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SYSTEM SPECIFICATION
FOR THE
TACTICAL AIR COMMAND
MAINTENANCE SKILLS TUTOR

CONTRACT NUMBER:

PREPARED FOR:
AIR FORCE SYSTEMS COMMAND HUMAN SYSTEMS DIVISION

Authenticated by ______________________ (Contracting Agency)

Approved by: ______________________ (Contractor)

Date ______________________

Date ______________________

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1. SCOPE

1.1 Identification

This specification establishes requirements for the Tactical Air Command (TAC) Maintenance Skills Tutor (MST) program.

1.2 System Overview

TAC has identified a need to improve troubleshooting skills for technicians performing flightline maintenance. These skills are normally taught through on-the-job training (OJT). This method is both time consuming and manpower intensive, requiring years of apprenticeship training under the tutoring of experienced maintenance technicians. Today's highly reliable systems fail less often and thus provide fewer opportunities to train technicians on the complex problems. At the same time, the Air Force has combined maintenance specialties and reduced the number of technicians per aircraft. Thus, technicians must have broader knowledge and more general skills.

In response to this need, the Human Resources Directorate (HRD) of Armstrong Laboratory is performing research under the Basic Job Skills (BJS) program in two areas: cognitive task analysis techniques to capture troubleshooting strategies used by experts and novices, and computer-based intelligent tutoring systems to provide a practice environment for working authentic troubleshooting problems while coaching the student with hints and feedback. Prototype tutors were demonstrated at TAC fighter wings at Langley and Eglin Air Force Bases. The results showed significant gains in proficiency by novice technicians. TAC has identified this technology as a high priority for fielding.

The MST program will develop and field operational tutors for TAC based upon the proven and improvin' BJS technologies. These tutors will focus on teaching advanced troubleshooting skills for 5- and 7-level, F-15 and F-16 flightline maintenance technicians.

1.3 Document Overview

This specification is written in accordance with DI-CMAN-80008A, as tailored for the MST program. The verb "shall" denotes binding requirements. Each "shall" in section 3 is followed by a number in brackets (e.g., [1], [2], [3], etc.) to relate the requirement to the verification method specified in the Qualification Matrix (section 4.5). The verb "will" indicates Government intent. Other verbs, such as "may" are used for information purposes and are non-binding.

[Statements in brackets, like this one, are notes to the author and/or reader and will not be included in the final version.]

2. APPLICABLE DOCUMENTS

2.1 Government Documents

The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

Specifications

Standards

MIL-STD-1472D 14 March 1989 Notice 1 20 March 1991	Human Engineering Design Criteria for Military Systems, Equipment, and Facilities
MIL-STD-1815A 22 January 1983	Ada Programming Language
DOD-STD-2167A 29 February 1988	Defense System Software Development

Other Publications

Det 5, AL **[Date?]**	(Draft) A Procedural Guide to Cognitive Task Analysis: The PARI Methodology
Det 5, AL **[Date?]**	(Draft) BJS Intelligent Tutor Development Guide
HSD/YAR **[Date]**	Maintenance Skills Tutor (MST) Software Engineering Reference Guide
4400 MTF 12 January 1990	Tactical Air Force (TAF) Maintenance Training Interactive Courseware (ICW) Style Guide

2.2 Non-Government Documents

Not applicable.

3. SYSTEM REQUIREMENTS

3.1 Definition

The MST program will include the development of a series of MST courses and supporting capabilities. Each course will be a computer-based training system that utilizes intelligent tutoring and interactive video technologies to teach advanced troubleshooting skills to F-15 or F-16 flightline on-equipment maintenance technicians. Each course will correspond to a major job within an Air Force maintenance specialty (such as the "engine" job within the Tactical Aircraft Maintenance specialty) as illustrated in figure 1. A course may also correspond to a part of a job if it is determined that the amount of training required for that job is too great for one course and the training can be cleanly partitioned into more than one course. The MST courses will target only those jobs, or portions of jobs, that require complex cognitive skills.

