GLAST LAT Technical Document	Document # **LAT-TD-00516-01**	Date 17 December 2001
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	Subsystem/Office Calorimeter Subsystem	

Document Title
Calorimeter Subsystem PDR Action Items

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes

1 ABSTRACT

This document summarizes the comments, questions, and requests-for-actions created at the Calorimeter Peer Design Review on July 17, 2001. Calorimeter team responses and proposed dispositions are also presented.

2 DEFINITIONS

ACD	The LAT Anti-Coincidence Detector Subsystem
AFEE	Analog Front End Electronics – CAL analog and readout boards
ASIC	Application Specific Integrated Circuit – custom electronic functionality in a single silicon device.
BTEM	Beam Test Engineering Model – CAL module built in development program
CAL	The LAT Calorimeter Subsystem
CDE	CsI Detector Element – CAL crystal with bonded PIN diodes and wrap
CES	Checkout Electronics System (Part of electrical ground support equipment
COTS	Commercial, off-the-shelf
FOV	Field of View
FWHM	Full Width Half Maximum
GCFE	GLAST CAL Front-End. The CAL analog front end ASIC.
GLAST	Gamma-ray Large Area Space Telescope
GSE	Ground Support Equipment – test equipment and fixtures needed in assembly and test of the CAL modules
IOC	Instrument Operations Center
IPO	Instrument Project Office – LAT project office at SLAC
IRD	Interface Requirements Document
LAT	Large Area Telescope
MC	Monte Carlo

MSS	Mission System Specification
NRL	Naval Research Laboratory
PEM	Pre Electronics Module – CAL mechanical structure with CDEs installed
PI	Principal Investigator
SAS	Science Analysis Software
SRD	Science Requirements Document
SSC	Science Support Center
T&DF	Trigger and Data Flow Subsystem (LAT)
TBR	To Be Resolved
TKR	The LAT Tracker Subsystem

3 Recommendations

The following recommendations were made during the review and were endorsed by the review committee. The Calorimeter team response follows each recommendation.

3.1 Requirements

1. **The positional resolution and angular resolution requirements (Level III) are not being met because of reduced radiation length of the calorimeter. A change is needed in the specification LAT-SS-00018-01, and the specification release plan needs to be resolved. These numbers are measurable in beam testing and were used as a handle for testing the modules. There is no impact on the Level II(b) specifications.**

   Response: These changes were proposed at the PDR and have been incorporated in the signed CAL Level III specification (LAT-SS-00018-09, dated 28 Nov 2001). Specifically, 5.5.5 specifies that the CAL position resolution for minimum ionizing particles shall be less than 3.0 cm (1σ) in all three dimensions for particle incident angles of less than 45 degrees off axis. And, 5.5.6 specifies that the angular resolution shall be better than $15 \times \cos^2(\theta)$ degrees (68% containment) for cosmic muons traversing all eight layers.

2. **The low energy limit of the dynamic range of the Analog Front End Electronics (AFEE) is 5 MeV, with a goal of 2 MeV. Ensure that this is stated correctly in the Level IV requirements.**

   Response: Section 5.2.2 of LAT-SS-00018-09, dated 28 Nov 2001, clearly states the single crystal energy domain. Analogously, Cal L-IV spec LAT-SS-00210 specifies in Section 5.3.2 that "The energy measurement range for each of the CsI scintillation crystals shall include the range from 5 MeV to 100 GeV. The goal is to achieve a low energy threshold of 1 MeV."

3. **The light yield of the large PIN photodiode should be stated as 5000 e^-/MeV (<u>as a goal</u>) and the conditions of this measurement should be clear: @ 20º C, shaping time 6 microsec (?).**

   Response: The CAL Level IV specification (LAT-SS-00210) states the requirement of at least 5000 e-/MeV measured by the large PIN photodiode for energy depositions at the longitudinal center of the CsI crystal. Similarly, the light yield measured by the small PIN photodiode shall be 800 e-/MeV. The conditions for these measurements are clarified below:

   This is a beginning of life requirement for laboratory measurements and acceptance of Crystal Detector Elements (CDE) in the mechanical structure. Radiation damage over the 10-year life of GLAST (10k Rad) is expected to reduce the light yield by approximately 25% based on measurements on BTEM crystals (LAT-TD-00242) and literature values. (The requirement in both the CAL Level IV Section 6.2.6 and the CsI crystal spec is to have no more than 50% light yield reduction)

These laboratory measurements are made at room temperature (20 – 25 deg C). We anticipate a reduction in the light yield of ~0.5% per deg C as the temperature is lowered to the LAT CAL flight temperatures (~ 0 – 10 deg C).

These measurements are made with typical laboratory shaping time constants using eV 5093 hybrid preamps and NIM shaping amps. The measurement techniques are specified in LAT TD-00381-01. The shaping time constant is 3 μsec with an ~ 6 μsec peaking time. The stimulating signal can be cosmic muons or radioactive source. At NRL, we prefer the photopeak of the 2.6 MeV gamma line from a collimated ^{228}Th radioactive source.

This is a requirement; it is not a goal. This performance is needed primarily at beginning of life for reasonable testing of CAL modules during assembly and test using the only generally available calibration signal – cosmic muons. This response to cosmic muons will permit preliminary calibration and monitoring of the CAL modules throughout the CAL assembly and test as well as the LAT assembly and test. It permits both energy scale calibration (at least for the low energy diode) and positioning calibration.

At end of life, the light yield in orbital conditions is anticipated to be as little as 2500 e-/MeV; that is, a reduction by as much as a factor of 2 in light yield. This has been considered in the gain adjustment capability of the GCFE (front end analog ASIC), the noise occupancy of CAL readout, and the low-energy threshold effects on the LAT energy resolution at lowest energies.

4. Requirement 5.3.4 for CsI crystal response to heavy ions is too tight. Make appropriate adjustments to requirements document. (Information from Benoit Lott to Tune Kamae).

Response: The specification for single crystal response to Carbon ions was based on measurements made at ion beams with prototype calorimeters. It was clearly stated in the requirements document as a mono-energetic beam test specification with a controlled beam size. That specification permits correlation of the diode responses at each end of the crystal to remove the fluctuation effects that concern Benoit Lott. However, the released Level III specification has been modified to require 2% energy resolution for high energy Carbon ions. This relaxed specification will permit independent analysis of the PIN signals and includes the resolution broadening caused by the fluctuations.

3.2 PIN Diode Bonding

5. The bonding of PIN photodiodes to the CsI crystals should be considered a "special topic" for the Instrument PDR

Response: Reports on the bonding study at NRL and France have been prepared. Bonding material and procedures have been identified and baselined for Engineering Model work. A presentation on these topics will be prepared for day 3 of the PDR. The bonding specification was submitted to GSFC materials branch for review and comments. All comments were incorporated. This spec will be updated to a final specification for flight production. Preliminary tests performed on samples prepared following the EM specification met mechanical and optical requirements. We are planning to have a bonding training program for all personnel involved in bonding of PIN photodiode to crystal.

