representing any one of the above track loads supply the necessary data to drive the National Airspace System (NAS), which then records performance data for later analysis. Figure 1 illustrates this entire process. The two tape drives in the figure's extreme left represent the 600 series input to the simulation, while the rest of the figure shows the various data recording and reduction tools available at the Technical Center.

LIMITATIONS OF THE CURRENT 600 SERIES WORKLOAD.

Despite their potential as a benchmark, the 600 series exhibit characteristics that do not truly reflect air traffic patterns. For instance, all loads from 602 to 606 have flights violating separation standards by departing at 1 minute intervals. This condition causes excessive processing in the algorithms connected with flight separation such as the present conflict alert and future flight plan conflict probe functions. To a lesser degree, a similar problem is encountered during the processing of unwanted minimum safe altitude warning (MSAW) alerts. Consequently, the series must be updated to prevent unrealistic conditions from impacting Host tests in the laboratory.

Because the 600 series were developed years ago, they fail to represent the more current mix of traffic, controller inputs, and, possibly, radar target returns measured at the sites during recent times. Site data analysis is needed, therefore, to determine how the series can be improved to more closely simulate conditions existing in the field today.

Since the future computers are expected to handle loads heavier than today's traffic, performance tests must use simulation loads that are, in turn, denser than the present 600 series. Therefore, the software tool used for building the 600 series needs an update to produce these denser loads. For instance, the FAA