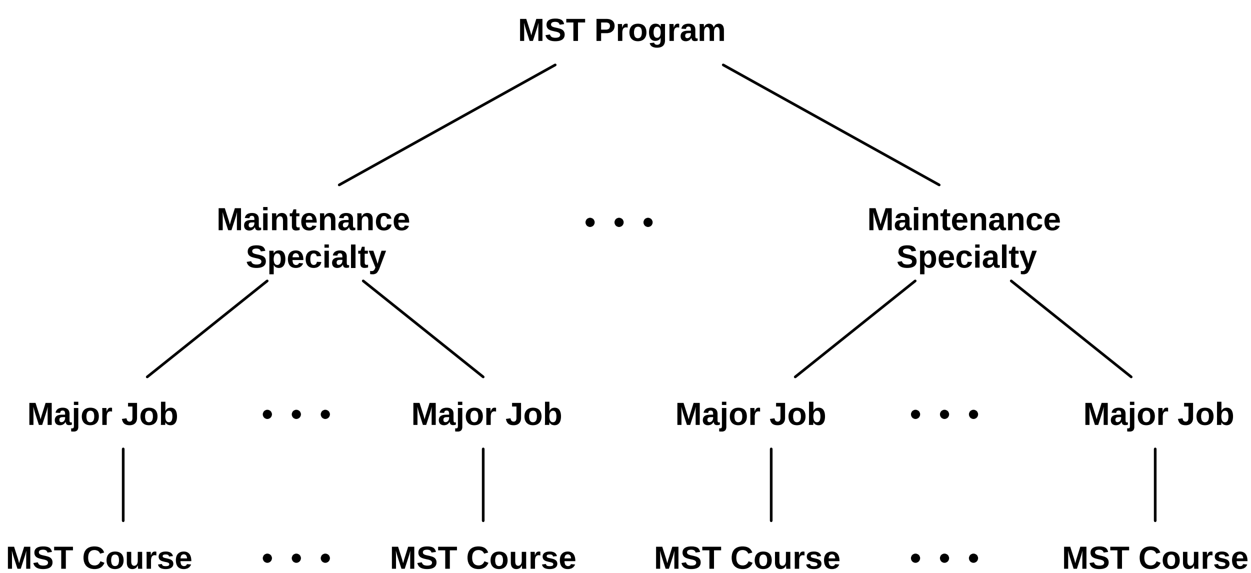

Figure 1. MST Courses

The MST courses will operate on Government IBM-compatible personal computers located within Aircraft Maintenance Units (AMUs) at TAC bases. The Government personal computers will also host TAC Interactive Courseware (ICW).

The MST supporting capabilities will include software that will operate on the Government personal computers to enable students to select between MST and ICW options, software to support MST training administration activities at the AMUs, capabilities to analyze MST training data at a central facility, and MST courseware development and maintenance capabilities. The concept of operation for the MST is described in 6.1.

3.1.1 Application of BJS Technology

The instruction embodied in each MST course will be based on the BJS technologies. The BJS technologies include two aspects: a) cognitive task analysis (CTA) techniques to capture expert knowledge of aircraft systems, expert troubleshooting strategies, and typical novice troubleshooting strategies; and, b) training development guidelines and instructional principles that describe how the CTA results are used to develop an instructional design. The CTA procedures and training development guidelines are described in *A Procedural Guide to Cognitive Task Analysis: The PARI Methodology* and the *BJS Intelligent Tutor Development Guide*, respectively.

The instructional philosophy of the BJS program is to provide an apprenticeship training environment in which students learn by doing, students are responsible for their own learning, and external support is provided in the form of hints, reminders, and explanations. Fading of external support occurs as the student's skill and autonomy build.

Each MST course will provide a coached practice environment wherein students practice troubleshooting faults in simulated equipment in the context of authentic troubleshooting scenarios and coaching is provided to the student either upon request or when determined to be necessary. The instructional content of each MST course will be derived from a CTA in accordance with *A Procedural Guide to Cognitive Task Analysis: The PARI Methodology* and the *BJS Intelligent Tutor Development Guide.* Instructional content is defined as the instructional material contained in an MST course that is specific to that course and includes:

a. Aircraft and test equipment simulations and representations;

b. Troubleshooting problems to be simulated;

c. Troubleshooting actions that are applicable to the equipment;

d. Expert knowledge, including system knowledge (the functions of systems, subsystems, and equipment components), procedural knowledge (how to troubleshoot equipment and interpret results), and strategic knowledge (the effective application of troubleshooting actions);

e. Student proficiency indicators to be tracked and the mapping of student actions to the proficiency indicators;

f. Criteria for selecting troubleshooting problems to be solved by the student; and,

g. The content of coaching to be provided to the student.