6. Bonding of PIN diodes to the CsI crystals qualifies as a "special process." Additional controls are required to ensure quality. Detailed plans and processing documentation should address the following:

a. Technical training and qualification

Response: A separate technical training and qualification procedure is being written in collaboration with France. A rough draft has been written. Qualification of various glues were conducted by NRL and France. A report on these bonding results has been written. Bonding material has been selected which meets NASA outgassing criteria and has been used previously by GSFC on other space programs. For details please see the Process Specification for Bonding of PIN Photodiode to Crystals, CF-GLAST-Q-41555-041-PA (GLAST France document).

b. In-process test and inspection with specific rejection/acceptance criteria

Response: In-process controls and specific in-process tests have been specified in the bonding process specification and has been reviewed by GSFC materials branch. Rejections acceptance criteria are also part of the bonding process specification.

c. Approval of glue for flight

Response: We have selected Dow Corning DC 93-500 with primer DC 92-023 on the basis of the studies conducted so far. We intend to do some more long term studies prior to gluing flight parts. Alternate materials have already been identified and are undergoing further test. We will present these topics in detail on day 3 of the PDR.

3.3 Integration and Test

7. Examine the possibility of allocating some of the 4 T/V cycles at module level to the already-planned log-level test. This may help reduce the cost of module testing.

Response: The overall environmental test program for LAT is being prepared by the LAT IPO. CAL test program will respond to the requirements of this program as well as address the concern of over testing. The current test program of CAL has been revised since the CAL PDR with a proposed reduction in PEM environmental testing in France. The substitution of thermal cycling for T/V cycling will also be addressed when the LAT program is clarified. The 4 T/V cycles at module level are part of the current baseline and have been appropriately budgeted.

8. Develop a requirements verification matrix for the ASICs and design the ASICs to accommodate verification testing. This will ensure all requirements for the ASICs are known and testable on actual hardware.

Response: The qualification and verification of all CAL ASICs is a collaboration among the CAL lead electronics engineer, the CAL Reliability and Quality Assurance manager, and the LAT chief electrical engineer. The qualification plan has been written by the CAL R&QA manager. The ASIC functional test and screening will be performed by automated testing techniques using specifically designed test vectors and responses. The adequacy of these vectors to verify the performance and functionality of the CAL ASICs will be reviewed and confirmed by the CAL management, CAL design engineers, CAL test engineer as well as the LAT chief electrical engineer. It is believed by the LAT chief engineer that there is no need to design specific test and verification capability into the ASICs. These structures and I/O pins create problems of device complexity and size – both in silicon and on the PCB.

For space-applications three main radiation issues are of concern.

Total ionizing radiation dose: MOS transistor threshold shifts and increase in pn-junction reverse leakage currents. The LAT goal is to meet performance specifications up to 10 Krad (Si).

Single-Effect Latch-up (SEL): forward biasing, via parasitic bipolar transistors, of a normally reverse biased junction due to charge induced by particle. Can be destructive. The LAT requirement for a minimum lateral energy threshold (LET) is 8 MeV/mg/cm^2.

Singe-Effect Upset (SEU): change of a stored bit (e.g. memory, register) from logic 0 to 1 or vice versa from charge induced by particle. The LAT requirement is the performance is met for a lateral energy threshold (LET) of at least 8 MeV/mg/cm^2. (essentially like to have stable configuration registers for more than one day).

The baseline for the LAT ASIC is the 0.5 micron Agilent Bulk-CMOS process. Due to the thin oxide layer, the process is intrinsically radiation tolerant. Several radiation experiments were performed by UCSC (Co60, laser, heavy-ion beam) and NRL (laser). Radiation doses up to 20 Krad showed negligent effects. No latch-up was observed up to least 85 MeV/mg/cm^2. (Insensitive due to the epitaxial layer in the employed process). Custom SEU-insensitive registers were designed at SLAC and used in all the LAT ASICs for all configuration registers. The LET for those registers is about 10-20 MeV/mg/cm^2 and the expected upset rate is less than 1 bit in 10 years, which is far better than required. More radiation testing will be performed on all lots (including prototype, engineering) prior to finalization of fight design. All flight lots will be radiation tested prior to use.

ASIC Engineering parts and flight parts (wafer and packaging parts) will be produced on the same process line. All process variables will be tightly controlled so that they do not shift from the fabrication of engineering parts to the fabrication of flight parts. All test vector sets developed during design will be used for testing each engineering and flight part over specified temperature and voltage extremes. Test vectors will verify an ASIC during several part acceptance activities that include characterization, tests, screens, and QCI. ASIC design team performs an engineering part electrical characterization to determine performance limits under all anticipated stresses and the team also resolves problems associated with meeting part requirements based on engineering part verification results. We will perform screening, qualification, and other tests on the flight parts, as stated in the attached viewgraphs in appendix A. ASIC specifications will state clearly how ASICs will undergo qualification tests and screens to assure continued quality and reliability considerations throughout an ASIC program. ASIC specifications presently generated have been submitted to GSFC for review.

9. Management of test data should be presented.

Response: Test data generation and control will be a part of a closed loop work order system that will be used by CAL subsystem. All work will be done by an approved Work Order Authorization (WOA) system. This work will include, but not limited to, integration, functional testing, trouble shooting, environmental tests, and transportation of the hardware. The WOA will specify the hardware items involved in the task, provide a brief description of the work to be performed, list the required documents, call out any hazards, and provide for the necessary approval signatures. The WOA form allows for short procedure steps to be included as part of the document in lieu of a separate formal procedure document. Attached procedures must be approved by the I&T Manager, System/Subsystem Leads and QA.

The WOA flow diagram shown in Figure 1 illustrates the process and provides a way to plan the work and keep a record of the work being performed/completed on the subsystem. A separate log will be maintained on a daily basis showing the status of all WOAs by WOA number and title. The WOA forms will be maintained by a QA representative, including the log-in and sign-off of the work as completed. WOAs will be initiated by Subsystem Leads, Systems and the I&T Manager or designated representative. WOAs must be approved by the I&T Manager, or delegated representative, Systems Lead, Systems, QA, and appropriate Subsystem Lead.