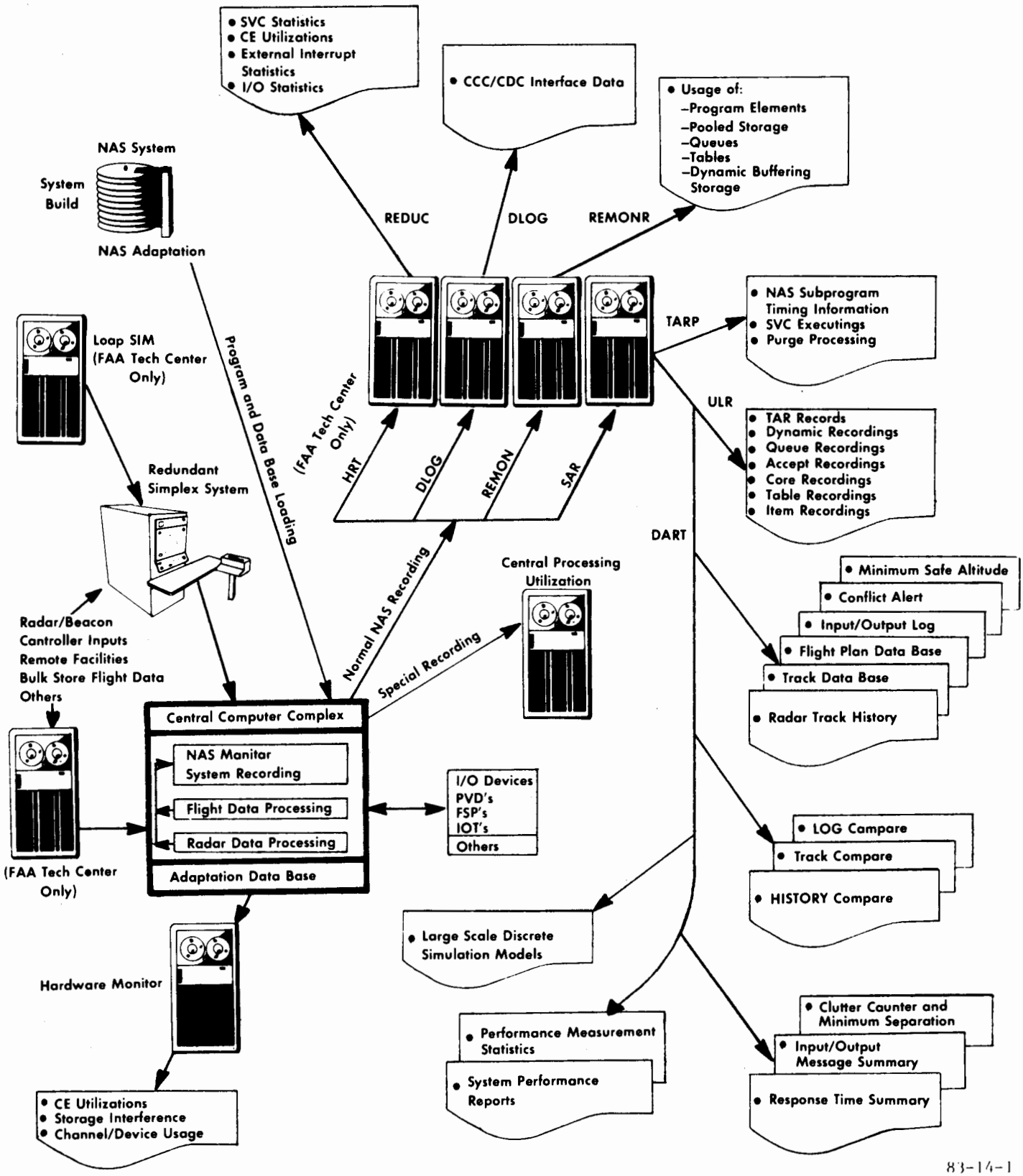

FIGURE 1. NATIONAL AIRSPACE SYSTEM SIMULATION, SYSTEM PERFORMANCE MEASUREMENT AND DATA REDUCTION CAPABILITIES

expects a load of 600 tracks by the year 1995 and 940 tracks by 2010 at Chicago alone, and, consequently, these projected loads must be reflected in the new benchmark.

Because of these difficulties, the services of a qualified contractor(s) are required to develop a new 600 series. For this purpose, a development plan (discussed in the next section) describes specific work activities leading to an acceptable benchmark.

BENCHMARK DEVELOPMENT

OVERVIEW.

The following management plan proposes a series of tasks which, when completed, will provide a new benchmark to be used during computer performance tests. The plan consists of four phases:

1. The design and development of a benchmark based on the 600 series workload.

2. The automation of manual steps taken during the benchmark construction. Because it may be desirable to vary traffic load parameters in the future to simulate specific situations, the FAA should have at its disposal the necessary tools to modify with ease the new benchmark. Consequently, the contractor will develop these tools during Phase II to allow for this future capability. Phase II remains an open item, however, since it is not known at this time how many traffic features should be automatically modified. Despite the uncertainty, a software tool that builds flight plans and one that creates flights according to specified mathematical ratios and statistical distributions are both highly desirable Without this tool, significant time may be spent to manually generate a new scenario everytime the FAA wants to vary the experiments.

3. A study that discusses in detail how to conduct a Host performance evaluation using the new benchmark, and also that recommends solutions to computer measurement difficulties foreseen when the Host will be benchmark-tested in the laboratory. Some of these difficulties are described in the section entitled "Phase III. Develop Performance Test Methodology."

4. A study discussing how the new benchmark can be extended to test the capacity of the AAS beyond the Host life in the field.

The flow chart in figure 2 illustrates how the tasks follow each other in time, while the milestone schedule shown in figure 3 provides their estimated completion times. In the following sections these tasks are discussed in terms of scope, schedule, and manpower. Figure 4 contains a manpower summary of the total effort.