The instructional content of each MST course shall [1] target a student population of 5 and 7 level technicians within each specialty with the objective of evolving the students' proficiencies to the level of independent master technician. The characteristics of the student populations and independent master technicians that are targeted by the instructional content shall [2] be those which are identified as important to the job by the CTA.

3.1.2 Student Course Materials

Student course materials for each MST course shall include [1a] a laser disk containing video and audio for that particular course, [1b] a high density 3.5 inch floppy disk for each student containing that student's course-related data, and [1c] an MST User's Guide. The student course materials and government-provided workstation are illustrated in figure 2. MST course materials will be controlled at the AMUs according to procedures established by the AMUs, as described in 6.1.

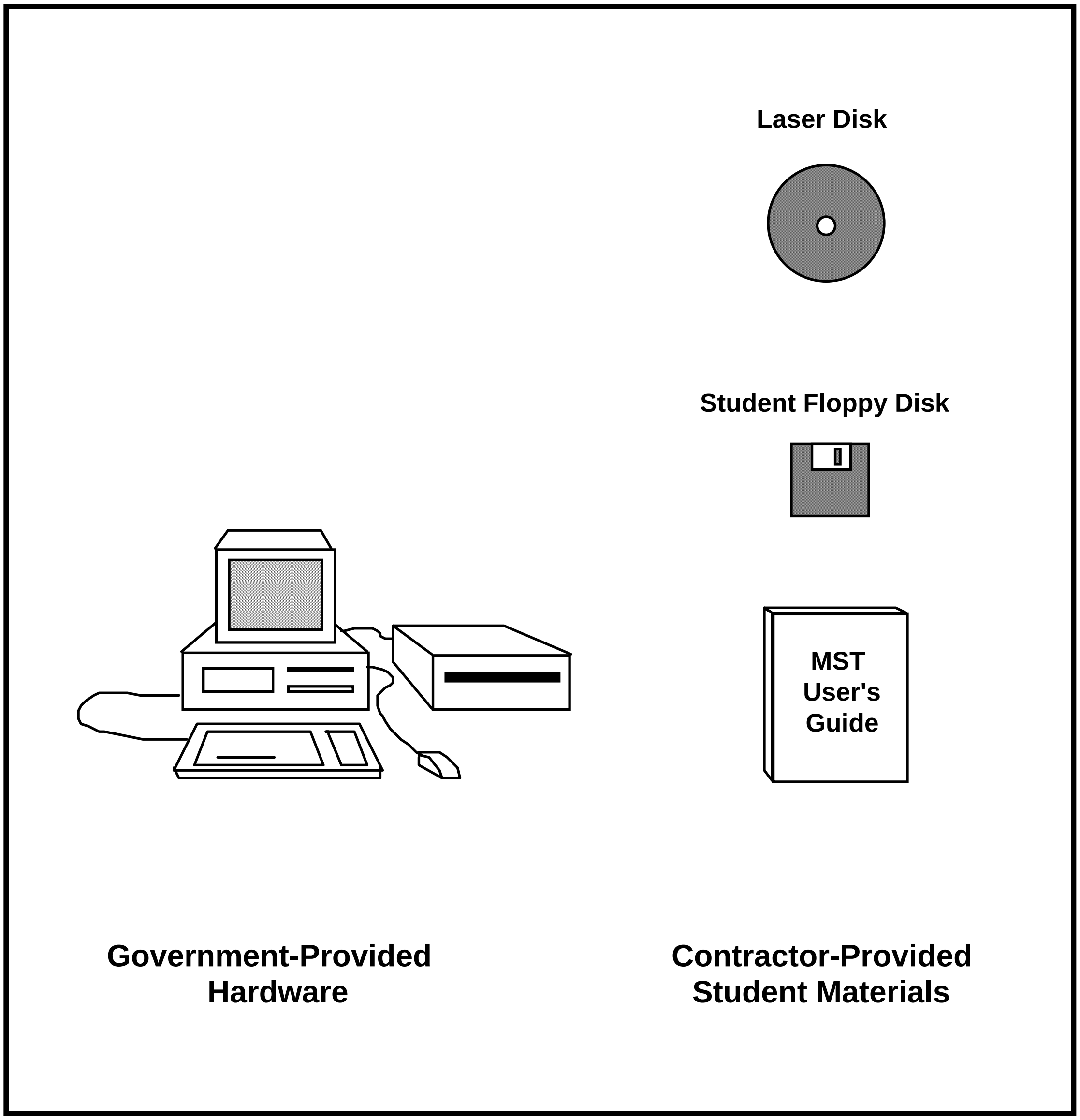

Figure 2. MST Student Materials

3.1.3 MST Software Architecture

A single, reusable software architecture shall [1] be developed and used in all MST courses. Software functions that are common to the courses shall [2] be implemented in software that is identical in all courses. Explicit provisions shall [3] be contained in the