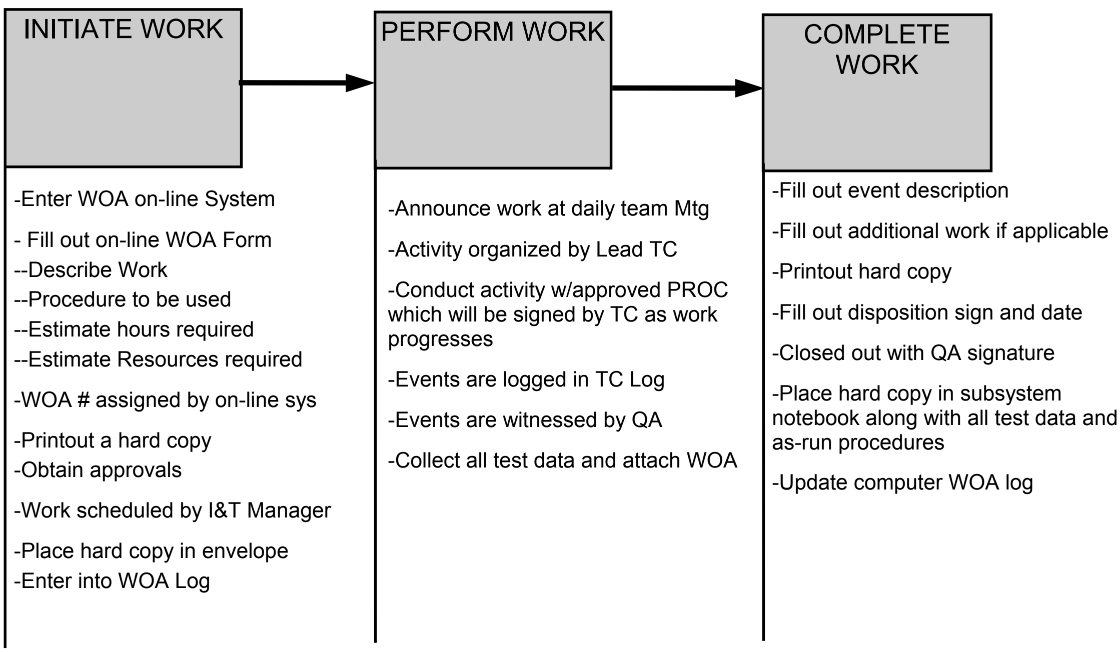


Figure 1 Work Order Authorization Flow

The WOA system is a Microsoft Access database. The database file resides on the Server. All users will be assigned a login username and password, which will determine their approval level. The computer requirements for using the WOA system are to have both Microsoft Access and a Microsoft Email Client (i.e. Outlook, Internet Mail, etc.) with valid user profile installed. A hard copy will be printed out at the initiator's request and the appropriate signatures will be obtained for approval. The hard copy will be the official document. The WOA log will be established and maintained by QA personnel.

10. The current test plan is to perform environmental testing of the PEM with dummy electronics in France, then remove them before shipment. After shipment to NRL, the units are acceptance tested, the flight electronics are added, and the module undergoes subsystem-level environmental testing. There is some concern that this plan is inefficient and introduces risk due to handling. Consider developing a plan that minimizes assembly and handling activities.

Response: The overall environmental test program for LAT is being prepared by the LAT IPO. CAL test program will respond to the requirements of this program as well as address the concern of over testing. The current test program of CAL has been revised since the CAL PDR with a proposed reduction in PEM environmental testing in France. Functional testing of the integrated CDE's is necessary to avoid de-integration at CAL Module level in case of damage during integration to PEM. The substitution of thermal cycling for T-V cycling will also be addressed when the LAT program is clarified.

11. The vibration test plan at NRL includes the power supply and TEM boxes. This test should also include the other boxes that would be attached, such as an SIU or Event Processor, or at a minimum, a mass mockup.

Response: The CAL test program has been modified from that presented at CAL PDR. The flight TEM and power supply will not be available for simultaneous testing with flight CAL modules. CAL module testing will be performed with EM versions of TEM and laboratory power supplies. Mass models of missing LAT components will be provided as appropriate and identified in the CAL environmental test and qualification plan. A draft of this document is LAT-SS-

12. Provide detail on the construction database. Show how it will track the state of the hardware and electronics and how it will interface to model tests and ground processing.

Response: All work will be performed using the close loop computer controlled WOA system that will track the fabrication, assembly, I&T of CAL subsystem activities. All information will be stored in the database linked to a unique work order authorization (WOA) number. Problem records written against the WOA are continually tracked to ensure a high level of product assurance. Real time user defined reports will be generated to display current status of each work order and problem records.

All test failures of flight hardware will be documented with a PR. The PRs are used to document and track single anomalous events and their resolution. The I&T Manager, supported by the Core Team, will periodically review outstanding PRs, maintain report files and present status. A review will be conducted on the resolution of all flight hardware anomalies. The WOA system will also provide a tracking system for assigning numbers, and for logging and reporting the status of the anomaly. For details please see the attached viewgraphs in appendix B

3.4 I-PDR Presentation

13. Show how much margin there is in the design for expected degradation of CsI due to radiation and show results of radiation testing.

Response: This information is available in the CAL PDR Design Report (LAT-TD-00242) and in the GCFE (ASIC) design description (LAT-DS-00424). Tests during the development program for the 1999 beam test indicated ~25% loss at 10 kRad. The GCFE is designed with a gain adjustment of ~ ×3. The crystal procurement specification requires less than 50% degradation in light yield on boule samples from each boule used in fabrication of flight detectors. Preliminary radiation test results on boule samples from Amcrys-H (the flight vendor) have recently been generated showing very limited performance degradation (<10%). This data is currently being finalized.

14. The mechanical presentation shows results, but it would be helpful to identify numbers as: analysis, tested on test units, or actual measurements. Also, compare the numbers with the requirements.

Response: Preliminary analyses have been completed. More detailed analyses will be complete by PDR. Summary reports and PDR presentations will be available and will address this recommendation.

15. Be prepared to explain the reason for the engineering model at the instrument PDR.

Response: The engineering model (EM) CAL module is a prototype with form, fit and function of a flight unit, built with processes and materials that are planned for the flight units to the extent possible. Deviations for non-flight EEE parts and perhaps other materials is expected. Modifications to the EM design are expected in some areas, eg. final GCFE and GCRC will not be available. The objectives of the EM are:

a. the EM will demonstrate feasibility of fabrication, assembly and test processes and identify assembly problems and potentials for improvement.

b. the EM is the first PEM delivered to US, demonstrating shipping and handling issues, verifies ICD completeness and accuracy and develops working relationship and procedures for France/US.

c. the EM provides the first full integration of the AFEE electronics with a PEM. This demonstrates assembly issues and measures performance.

d. the EM will verify functional test procedures and EGSE software prior to flight usage

e. the EM will test the muon calibration procedures to establish the baseline calibration database. This tests processes and software.

f. the EM will undergo full environmental testing at NRL which might uncover design flaws or issues that need to be incorporated in the flight units as well as verify the environmental test procedures and activities before the flight "production line" begins.

g. the EM will be taken to electron and heavy ion accelerators for calibration and characterization at energies and with accuracies that will not likely be possible with the flight units.

h. the EM will be delivered to SLAC for software testing and development.

i. the EM will be returned to the CAL team for extended calibrations and investigations in other accelerator beams. Refurbishment with flight electronics boards should be considered.

The point of the EM is to demonstrate the design and processes for the flight unit and show that it meets the environmental and performance requirements. In this regard it is used to retire design and fabrication risks well before fabrication and assembly of the flight units. This demonstrates readiness for CDR. Thus, priority is placed on functional and environmental testing, with beam test performance continuing in the current schedule after CDR.