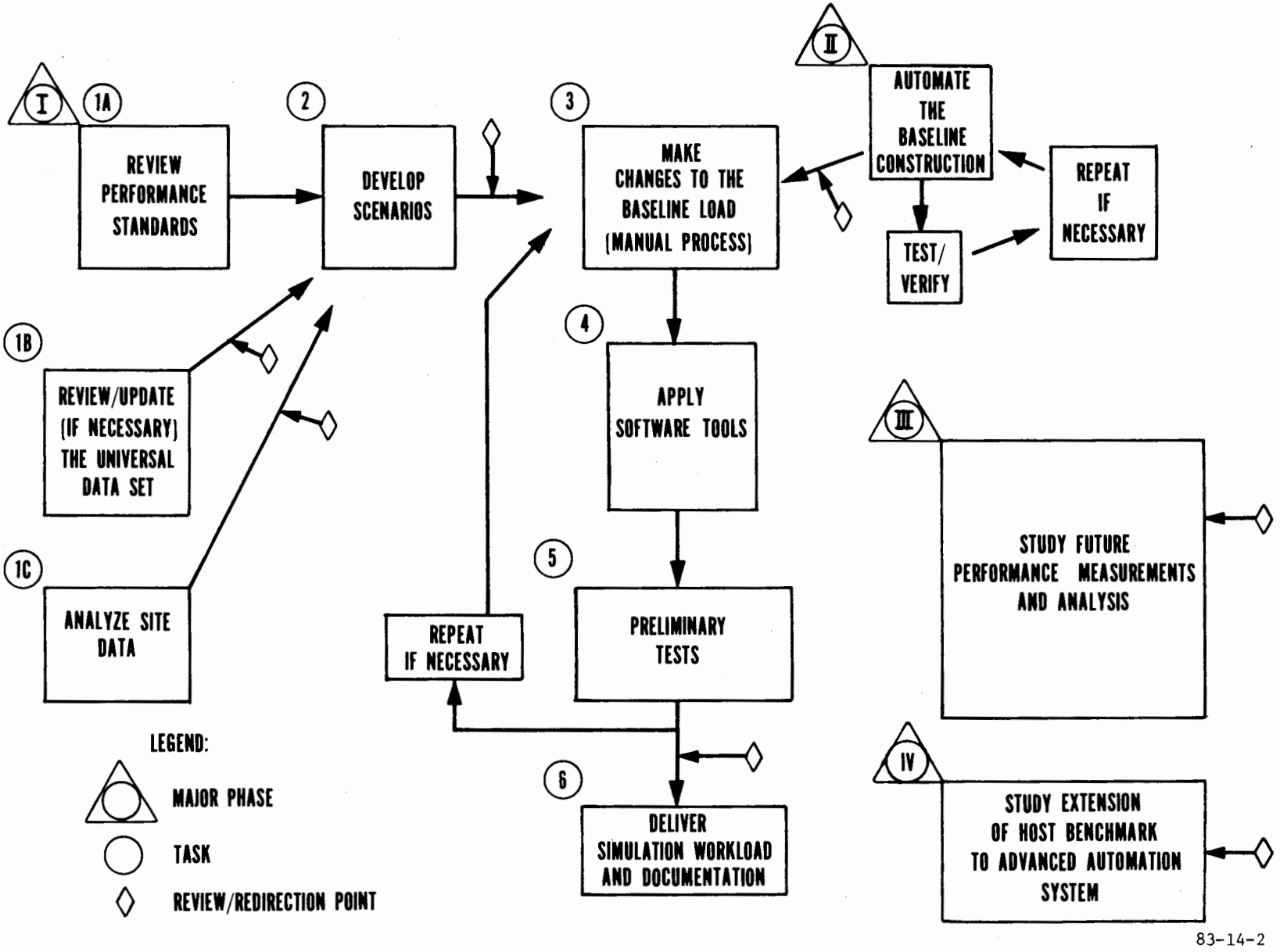

FIGURE 2. FLOW OF ACTIVITIES

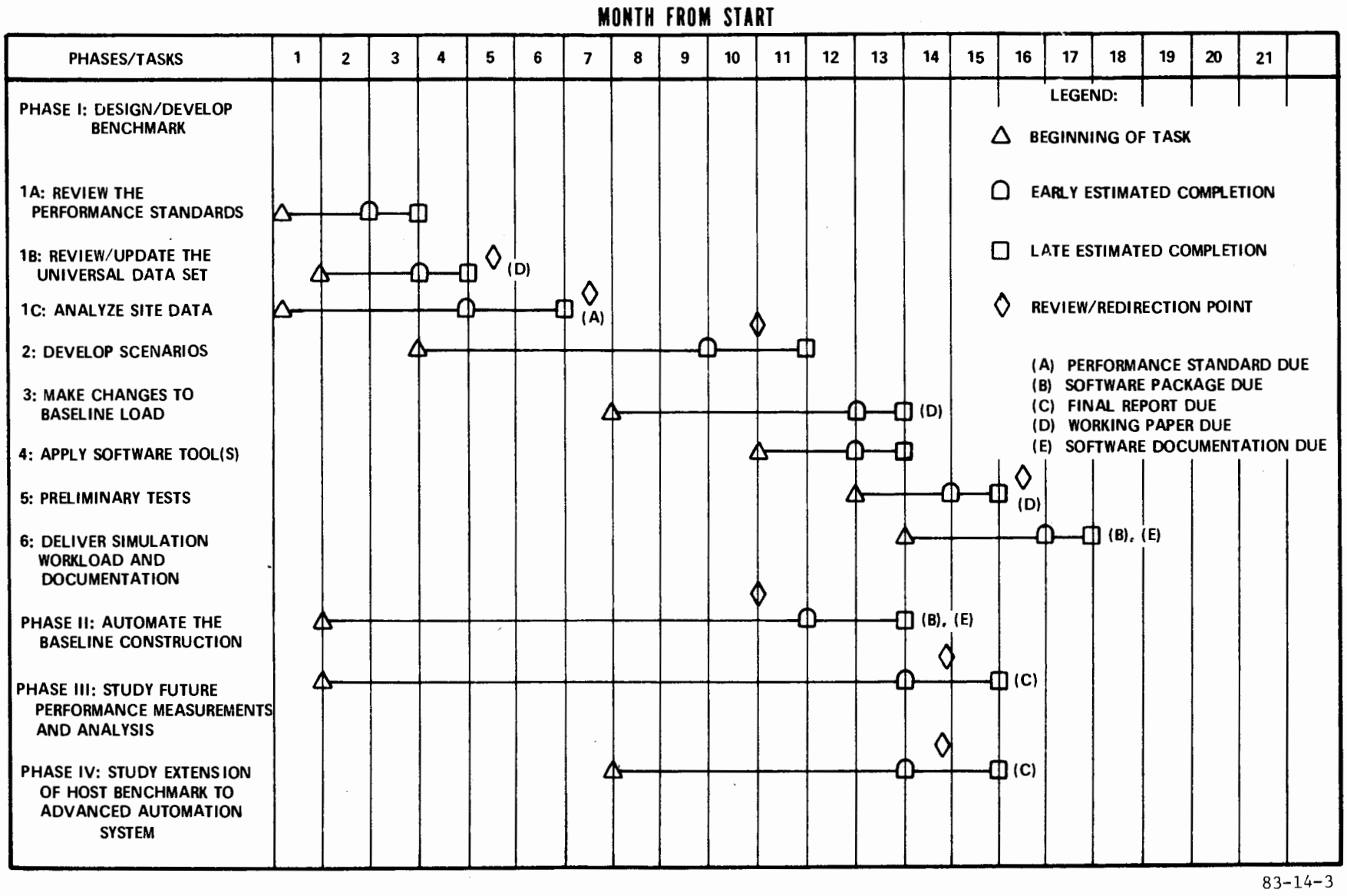

FIGURE 3. MILESTONE SCHEDULE

	No. of Personnel	No. of Months	Man Months
PHASE I: DEVELOP BENCHMARK			
Task 1A: Review Performance Standards	2	2 to 3	4 to 6
Task 1B: Review/Update UDS	2	2 to 3	4 to 6
Task 1C: Analyze Site Data	3	4 to 6	12 to 18
Task 2: Develop Scenarios	3	6 to 8	18 to 24
Task 3: Change Baseline Load	2	5 to 6	10 to 12
Task 4: Apply Software Tools	2	2 to 3	4 to 6
Task 5: Preliminary Tests	2	2 to 3	4 to 6
Task 6: Deliver Simulation Workload and Documentation	2	3 to 4	6 to 8
PHASE II: AUTOMATE BASELINE CONSTRUCTION	2	10 to 12	20 to 24
PHASE III: DEVELOP TEST METHODOLOGY	2	12 to 14	24 to 28
PHASE IV: EXTENSION TO AAS	1	6 to 8	6 to 8
		Total Man Months	112 to 146

FIGURE 4. MANPOWER SUMMARY

DESCRIPTION OF ACTIVITIES.

PHASE I. Design and Develop the Benchmark.

TASK 1a. Review and Identify Changes to the NAS En Route Computer Performance Standards.

Scope. During this activity, the contractor will review a series of documents that deal in whole or in part with system performance. The following is a partial list of these documents:

1. "Advanced Automation System (System Level Specifications)," FAA-ER-130-005B, November 1982.

2. "Derivation of Performance Characteristics for the Advanced Automation System," MITRE Working Paper 83W00004, FAA Contract DTFA01-82-C-10003, Project No. 1493B, January 10, 1983.