architecture to isolate the course-unique software from common software. At a minimum, the software which is common to all courses shall [4] include the functional capabilities specified in *The MST Software Engineering Reference Guide*[1]. These functional capabilities are identified in figure 3. A standard protocol shall [5] be defined for the interfaces between software components. This protocol shall [6] be used by both developed and commercial off-the-shelf (COTS) software. All interfaces between software components (applications and COTS) shall [7] be isolated to a single software component, referred to below as the "executive".

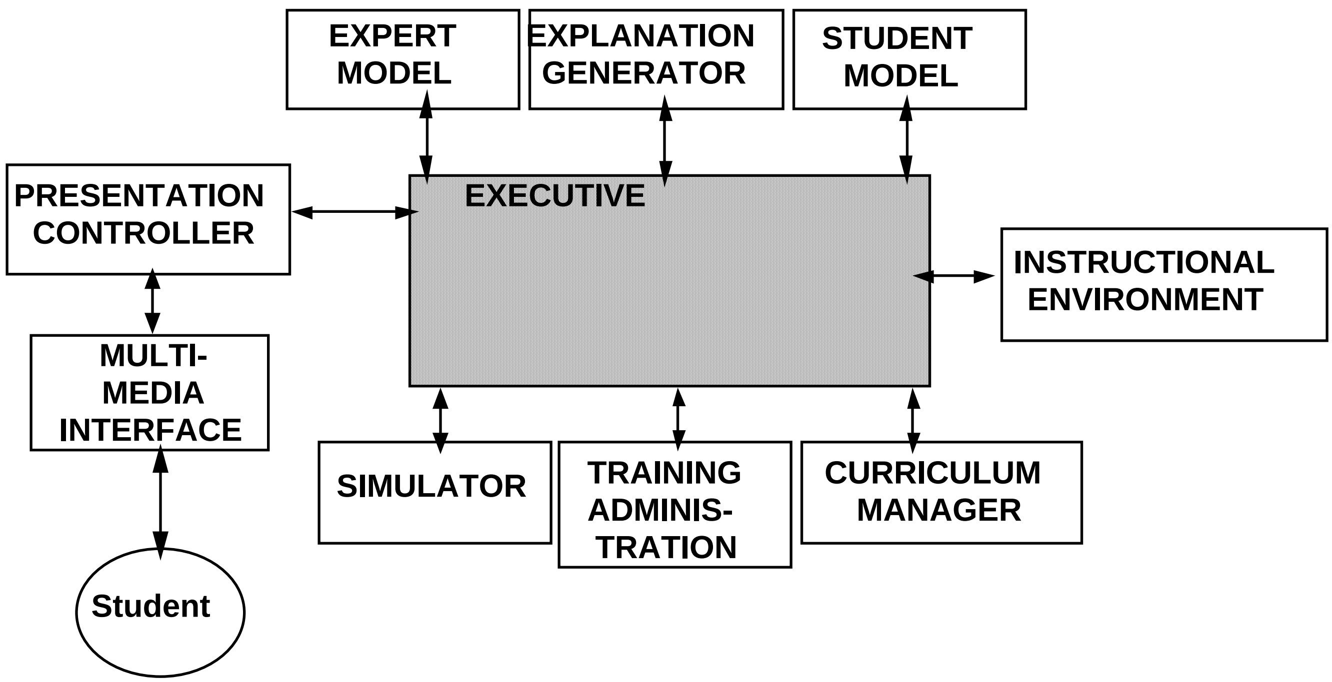

Figure 3. MST Functional Components

3.1.4 Hardware Platform

Each MST course shall [1] operate on standalone[2] IBM-compatible personal computers (referred to as "workstations") configured as follows[3], while meeting the requirements specified within this document:

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[1]The MST Software Engineering Reference Guide specifies functional capabilities that are to be implemented in software that is identical in all MST courses. However, the software design is not bound by the organization of the functional capabilities. The contractor is responsible for the determining the software design.