3.5 Other Issues

16. The grounding plan between the power supplies, the CAL PCB and the shielding of the Kapton flex cables needs to be finalized.

Response: The grounding plan for CAL is (and was) described in the document LAT-SS-00272. Concepts for this approach have been reviewed by the LAT chief electrical engineer and by CNES EMI/EMC experts. The CAL EM will verify the efficacy of the approach with EMI/EMC testing.

17. Describe the EMI/EMC program for the calorimeter, i.e. requirements, concerns, testing, analyses, resolution of concerns, control plan, etc.

Response: The Engineering (Qual unit) and first flight calorimeter built will undergo Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) testing at NRL, according to GLAST LAT requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment. NRL has an anechoic chamber setup for performing these measurements. The remaining flight calorimeter units will be accepted by similarity. Since the remaining flight calorimeters have some enclosure in metal, radiated emissions and radiation susceptibility will be the same, within very small acceptable variations. Conducted emissions from the power supply is the only real possible variance from the first flight Calorimeter EMI/EMC test results. We will require certification of EMI conformance for each power supply delivered by SLAC.

18. Due to the susceptibility of the CsI crystals to damage from high humidity, perform the following:

a. Specify the humidity, temperature, etc. required and identify any special equipment or handling procedures for the calorimeter during ground storage, instrument/spacecraft integration and test, shipping/handling and launch vehicle operations.

Response: Crystal and crystal assemblies will be environmentally controlled from the receipt of crystal, assembly I&T, LAT I&T and spacecraft integration. These requirements are specified in the Calorimeter Contamination Control Plan, LAT-SS-00228.

Crystals will be exposed and handled in controlled temperature environment, RH 35%-50%, in a class 100,000 clean room.

Special handling procedures for receiving inspection, handling, and storage are being developed.

b. Identify the worst-case humidity exposure time that the calorimeter can survive and the exposure time when damage occurs.

Response: Worst case humidity exposure time is 2 hrs at 65% RH, but we will not allow in our procedure beyond 55% RH for a maximum of 1 hr. If humidity reaches beyond 55% we require humidifiers to be shut down immediately and work will stop until the RH. Is between 35-50%

c. Ensure that a data recorder for humidity keeps a history of humidity exposure.

Response: The Calorimeter Contamination Control Plan, LAT-SS-00228, addresses all the above issues. At each and every station where crystals are handled all records for temperature and humidity are kept on a data recorder with the date on the chart.

19. Changes to version 3 tooling and production tooling should be controlled to only very minor changes. If significant changes are introduced, the VM2 models become questionable. In either case, a review of changes should be performed.

Response**:** Tool design and configuration will be part of the mechanical baseline and appropriately maintained under configuration control. Design and analyses will reflect and support any changes. The verification program will also be appropriately modified as needed. All changes will be implemented through change board process.

20. Are there significant shaping and memory times associated with the CAL detectors that could cause pile-up problems? See J. J. Russell's email in Appendix A.

Response: The CAL GCFE requirements specification (LAT-SS-00089**)** requires recovery from ×1000 overload in 100 µsec. This recovery is to below zero-suppression threshold. This is usable as a worst-case time for pileup sensitivity. A reasonable estimate for the LAT background rate is 10,000 events/second. As summarized in Table 1, the probability that a single crystal has residual signal from a previous event, given this rate and pileup time, is 1.9%. The probability that a given crystal is involved in two time-adjacent events is about 0.7%.

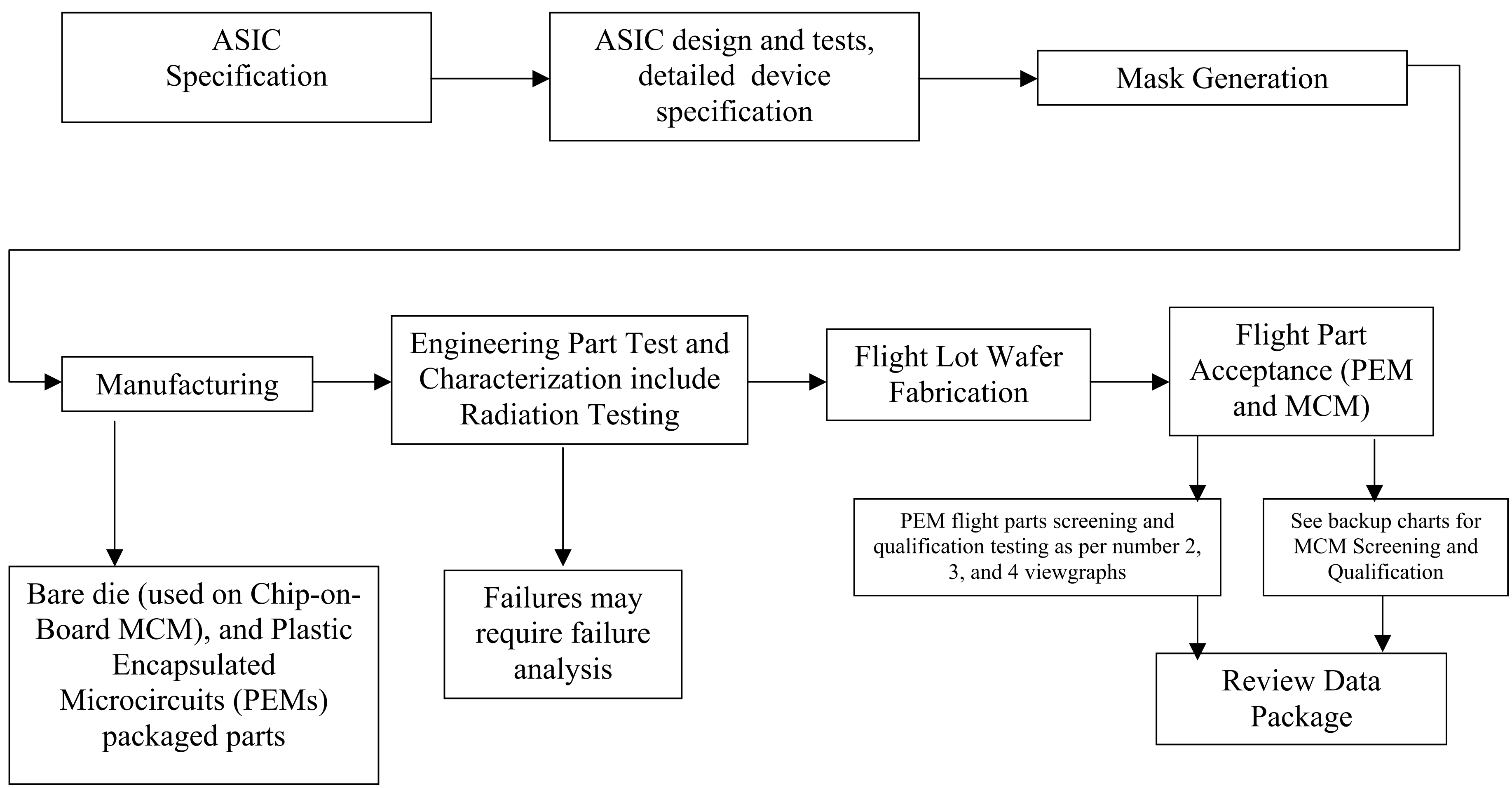
This is a worst case in many areas. For example, a large fraction (~80%) of the LAT event rate is from cosmic protons that generally leave less than 1 GeV in a crystal. This energy deposition represents essentially no overload to the low energy preamp. Consequently, recovery to baseline occurs in much less than the 100 µsec used above. Protons on average leave less than 200 MeV in any individual crystal. The average proton event involves 24 crystals and less than two of these crystals register as much as 200 MeV. There are tails to high energies in the distributions.