3. "Performance Specifications," NAS MD-318, latest release available from the FAA NAS Documentation Facility.

4. Management Plan, ARD-141, FAA Project No. 122-114-05A, April 18, 1979, (available from J. Press, ACT-120).

5. "Improved 600 Load Development Report," CSC/TM-80/6047, DOT-FA76WA-3815, February 1980.

6. "Improved 600 Load Simulation Tape Description and Modification Procedures," CSC/TM-79/6327, DOT-FA76WA-3815, February 1980.

7. "Improved Workload Generation Task Technical Requirements and Approach," Computer Sciences Corporation, DOT/FA76WA-3815, April 1979.

8. FAA document titled "Universal Data Set" (UDS).

9. Any of the IBM documents known as System Performance Analysis Reports, Memos, and Specifications (SPAR's, SPAM's, SPAS's) available at the FAA NAS Documentation Facility.

As other documents become pertinent, they will be added to this list.

After reviewing these documents, the contractor will identify all areas in the current performance standards that should be changed to meet the Host and AAS performance specifications. Major performance changes are already implied in items 1 and 2 above. Furthermore, at the end of Task 1C (described in a later section), the contractor shall make all the necessary changes to the NAS MD-318 Performance Specifications, and ultimately produce a stand-alone document to be used as a guideline during the scenario development (Task 2). The contractor shall ensure that all of the performance specifications for the new computers are addressed during this Task.

Schedule. Two to three months.

Manpower. Two computer systems analysts familiar with the en route NAS performance characteristics.

TASK 1b. Review and Update (if necessary) the UDS.

Scope. The UDS is the simulation data base used at the FAA Technical Center for the NAS en route software development. Over the years the UDS software data

base has been updated and modified to accommodate new and revised en route functions, but these changes have not been included in the UDS. Therefore, the contractor will update the UDS to reflect these modifications. This activity is necessary because analysts will later use the new UDS during the scenario development in Task 2.

As part of this task, the contractor will produce 20 copies of:

24"x34" - UDS maps.

24"x34" - UDS Radar Sort Box (RSB) transparent overlays.

24"x34" - En Route Minimum Safe Altitude Warning (E-MSAW) area transparent overlays.

Any additional overlays to be defined at a later time if necessary.

Schedule. Two to three months from start date.

Manpower. Two analysts.

TASK 1c. Analyze Site Data (Messages, Flight and Track Characteristics).

