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Quality Assurance Plan For VOILA

Dwg. No. 85-01001

Revision A
October 20th, 2003



**Quality Assurance Plan
Center for Space Research
Massachusetts Institute of Technology**

1.0 PURPOSE

The purpose of this document is to provide documentation of the Quality Assurance (QA) provisions the Center for Space Research (CSR) of the Massachusetts Institute of Technology (MIT) will employ under contract to NASA for the fabrication of flight hardware and software in support of experiment E085/E507, *Visuomotor and Orientation Investigations in Long-duration Astronauts (VOILA)*. VOILA will extend, simplify, and merge two sensory motor and performance experiments originally developed for the 1998 STS-90 Neurolab mission. The two components retain separate numbers (E085/E507) on ISS, but are performed together.

2.0 SCOPE

This document covers the processes and procedures to be followed by MIT-CSR personnel for the design, development and fabrication of the flight hardware and software at their institutions. Since the hardware and software is being built under contract to NASA, the hardware and software will be certified for flight by NASA and will undergo design reviews at NASA per NASA procedures. The requirements for the hardware and software are defined in the Hardware Requirements Document (HRD) that will be approved and maintained by NASA. With the merging of E507, which is a European experiment, with E085, it is recognized that certain software components will be developed outside the scope of the NASA/MIT-CSR contract by the E507 team. Software components provided by the E507 team will be integrated into the flight software release by MIT-CSR, but will be developed under E507 Team processes and procedures.

3.0 OBJECTIVE

The quality objective to be attained by MIT-CSR is the successful fabrication of the flight hardware and software specified in the Experiment Document section 7.0 which meets or exceeds the requirements specified in the VOILA Hardware Requirements Document. The certification of the system for flight will serve as the measurement that this quality objective was achieved.

4.0 RESPONSIBILITIES

This section defines the responsibilities and authority of the NASA and CSR personnel responsible for implementing this Quality Plan.

4.1 NASA Experiment Systems Manager (ESM)/Contracting Officer's Technical Representative (COTR) - As the NASA technical expert on the contract, the ESM/COTR is responsible for providing the necessary oversight to the contract to ensure that the Quality Plan is adhered to. The ESM/COTR is responsible for setting up the appropriate NASA hardware design reviews, serves as the NASA point of contact for CSR for any problems that occur during fabrication, and arranges for some of the testing (EMI/EMC, flammability, offgassing) which involves NASA facilities and certification of the hardware for flight.

4.2 CSR Personnel

Due to the funding available for this experiment, a full-time R&QA engineer is not planned. . One should also note that electronic hardware will be approximately 95 percent Commercial Off The Shelf (COTS) rather than designed and fabricated at CSR. COTS products will not be expected to meet NASA workmanship standards and rework will be performed only in case of prohibited parts replacement or if deemed necessary for qualitative purposes. Therefore, the main activity at CSR is to (1) determine the quality of the commercial items, the materials used, and the testing performed, and (2) re-work the COTS hardware to make it acceptable for use on the Space Station (e.g., minimal EEE part substitution, re-make of non-metallic parts, bake-out and conformal coat of PC boards, etc.).

4.2.1 Project Manager - Oversees the overall operation of the project and is responsible for assuring that all necessary project activities are carried out. This is a part-time position varying from 25 to 50%.

4.2.2 CSR R&QA Manager - The CSR R&QA Manager is a part-time position. He will generate the detailed R&QA Implementation Plan and supervise the project personnel involved in the R&QA efforts.

4.2.3 Mechanical Engineer – CSR will provide a near full time Mechanical Engineer to the project to perform the mechanical systems engineering, piecepart design, drafting and mechanical assembly supervision for the project. CSR has not planned for a dedicated verification engineer to accomplish the significant number (~1500) of verification reports that have to be generated. Instead, the verification reports will be assigned to the different members of the Voila team. Monitoring and tracking of the reports will be done by the CSR R&QA Manager to assure completeness of the verification matrix.