Table 1. CAL Event Rate and Pileup Considerations

LAT Event Flux		10000	events/sec
Ave Crystals per event	30		
Number of CAL Crystals	1536		
CDE Event rate		195	events/sec
Overload recovery time		100	microsec
Probability that event pileup occurs in single crystal		1.93%	
Probability that the same crystal is involved in two adjacent events		0.72%	

Appendix A

ASIC Flow Major Processes



Manufacturer Selection, Screening and Qualification of ASICs (PEMs)

Manufacturer Selection

- QML qualified vendor where possible with in-process control.
- Audit manufacturer

Radiation Testing

- Single Event Upset (SEU) and Total Ionizing Dose (TID)
- Radiation testing will be performed prior to the following tests.

Screening of ASICs PEMs (100%)

- External Visual
- Temperature Cycle
  - As per MIL-STD-883, method 1010, 20 cycles at manufacturer suggested temperature
- Serialization
- Initial Electrical Parameters @ + 25 degrees C (Pre burn-in test)
- Static Burn-in
  - As per MIL-STD-883, method 1015, condition A/B, 48 hrs at temperature not to exceed junction temperature.

Manufacturer Selection, Screening and Qualification of ASICs (PEMs)

Screening for ASICs PEMs (100%) (cont'd)

- Dynamic Burn-In test as per MIL-STD-883, Method 1015, condition D, 160 hours minimum at temperature not to exceed junction temperature.
- Final Electrical Test
  - Static Tests @ +25 degrees C, maximum and minimum rated operating temperature.
  - Dynamic and functional tests @ +25 degrees C, maximum and minimum operating temperature.
  - Switching test and +25 degrees C, maximum and minimum rated operating temperature.
- Percent Defective Allowable (PDA) Calculation
  - 10% from static and fu 2 tional tests measured @ + 25 degrees C.
- C-Mode Scanning Acoustic Microscopy (CSAM) as per IPC/JEDEC, J-035
- External Visual as per MIL-STD-883D, method 2009
- Pull 30 + 22 parts for qualification
- Bake flight parts 24hrs as per manufacturer maximum storage temperature.
- Bag flight parts in nitrogen purged bags.

Manufacturer Selection, Screening and Qualification of ASICs (PEMs)

ASICs PEM Qualification Includes:

- Preconditioning for moisture intake and reflow simulation (30pcs)
  - 168 hours, +85 degrees C, 85% RH, per JESD 22-A113, para. 3.1.5
- Highly Accelerated Stress Test (HAST) (30pcs)
  - Electrical testing
  - Biased HAST – 260 hrs at maximum temperature the part can operate and 85% RH
  - Electrical Testing
- C-Mode Scanning Acoustic Microscope (CSAM) as per IPC/JEDEC, J-035 (15pcs).
- Destructive Physical Analysis (5pcs)
- Operation Life Test
  - As per MIL-STD-883, method 1005, condition D, 1000 hrs 22 pieces from flight screening lot.

Appendix B

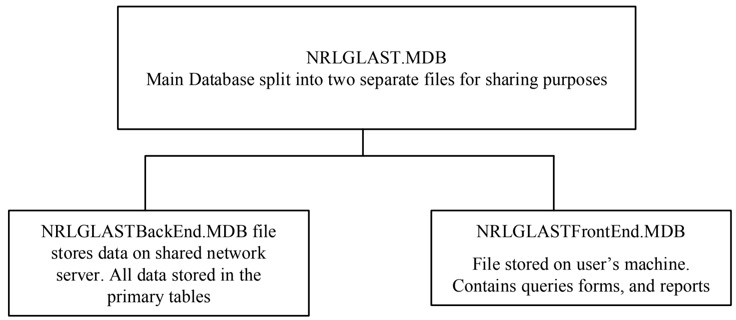
Closed Loop Work Order Authorization (WOA) Database System

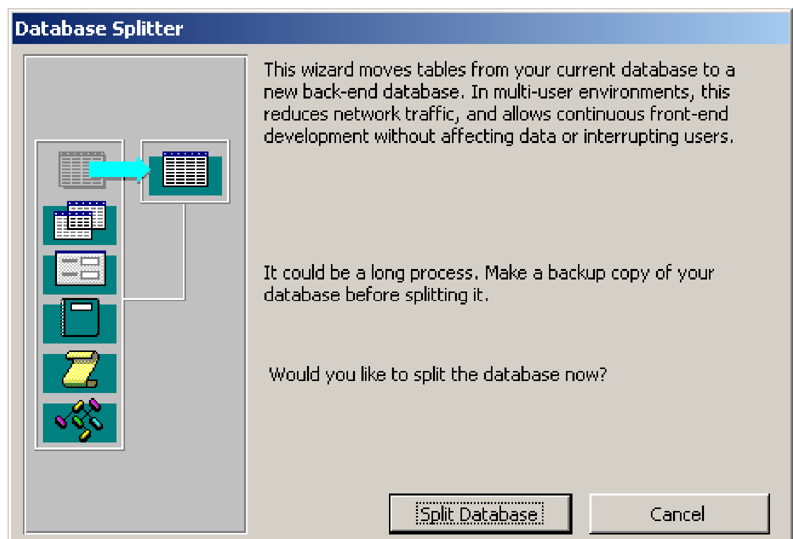
(to be used for all work including fabrication, assembly, testing, and shipping of CAL modules to SLAC)

User Guide For The Work Order Authorization Database

Purpose: To track the status of work orders and associated problem records. All information will be stored in the database linked to a unique work order authorization (WOA) number. Problem records written against the WOA are continually tracked to ensure a high level of product assurance. Real time user defined reports will be generated to display current status of each work order and problem records.