[2]The workstations will not be networked. Therefore, all data required to provide continuity of training and still allow students to use different workstations must be contained on the student floppy disk.

[3]As required in the Statement of Work, the contractor will analyze the adequacy of the specified hardware platform and will identify any recommended changes or additions.

a. Intel Corporation 486, 33 megahertz (Mhz) central processing unit (CPU) with 16 megabytes (Mbytes) of random access memory (RAM);

b. 200 Mbytes of hard disk available for MST software, courseware, and recorded data;

c. Digital video display board with resolution capabilities of 640 by 480, 800 by 600, and 1024 by 768 pixels, and the capability to simultaneously display 256 colors; **[Note: The actual board or boards selected by the 4400 MTF will have to be specified here when the information becomes available.]**

d. (EISA or AT) bus; **[Note: The bus will have to be specified here when the information becomes available]**

e. Two 3.5 inch high density floppy disk drives;

f. One 16 inch Super VGA multisynch color monitor with 1024 by 768 pixel resolution;

g. An IBM PC AT compatible keyboard and mouse;

h. A laser disk player with RS-232 interface; and,

i. An IBM PC AT compatible printer.

[Note: It may be necessary to add a removable mass storage device to this list when the hardware selection is made by the 4400 MTF. The contractor may also recommend addition of an audio board depending on the need for audio in the tutors.]

At a minimum, all MST courses for any individual Air Force maintenance specialty shall [2] reside concurrently on a hard disk specified in item b above; the design goal shall [3] be to concurrently contain all MST courses for all specialties located at an AMU on a hard disk specified in item b.

[Note: Ideally, the hard disk would contain all MST courses and all ICW for all specialties in an AMU. Mr. Embry at the 4400 MTF roughly estimates the size of the ICW available today at about 1.2 Mbytes/course and the future ICW at about 4 Mbytes/course. If one assumes about 30 old ICW courses and 30 new ones under development, the total size for the ICW is about 156 Mbytes. If one further assumes that the ICW courses are split evenly between F-15 and F-16 aircraft, then there would be about 78 Mbytes for ICW required at an AMU. Additional storage space should be assumed for such things as utilities, student data, etc. Therefore, a rough estimate would be about 100 Mbytes required for all of the ICW for a particular aircraft.

If one assumes a 300 Mbyte hard disk, this would leave about 200 Mbytes for the MST courses. The March version of Sherlock II takes up about 7 Mbytes. Each additional student requires an additional 20 Kbytes. As a rough guess, an MST course may average

around 20 Mbytes. If so, all of the MST courses for an aircraft at an AMU may fit with all of the ICW on a 300 Mbyte hard disk.

However, in addition to memory required to store the courses themselves, the concept calls for backing up student data on the hard disk (including the student model data, bookmark data, etc.). According to section 2.1.3 of the MST Requirements Analysis, a typical AMU would contain two TAMS flights with about 40 personnel each. The distribution would be about 25% level 3, 50% level 5, and 25% level 7. The Avionics and Electrical/Environmental flight would have about 40 personnel with a distribution of about 20% level 3, 60% level 5, and 20% level 7. Therefore, there would be about 92 personnel at an AMU at levels 5 and 7 (30 each for the two TAMS flights and 32 for the other). If they are all registered for MST courses, the student data could take up a <u>lot</u> of space.

Mr. Embry at the 4400 indicated that they are considering using a CD-ROM that will hold about 640 Mbytes. The courses can be down-loaded from the CD-ROM to the hard disk. This would take care of the storage problems.