Scope. Personnel assigned to this task will analyze recent field data to derive real flight, track, and message mix characteristics which will then be used to prepare the benchmark. Such characteristics include (but are not limited to):

Percent and types of tracks (number of instrument flight rules (IFR) and controlled visual flight rules (VFR)).

Percent of IFR above and below 18,000 feet.

Percent of IFR below 6,000 feet (for E-MSAW purposes).

Percent of IFR with beacon capability.

Percent of IFR beacon aircraft that are discrete beacon.

Percent of IFR discrete beacon with Mode C.

Percent of VFR with beacon capability.

Percent of VFR with Mode C capability.

Percent of uncontrolled aircraft.

Average speed distribution on controlled and uncontrolled flights.

Flight type characteristics:

Percent of departures and their average speed.

Percent of arrivals and their average speed.

Percent of over flights and their average speed.

Percent of within flights and their average speed.

Control life of each flight type.

Average active flight plan life of each flight type.

Average pending flight plan life of each flight type.

Average life of each VFR flight.

Average number of sectors traversed for each flight.

Altitude:

Altitude range of IFR flights.

Altitude range of VFR flights.

Frequency of conflict alerts and E-MSAW alerts per 100 tracks per hour.

Frequency of potential conflicts per 100 tracks per hour. (A potential conflict is one being monitored by the conflict alert algorithm.)

Departure arrival routes:

For departure routes:

Number of preferentail departure routes (PDR's) used.

Number of preferential arrival/departure routes (PDARs) used.

Number of standard instrument departures (SID's) used.

Number of nonadapted departure routes used.

For Arrival Routes:

Number of standard terminal arrivals (STAR's) used.

Number of precision approach radars (PAR's) used.

Number of PDAR's used.

Number of nonadapted arrival routes used.

Types of Routes Used:

Number of the following:

Adapted Routes.

Adapted and direct routes.

Direct routes.

Message Inputs:

Determine the number and source of messages. The sources include bulk storage, adjacent NAS, teletypewriter (TTY), computer entry device (CED), data entry control (DEC), flight data entry and printout (FDEP), Automated Radar Terminal Systems (ARTS). The message types are as follows:

1. Initial flight plan (FP) data.

2. Flight data inputs:

    Discrete code requests.

    Code modifications.

    Qualifier modifications.

    FP amendment.

    Strip requests and flight plan readout requests.

    Route Modifications:

    Speed modifications.

    Altitude modifications.

3. Hold.

4. Progress reports.

5. Track reroutes.

6. Track control:

    Initiate transfer.

    Accept handoff.

    Select automatic handoff.

7. Intercenter:

    Accept transfer.

    Initiate transfer.

    Track update.

8. Display:

Code delete.

Code insert.

Data block offset.

Forced data block.

Modified altitude limits.

Flight strips.

Reposition list.

Request/suppress data block.

Route display.

At the end of Task 1 the contractor will deliver to the FAA a document, based on the current NAS MD-318 specifications, which reflects computer performance standards applicable to the future computer systems.

Schedule. Four to six months.

Manpower. Three system analysts familiar with NAS off-line data reduction and analysis.

TASK 2. Develop Scenarios.

Scope. Analytical in nature, this activity combines the results of the previous tasks to produce simulation scenarios subject to a variety of load patterns. Detailed work sheets must be assembled to translate Task 1 results into numerical tables for use during Task 3's "Baseline Changes." Task 2 represents, therefore, the interim step between upgrading the performance standards and computer-coding the benchmark. Moreover, during this task the contractor will obtain track load projection figures for the year 1995 and beyond from the FAA's Policy and Planning Staff so that he can properly size the simulation scenarios' traffic loads. These projection figures should include not only track loads but also aviation cross-section mixes such as IFR to VFR traffic ratio estimates expected in the future.