Database File Sharing

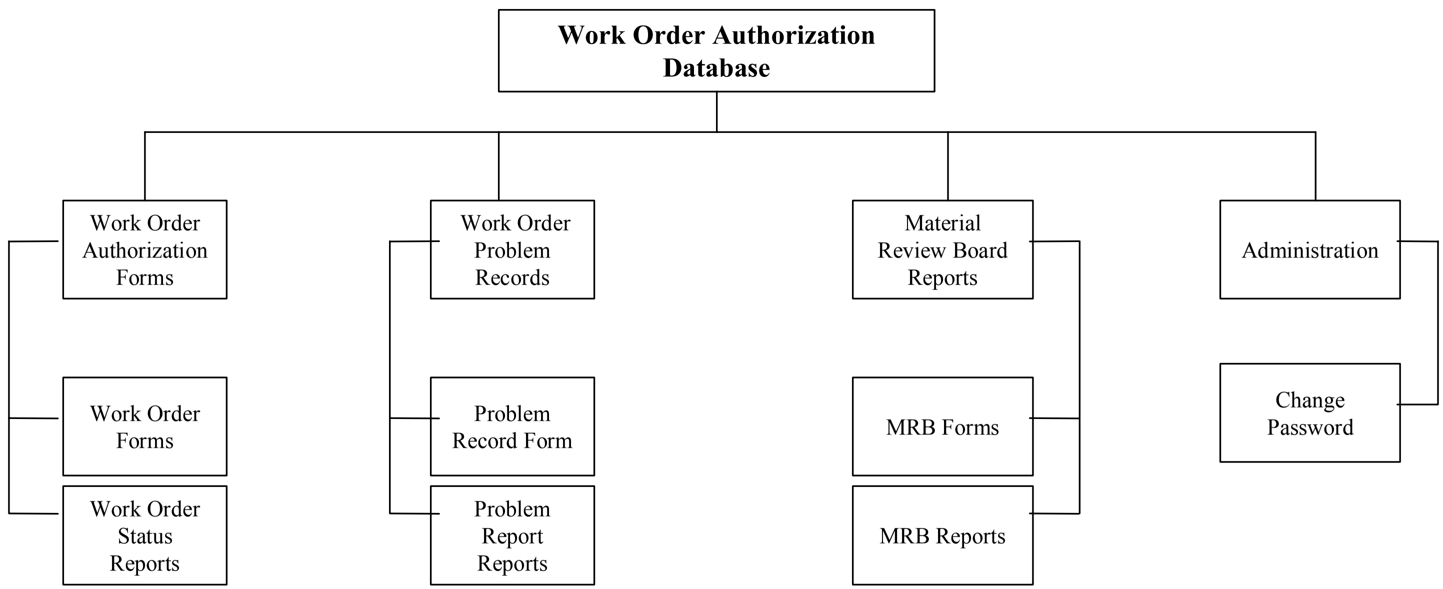




General Work Order And Problem Record Procedure

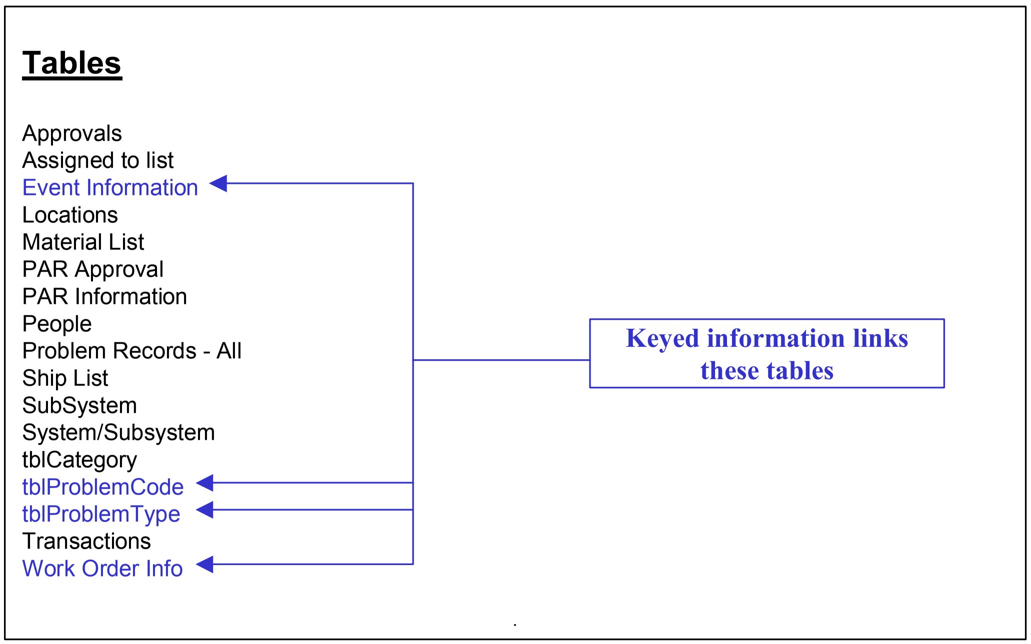
1) Work order created by initiator.
2) Modify / edit work order to meet objectives.
3) All cognizant managers authorize work order events via electronic password signature.
4) QA to ensure all required witness, inspection, and safety steps are included.
5) Final QA approval before work order is released to the floor.
6) Execute the work order events in sequential order.
7) Document problems on work order as they occur.
8) Lead engineer or QA enters problem into database.
9) Problem is evaluated by the red team.
10) Evaluation personnel include Calorimeter, systems engineering, QA and program manager.
11) Problem is assigned a status code of red(critical), yellow(urgent), and green(routine).
12) A critical problem will be reported to QA for MRB.
13) The cause and corrective action is established by the Calorimeter team.
14) The disposition is approved by all members of the material review board (MRB).
15) Problem record is closed out, work order event is closed out upon all problem resolutions.
16) QA ensures all problems associated with work order are properly dispositioned and closed.
17) QA proceeds with final signoff for the last event of the work order.
18) QA closes out the work order via electronic signature in the database.

Database Structure



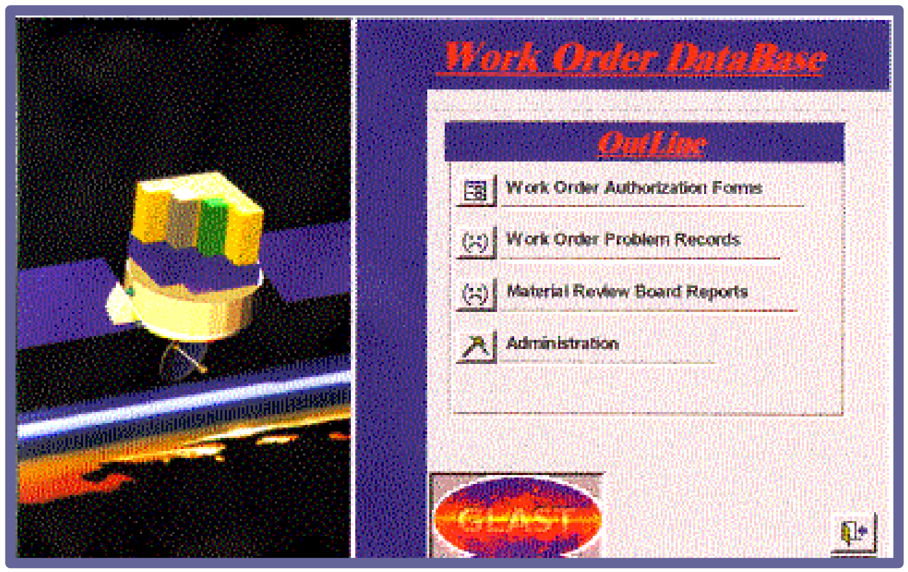
Listing Of Database Tables

A work order with a unique ID number is initiated and the event information is saved in the tables listed below. The database links the tables to each other so that redundant information is minimized. The problem code and problem type tables contain data associated with problem records that are linked to the unique work order number. Reports are generated from the data in the tables by filtering and sorting the fields to meet project requirements.