It is not yet known if the specified storage capacities are adequate. It is also not known if the amount of data needed for the student model and bookmarking can be stored on a 3.5 inch high density floppy disk. There should be a SOW task for the contractor to study the performance and storage requirements, and other possible hardware requirements such as the need for an audio board.]

3.2 Characteristics

3.2.1 Performance Characteristics

Performance characteristics are specified for the following capabilities:

a. Student training - all of the capabilities needed for a student to receive MST training, including but not limited to starting-up a workstation, selecting a course, registering for a course, receiving troubleshooting training, and completing a course;

b. On-site training administration - capabilities to support the management of MST training at the AMUs, including but not limited to loading new or updated MST courses onto a workstation, copying recorded data to removable media, generating hardcopy reports of MST usage, and backup and restoral of recorded data in case of failure;

c. Training data analysis - the capabilities provided in a central facility to read and analyze training data collected at multiple MST sites and generate summary usage reports; and,

d. Courseware development and maintenance - the capabilities to develop new MST courseware, modify existing courseware, and maintain configuration control.

3.2.1.1 Student Training

Student training capabilities include:

a. Start-up;

b. Logon;

c. New student registration;

d. Coached practice;

e. Course exit;

f. Student interface; and,

g. Student training failure recovery.

A general overview of an MST course structure is presented in figure 4.

3.2.1.1.1 Start-up

Start-up is defined as powering up the hardware, loading and initializing system software, performing diagnostics and readiness checks, and bringing the workstation to an operational state. If the workstation is turned off, the student will turn on the power button to start the workstation. After the power is turned on, the workstation shall [1] be brought automatically to an operational state wherein the workstation presents the student with the option of selecting either ICW or MST training. If the workstation is turned on but not in use, the ICW/MST selection option shall [2] be presented and available for selection by a student. The time to bring the workstation from the off condition to the presentation of the ICW and MST options includes two components: a) the hardware-dependent time required by the platform to power up and become operational (this time ends when the platform provides an operating system prompt that indicates that the platform is ready), and b) the time to load and initialize the ICW/MST selection control software and present the ICW and MST options. The time from the operating system prompt until the presentation of the ICW and MST options shall [3] not exceed 5 seconds.

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If the ICW option is selected, the workstation shall [4] be brought to a state where it is ready to begin ICW training, as described in the *TAF Maintenance Training ICW Style Guide*. Although the ICW is not part of the MST program, the capability to bring the workstation to the state where it is ready to begin ICW training shall [5] be provided under the MST program.

If the MST option is selected, the system shall [6a] identify the MST courses that are available on the workstation and shall [6b] prompt the student to select a course. The system shall [7a] prompt the student to insert the student disk and laser disk for the selected course and shall [7b] prompt the student to confirm that the disks have been inserted. The system shall [8] present an introduction that identifies the course. The introduction may include motivational material, such as a brief audio and video segment.