4.2.4 Project Engineer - The project engineer will be responsible for the overall system design and the environmental testing of the E085/E507 hardware. This has been planned as a half-time position. This person will also double as the electrical engineer for the project, although not much effort is expected in this area due to the COTS nature of most of the hardware. For the major COTS components, the CSR Project Engineer will be the primary technical contact with the vendor and negotiate any technical customizations required by the Voila Project.

4.2.5 Programmers – There will be a single, part time Software Engineer assigned to the Voila Project. He will be responsible for the functionality of what is referred to as the “Session Manager” component. The virtual reality based experiment software components will be written by the Project Scientists for E085 and E507. The primary Session Manager functions will manage the selection of experiment to run and interface with the NASA software on the Rack2 Workstation for telemetry needs. Various other secondary utilities will be provided by the Software Engineer, as well as maintaining a simple bug tracking, revision release system and required documentation.

As a point of information, in addition to writing the software for the E507 Experiment, the E507 Project Scientist will work with the appropriate vendors, providing software for the tracker subsystem, to assure it’s functionality for the E085/E507 experiments. The E085 Project Scientist will oversee the software design of the CSR Programmer and be the primary interface to the Virtual Reality Software Vendor providing the E085 Virtual Reality tools.

4.2.6 Technicians - The CSR technicians who will work on the E085/E507 hardware have been NASA certified for Staking, Conformal Coating, Soldering, Crimping, Cabling, Harnessing, and ESD. Recertification will be performed as necessary. Many of the technicians employed by the commercial vendors have never been NASA certified. CSR will inspect the COTS hardware and perform any necessary re-work of this hardware.

5.0 DESIGN PHASE

CSR will work closely with NASA during the design phase to ensure that the hardware will meet the performance requirements as well as spaceflight-specific requirements (safety, environmental parameters, human factors, etc.). CSR will build/purchase commercial/prototype hardware and software for the purpose of interface testing as well as evaluation by JSC personnel prior to flight system fabrication. A hardware Preliminary Design Review (PDR) and Critical Design Review (CDR) will be held at JSC where the hardware requirements, drawings, materials, and operations will be reviewed; upon successful completion of the CDR and closure of any Review Item Dispositions (RID)’s submitted, the flight system will be fabricated and tested.

6.0 DEVELOPMENT PHASE

As mentioned briefly above, most of the major elements of the E085/E507 experiment are being purchased as Commercial Off-The-Shelf (COTS) hardware. Therefore, the CSR role on the E085 experiment is more in the area of system engineering and system integration. CSR is responsible for acquiring this hardware, modifying it as necessary to meet space standards (e.g., replacement of Cd plated connectors), testing of the individual items, assembling the hardware into a functioning experiment, testing against potential safety hazards, and generating the numerous verification reports required by the Hardware Requirements Document in order to meet the Space Station guidelines. In some cases, the COTs Vendor may be

involved in providing these upgrades, where it is practical or necessary. Furthermore, E085 and E507 personnel are developing the software for the experiment and verifying it meets both experiment and ISS requirements.

6.1 Procurement – As noted above, most hardware used on the E085/E507 experiment will be purchased from commercial vendors (COTS hardware). MIT will perform a source inspection of the potential vendors and then work with the selected vendor to obtain the highest quality possible within the constraints of the vendor’s fabrication system. Some of the planned vendors do have a “high reliability” version of their commercial product. MIT will attempt to obtain drawings and documentation of the purchased hardware, including the specific non-metallic materials used in the purchased items (some of this information might be unknown, or considered proprietary, by the vendor and not available). For MIT designed and fabricated hardware, the component parts procured will be of the highest quality available (within cost and schedule constraints) per the approved drawings reviewed at the hardware CDR. CSR will implement a Configuration Management system with a full Configuration Database. Each part and drawing will be assigned an E085 unique number. This Configuration Database will be published periodically and made available to JSC. CSR will test each item of hardware as received and will maintain records of certificates of compliance for all purchases and will log and assign a serial number to all major hardware received; this information will be maintained in logbooks to ensure traceability of all parts used in the fabrication of flight hardware. All components to be used for flight will be stored in a designated flight bond room or flight assembly area at CSR to separate them from other laboratory hardware. Any limited shelf life items will be identified in the Shelf Life List