Initial Logon Screen

Main Switchboard With Four Selection Buttons



Work Order Authorization Entry Screen
Behind Switchboard Button # 1

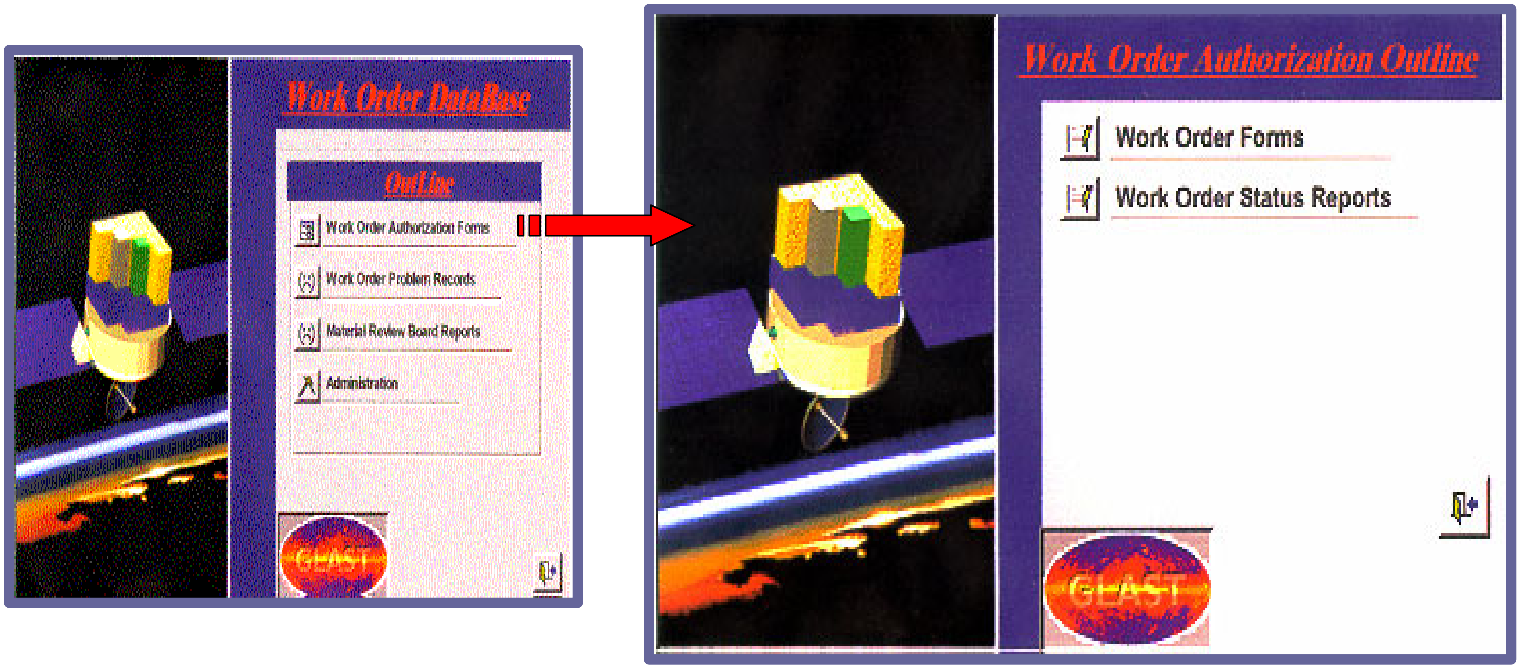
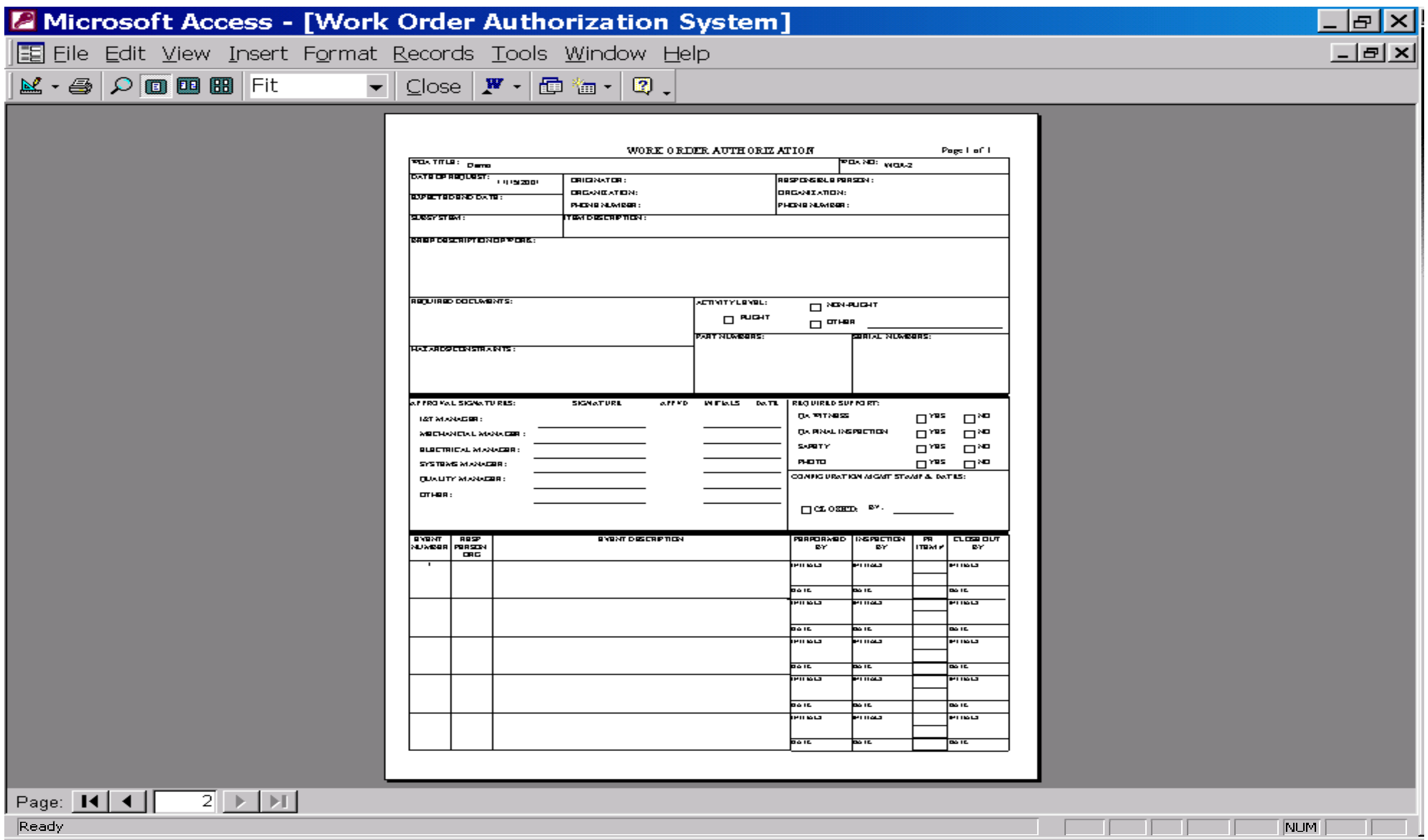
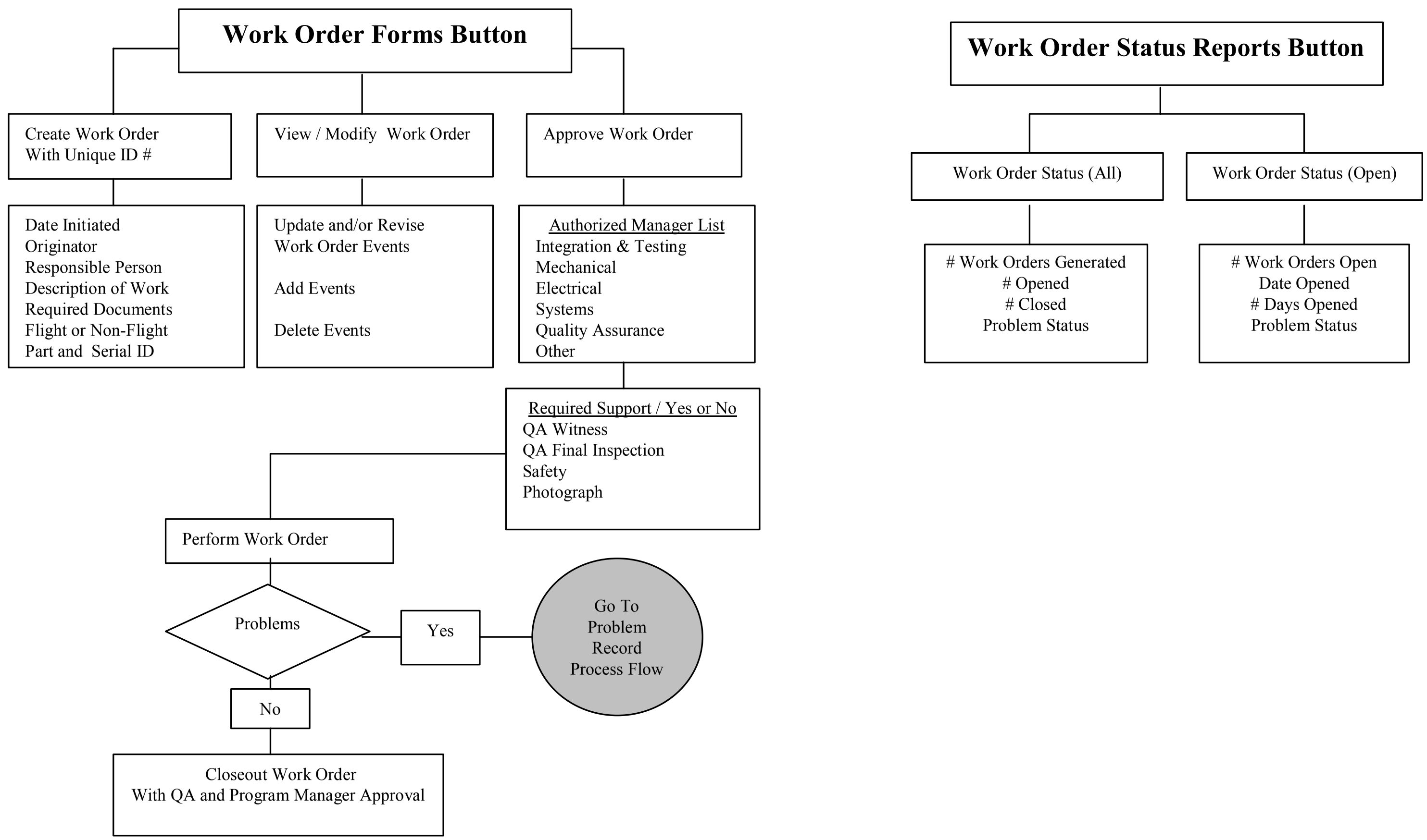