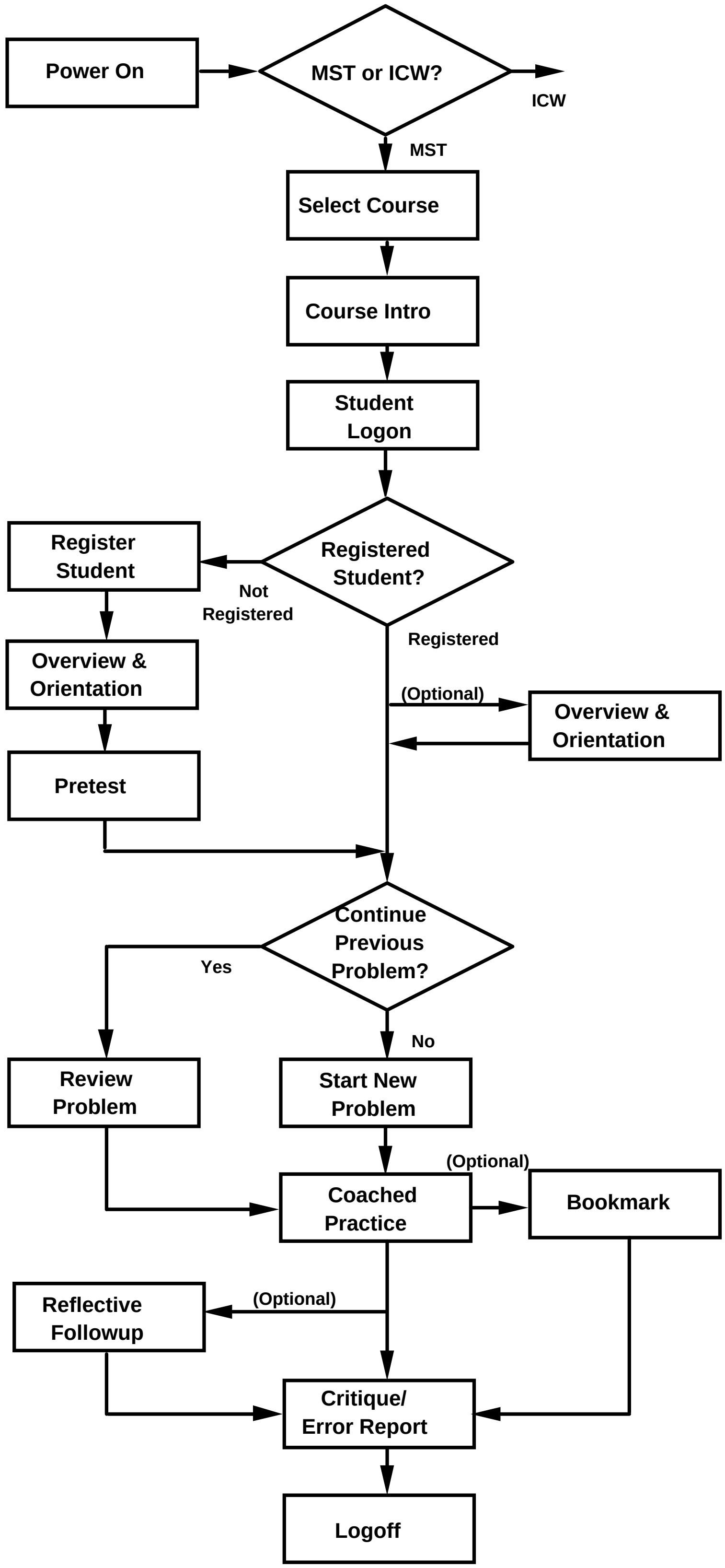

Figure 4. MST Course Overview

The time from when the student confirms that the disks have been inserted until the presentation of the introduction shall [9] not exceed 2 seconds. This time interval begins when the student enters the confirmation (e.g., clicks on the appropriate box on a display). If the introduction consists of a still image, the time interval ends when the complete image is presented. If the introduction consists of an audio and video segment, the time interval ends when the first image and/or sound of the segment is presented.

3.2.1.1.2 Logon

Each MST course shall [1] require students to logon every time they use the course. Logon shall [2] consist of entering the student's last name and employee number. The course shall [3] provide the option to the student to correct his/her last name and employee number in case they were entered incorrectly. The course shall [4] determine if the student is already registered or if the student is new to the course. If the student is new to the course, the course shall [5] perform the registration and orientation procedures specified in 3.2.1.1.3. If the student is already registered and has taken the pretest, the course shall [6] provide the option to return the student to the place where he/she exited at the end of the previous training session, either at a bookmark location or the start of a new troubleshooting problem. The course shall [7a] not present the overview (3.2.1.1.3.1) or navigational instruction (3.2.1.1.3.2) to the students automatically on the second or subsequent uses of the course; however, the course shall [7b] provide access to the overview and navigational instruction as options to those students.

3.2.1.1.3 New Student Registration and Orientation

The course shall [1] verify that a student is a new student. If the student is a new student, the course shall [2a] register the student for the course, [2b] present an overview of the course, [2c] provide instruction on how to navigate through the course, and [2d] conduct a pretest of the student, as specified below.

3.2.1.1.3.1 Course Overview

Each course shall [1] provide an overview of the course. At a minimum, the overview shall [2] describe the subject of the course and the organization of the course from the student's perspective. Motivational information (e.g., describing how the course will benefit the student) may also be provided.

3.2.1.1.3.2 Navigational Instruction

Each course shall [1] provide instruction on how to use and interact with the course. At a minimum, the navigational instruction shall [2] include descriptions of display layouts, definitions of icons and other display features, and demonstrations of the actions available to the student and the results of those actions (e.g., troubleshooting actions, coaching requests, help requests, bookmarking). Each course shall [3] provide a practice capability wherein the student practices interacting with the features of the user interface.