6.2 Manufacture/Assembly – Again, as noted above, the manufacture of the flight hardware elements will be performed by reputable commercial vendors. Although these vendors undoubtedly have documented procedures, they very likely do not meet NASA standards. Other than purchased COTS items, work performed will meet the intent of the NASA workmanship standards.. The assembly of these hardware items into E085/E507 systems will be performed by CSR per detailed assembly drawings and procedures generated by CSR to the CDR approved design. These drawings and procedures will be part of the project Configuration Database. The hardware shop follower will document the exact procedures used (including revision number) and the name of the technician or engineer performing the activity. The MIT/CSR Technicians have been NASA Certified/Recertified for Staking, Conformal Coating, Soldering, Crimping, Cabling, Harnessing, and ESD . When the flight hardware is not involved in testing or training, it will be kept in bond or the designated flight area.

The following chart is a list of the Workmanship Standards MIT technicians will use in the fabrication of all VOILA hardware:

<u>Workmanship</u>	<u>Standard</u>
Crimping, Harnessing	NASA-STD-8739.4
Conformal Coating, Staking	NASA-STD-8739.1
Soldering	NASA-STD-8739.3
Cabling, Wiring	NASA-STD-8739.4
ESD	ANSI/ESD S20.20-1999

6.3 Quality Inspections – The E085 project has not budgeted for a full-time SR&QA Engineer. CSR has made available part-time of the CSR SR&QA Manager to assist the project. It is envisioned that his efforts will be devoted to the generation of E085 specific documents, source inspections of the proposed vendors, some (first item) inspections of the flight hardware fabricated by the commercial vendors at his facility, general oversight of the verification process, and liaison with the local government representative (Mr. Abe Sabbag of the Office of Naval Research). The scope of work performed by ONR on this project for NASA will be negotiated between ONR and NASA EM/COTR. When received at MIT, the first item flight hardware will be inspected (dis-assembled if necessary) and a set of

modifications identified for each type of hardware. The inspection of subsequent deliveries and the re-work modifications will be performed by the appropriate CSR technician. Inspection of work performed at MIT will be done by a CSR technician other than the one who performed the work. CSR Technicians understand that their sign off on the inspection points is a personal warranty that items meet specification. . The ONR representative will be contacted to coordinate government inspection points and those points will be documented in the MIT travelers, routers, or other work authorizing documents. The ONR representative will be notified at least 48 hours in advance when items will be ready for government inspection. Records of the inspections performed will be maintained with the shop-follower for each item.