Personnel assigned to this task must ensure that the limitations inherent in the current 600 series are overcome when this activity is complete. For instance, because the future computers must be tested at loads beyond the current 666-track maximum, the analysts will replicate several times the baseline (or fundamental) 600 series into a well separated, conflict-free set of flights.

Schedule. Six to eight months.

Manpower. Three analysts.

TASK 3. Baseline Changes.

TASK 4. Software Tool (OS/SIM) Application.

TASK 5. Preliminary Tests.

TASK 6. Benchmark Delivery.

Scope. Related to each other, these four tasks represent the programming implementation of the scenario analysis described in the previous activity. During Task 3 a programmer(s) will insert changes to the fundamental set of flights to create the Host baseline set. During Task 4 the same programmer will execute the O/S SIM program to replicate flights beyond the maximum track loads produced by SIM at the present.

During Task 5 the contractor shall conduct performance tests on the 9020 equipment to verify the new benchmark loads. Because of the limited 9020 capacity, these tests can handle no more than a 444-track load on the 9020D system. Despite this constraint, the tests are a necessary part of the benchmark development because the user can refine the benchmark scenarios until the lab capacity tests produce statistical results which closely match the performance specifications. For instance, if the Host performance standards require a certain mix of arrivals and departures and the actual lab test results indicate that a different mix was occurring during the experiments, then the simulation inputs need to be modified and rerun one or more times until lab results truly reflect the desired performance standards. This calibration process may be repetitive, but is an important part of the project because it will lead toward a reliable benchmark.

Task 6 consists of the benchmark load tape delivery along with all documentation related to the entire effort (readable worksheets, user guides, system design documents, annotated listings of any new programs developed during the project, etc.)

Schedule. Eight months.

Task 3: five to six months.
Task 4: two to three months.
Task 5: two to three months.
Task 6: three to four months.

Manpower. Two computer programmers or software specialists to interface with the two analysts assigned to Task 2.

PHASE II. Automate the Baseline Load Construction.

In this phase, an analyst and a programmer will provide a set of computer programs, written in a suitable simulation language, which automate the several manual procedures performed during Tasks 2 and 3. With these new programs, other analysts will be able to easily change scenarios during future applications. For instance, by using the programs along with the new baseline workload, an analyst should easily vary the number of aircraft, the types of routes, the number of desired conflicts, track life, flight altitude assignments, load patterns as a function of simulated time, weather loads, controller messages, etc.

Additional scenario features can be added to this list if deemed relevant. The contractor shall deliver any annotated listings, user guide(s), and system design document(s) prepared during this phase.

Schedule. Ten to twelve months.

Manpower. Two analysts familiar with support utilities such as Operating System Job Control Language, simulation languages, statistical packages, etc.

PHASE III. Develop Performance Test Methodology.

During this study the contractor will produce a document describing in detail the future Host performance measurements which are to be based on the new benchmark. Furthermore, the study will recommend solutions to several potential problems expected during these measurements. A partial list of these problems include:

1. "Loop Sim" Communications. During current performance tests a program called Loop Sim, stored in a simplex portion of the 9020 computer, handles communication messages between UDS and simulated adjacent facilities. Loop Sim also provides a radar load that is synchronized with the simulated air traffic imposed on the lab facility. When the Host is installed in the laboratory, the analysts conducting the performance measurements must ensure that Loop Sim's executions remain compatible with the new benchmark. Consequently, any differences between Loop Sim and the Host benchmark requires an investigation before executing these test.

2. Increased Adaptation Airspace in UDS. Since the FAA plans to consolidate en route facilities, the UDS airspace may need modifications in order to reflect these geographic changes during simulation runs in the laboratory. Consolidation will probably increase the airspace size and, consequently, UDS will have to grow in size as well. For instance, in the future the current boundaries between the en route centers and terminal facilities will no longer exist, but instead will give way to a completely new control network known as Area Control Facilities (ACF's). ACF's type "A" will replace the en route systems, ACF's type "B" will replace the airport terminal systems, while ACF's type "C" will represent the terminal system airspace which does not touch the ground. All these concepts will impact the UDS geography if realistic simulations are required in the future. Moreover, new routes, airports, and sectors may have to be added to the UDS geography to accommodate the heavier simulated traffic loads expected to drive the Host and AAS tests. The impact of all these potential changes on performance tests requires an investigation.