3.2.1.1.3.3 Pretest

Each MST course shall [1] test new students to determine their entering proficiencies and deficiencies. Each course shall [2a] pretest the student once and only once; i.e., students shall [2b] not be allowed to retake the pretest. Once the pretest is begun, the course shall [3] not allow the student to exit the course until the student has completed the pretest. Prior to beginning the pretest, the course shall [4a] describe the organization of the pretest to the student (e.g., the number of questions and exercises) and [4b] inform the student of the approximate time required to complete the pretest. The course shall [5] provide the option to exit prior to beginning the pretest and return at a later time.

At a minimum, the pretest shall [6] include one or more troubleshooting problems; knowledge-based questions and other exercises, such as identifying components on block diagrams, may also be used. The course shall [7] initialize the student model (3.2.1.1.4.4) based on the pretest results. The pretest results shall [8] be recorded and stored with the student's data for as long as the student is registered for the course. The pretest shall provide an objective basis for [9a] comparing the student's entering proficiency to his/her proficiency at any point during the student's training and [9b] quantitatively measuring changes.

[Should the student be given feedback on his/her performance on the pretest? For example, should the student be told which answers are wrong and what the correct answers are? For pretest exercises, should the student be restricted from requesting coaching? Is there a requirement to allow the student to print the pretest results? Perhaps the SOW should include a special study to determine the best approach to the pretest.]

3.2.1.1.4 Coached Practice

Each MST course shall [1] teach troubleshooting skills through coached practice. Coached practice is defined as a training environment in which the student practices isolating and repairing faults in simulated equipment subsystems in the context of authentic scenarios and coaching is provided as requested by the student or when it is determined by the course that the student requires assistance.

At a minimum, coached practice capabilities include:

a. Problem selection;

b. Scenario presentation;

c. Troubleshooting capabilities;

d. Student modeling;

e. Coaching; and,

f. Reflective followup.

3.2.1.1.4.1 Problem Selection

A troubleshooting problem is defined as a specific simulated fault in a flightline-replaceable equipment component, with a specific set of associated symptoms, that is isolated and repaired by a student through simulated troubleshooting actions. Each MST course shall [1] provide a set of troubleshooting problems for coached practice. Each problem shall [2] correspond to a single[4] faulty flightline-replaceable equipment component[5]. The set of troubleshooting problems shall [3] include subsystems and equipment components involved in the job that are identified by the CTA as requiring cognitively complex skills to troubleshoot.

[A definition of "cognitively complex skill" is needed from the lab since the term is used to determine what is within the scope of a course and what is not.]

Each course shall [4] provide the following capabilities for selecting troubleshooting problems for coached practice:

a. A problem is selected automatically by the course; and,

b. Upon achieving some predefined level of competence, the student specifies a type of problem to practice and a problem that possesses those characteristics is automatically selected by the course.

Each course shall [5] present any individual problem to a student at most once.

[What happens after a student has been through all of the problems for a subsystem? Do we tell him/her that they ran out and that's it? Should we give the student the option of having the already completed problems reinstated? For example, the student may approach the same problem in a more efficient manner later in the training.]

[Note: The previous version of the specification contained an estimated number of scenarios and an average duration for the problems to provide a basis for the offerors to scope the effort. It was agreed at the last meeting that that would be deleted from the spec and the SOW would include the scoping assumptions, like the number of problems in each course and the average duration of the problems.]

3.2.1.1.4.1.1 Automatic Problem Selection

Each course shall [1] automatically develop a curriculum for each student. Curriculum is defined as the sequence of troubleshooting problems given to a student during the course of the student's training. Each course shall [2] determine the curriculum dynamically by selecting problems that

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[4] Simulation of multiple faults is not required.

[5] An individual flightline-replaceable component may experience different types of faults and exhibit different types of faulty behavior. Furthermore, the same fault may have multiple sets of associated symptoms depending on how the fault was detected (e.g., through symptoms detected during flight, or through built-in test). Therefore, there may be multiple troubleshooting problems in the course corresponding to a fault in a component.