- 6.4 Hardware Modifications** – CSR uses a relatively standard Engineering Change Order (ECO) system for the initial release of, and any changes to, each drawing. The ECO must be approved by the Program Manager, Project Engineer, and SR&QA Manager. CSR proposes the following plan (which was used on the Spacelab project): any changes to the flight design prior to CDR are handled via the ECO system entirely within CSR; after CDR, but prior to the start of environmental testing, all ECO's will be periodically (~weekly) made available to JSC after the fact (not prior approval); after the start of final flight environmental testing, any proposed changes to the hardware must receive prior approval of the NASA ESM/COTR. The last revision of the drawing set will reflect the as built and delivered configuration.
- 6.5 Acceptance Testing** – Due to the extremely large quantity of verifications required by the HRD, CSR proposes that the verifications be subdivided into three categories. (1) For functional and environmental testing (vibration, thermal, etc), CSR will write detailed test procedures to document the test levels and functionally test the hardware; these procedures will be reviewed and approved by the NASA ESM/COTR and the CSR Project Engineer prior to testing. A full report based on the execution of these procedures will be prepared for each item delivered. This testing at CSR will be supervised by the Project Engineer. The ONR Representative and the NASA COTR will be invited to witness the test. MIT/CSR will submit Environmental and Qualification Test Procedures to JSC for review and comment at least 30days prior to the start of test. Testing performed for engineering evaluation purposes will not require external verification. Note that any environmental testing (e.g., EMI/EMC) done at JSC will be to a standard JSC procedure. (2) Testing (or analyses) related to the closeout of Safety Hazard Reports will be performed by the E085/E507 Engineering Group and approved by the CSR R&QA Manager. These are expected to be rather simple one-paragraph procedures that document what was done and what equipment was used. (3) The verification reports related to the proof of compliance with interface requirements will be accomplished by the assigned engineer. These are expected to be relatively simple inspections, demonstrations, documentation checks, etc. Each of these verifications is expected to be about one page in length and will be signed by the engineer. For all three types, each specific topic will be assigned an E085/E507 part number. For the multiple hardware items being delivered, the same set of reports will be generated for each serial number. Due to the large number of reports, the completed reports will be sent to JSC as soon as a significant number have accumulated (monthly in the beginning of the verification phase, and weekly at the end). A full set of all reports will be delivered with the hardware as part of the Acceptance Data Package. Due to use of the HRF computer on E085, the final hardware acceptance test will be performed at JSC per the CSR-generated procedure and documented on a Task Performance Sheet (TPS) with a JSC witness. Electronic Submittals of documentation in revision controlled PDF format is acceptable.
- 6.6 Delivery to JSC** – CSR will prepare an Acceptance Data Package (ADP) for each flight hardware assembly, which will include copies, electronic copies where practical, of all required paperwork and drawings (ADP contents are documented in the HRD). CSR will package the hardware for shipment to ensure the hardware does not become damaged during transport and will have the hardware sent directly to JSC bonded storage. The hardware will be sent on a DD-250 form signed by the ONR representative. The DD-250 will not be signed by the NASA ESM/COTR until after all environmental and functional testing has been completed at JSC. After all testing has been successfully completed, the DD-250 will be signed and NASA will officially accept the hardware.
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6.7 Software Development and Delivery

- 6.7.1** Software Quality Assurance activities will be performed with the responsible E085 and E507 Project Scientists and the Project Programmer.. E085 and E507 personnel are responsible for performing code reviews, testing, configuration verification, and a virus scan prior to shipment. Final Determination of the suitability of the experiment software components to perform the required science will be made by the Principal Investigators for the E085 and E507 experiments.
- 6.7.2** Alpha release of experiment baseloads will be via the same Engineering Change Order (ECO) process as the flight hardware. Numeric releases during the initial software development period will be implemented, but not require the formal peer review process.
- 6.7.3** The software will be shipped directly to JSC bonded storage with a DD-250 form signed by the ONR representative. The software test plan and version description document will be sent to the experiment team to support software functional testing. The DD-250 will not be signed by the NASA ESM/COTR until after functional testing per the software test plan has been completed at JSC.

7.0 TESTING

Environmental Testing for hardware developed for VOILA will conform to the VOILA Environmental Test Matrix, to be included in the Hardware Requirements Document (HRD). The matrix includes the responsible party for testing and the environments the hardware will be tested in. Details for the testing will be provided in the VOILA Hardware Requirements Document.

8.0 CHANGES TO QUALITY PLAN

Any required changes to this quality plan after it has become an official part of the contract will require review and approval by the ESM/COTR NASA SR&QA Manager, CSR SR&QA Manager and CSR Project Manager. Changes will be clearly documented against the original Quality Plan (change bars, strikethroughs, etc.) and the updated document will replace the original in the contract via a contract modification from the JSC Contracting Officer.

9.0 APPROVALS

The signatures below signify acceptance of this plan as technically acceptable to NASA and CSR.

NASA SR&QA\ Alan Dover

CSR SR&QA Manager\ B. Klatt

NASA ESM/COTR\ Dave Baumann

CSR Program Manager\R. Foster