3. Software Impact of High Track Loads. High track loads, even at 555 and 666 tracks, cause dynamic data tables to become saturated in the en route software. Provisions must be made to increase the size of these tables before Host performance testing. A study is required to identify those tables that become saturated as well as to estimate their projected sizes.

4. Modification of Performance Measures. Unlike the 9020, the Host will execute the NAS software using a Virtual Machine Control Program (VMCP). Consequently, steps must be taken to modify any of the performance measures and their associated reduction tools to reflect the VMCP overhead. Host tests using the benchmark loads should include the following measures as a minimum:

a. CPU Utilization. At selected intervals during the measurement period, Timing Analysis Reports (TAR's) recordings will be used as a CPU utilization measure of the NAS system. The NAS software gathers TAR data and time-stamps it at a resolution of 16 2/3 milliseconds for all input/output (I/O) and external interrupts, supervisor calls (SVC), program element dispatcher processing, and idle time. These data are used by the TARP/REDUC tool to produce statistics by CPU, Program Element (PE), and NAS Monitor for the entire measurement period.

The on-line CPU monitor will be activated to collect total average CPU utilization along with track and flight plan count during every minute of the measurement.

b. Selector Channel Utilization. The selector channel utilization monitor will be activated in a manner similar to the CPU monitor in order to collect performance data on channel activity.

c. Response Time Analysis Data. During the entire measurement period, a minimum of SAR category level 1 will be required to identify the system inputs and outputs. The tape on which these data are collected will be processed by the "RESPONSE" option of the Data Analysis and Reduction Tool (DART) to determine message response times. Several response time reports can be produced including message counts by type, by devices, and by priority class (as specified in NAS-MD-318).

d. Periodic Subprogram Execution Analysis Data. TAR will provide a measure of the periodic subprogram execution activity. Such information will be available through TARP, an off-line reduction tool.

e. Software Resource Utilization Analysis Data. During the entire measurement period, REMON recording will be activated to aid in evaluation of software resource utilization. The data collected will later be processed by the reduction tool REMONR. REMONR produces several software resource utilization summaries for pool and tables, device and program queues, table entry read and write locks, program elements, and dynamic program buffering.

f. I/O Device Utilization Data. For the selected intervals of the measurement period for which the TAR data are recorded, I/O device utilization statistics will be recorded and produced. These TAR data will be processed by special TARP and REDUC programs. REDUC produces an I/O device utilization summary report which includes data on: utilization for control unit and channel, the number of Start I/O's (SIO's) issued by device, the frequency of SIO's per second, and by device, the number of channel ends and device ends.

5. Incorporation of New Tools. The preceding measures represent performance characteristics unique to the NAS en route system. With the advent of the Host, other tools may be required to measure the new equipment in the laboratory. These tools, either developed by the manufacturer or by an independent contractor, must eventually be incorporated in the Host performance evaluation. These future tools will require a study to determine how readily they can be integrated during performance tests.

Schedule. Twelve to fourteen months.

Manpower. Two computer specialists with system performance measurement experience.

PHASE IV. Extension of Host Benchmark to the Advanced Automation System

During this phase the contractor will investigate the potential of extending the Host benchmark to the AAS since the AAS will become the automation system of the future beyond Host era. This study shall include a description of all areas where a duplication between the Host and AAS benchmarks may exist. Furthermore, the contractor will identify any lack of commonality between the two systems and will recommend in his final report a direction which the FAA should take to properly develop the AAS benchmark.

Schedule. Six to eight months.

Manpower. One computer specialist with system performance analysis background.