Exhibit Of Work Order Authorization Form



Work Order and Problem Record Process Flow



Work Order Authorization
Form Fields

WOA Title – a unique user assigned title for this work order activity.

WOA Number – a sequential work order number assigned by the database system.

Date of Request / Expected End Date – the beginning and end of the work order procedure.

Originator – choose form the pull down menu, the person who is creating this work order.

Responsible Person – choose form the pull down menu, the person assigned responsibility to carry out this work order to completion (may be the same as the originator).

Subsystem – choose for the pull down menu, the main system involved in the activity.

Item Description – the specific hardware items involved in the work order activity.

Brief Description – describe the work to be performed in general terms.

Required Documents – list the documents required to perform this work order activity.

Work Order Authorization
Form Fields (cont'd)

<u>Hazards/Constraints</u> – list all potential hazards to both personnel and hardware that will occur during the work order activity.

<u>Activity Level</u> – check all that apply to the hardware status level for the work to be performed.

<u>Part Numbers</u> – list the major hardware part numbers involved in this activity.

<u>Serial Numbers</u> – list the serial numbers for the major part numbers involved in the work order activity.

<u>Approval Signatures</u> - choose for the pull down menu, the personnel approvals required for the work order activity.

<u>Required Support</u> – determine the level of required support for the work order activity. All flight work must have "Final QA Inspection Required" checked.

<u>Configuration Management Stamp & Dates</u> – automated approval stamp and date for open and closed work orders.

<u>Event Number</u> – input sequential number of steps involved in the work order activity. Must be assigned by user and the numbers will be allocated by tens' (i.e., 10, 20, 30, etc…).

Work Order Authorization
Form Fields (cont'd)

<u>Responsible Person's Organization</u> – abbreviation of the organization in which the responsible person for the work order belongs (i.e. NRL, SLAC, etc…).

<u>Event Description</u> – a detailed description of the step to be performed in the work order activity.

<u>Performed By</u> – initial and date of person who performed the associated step of the work order activity. TO BE INITIALED AND DATED BY HAND.

<u>Inspection By</u> - initial and date of person who inspected the execution of associated step of the work order activity. TO BE INITIALED AND DATED BY HAND.

<u>PR Item #</u> - number of associated problem record (if any) for the step of the work order activity performed.

<u>Closeout By</u> - initial and date of person who approved the execution of the associated step of the work order activity. TO BE INITIALED AND DATED BY HAND.

Work Order Problem Record Entry
Screen Behind Switchboard Button # 2

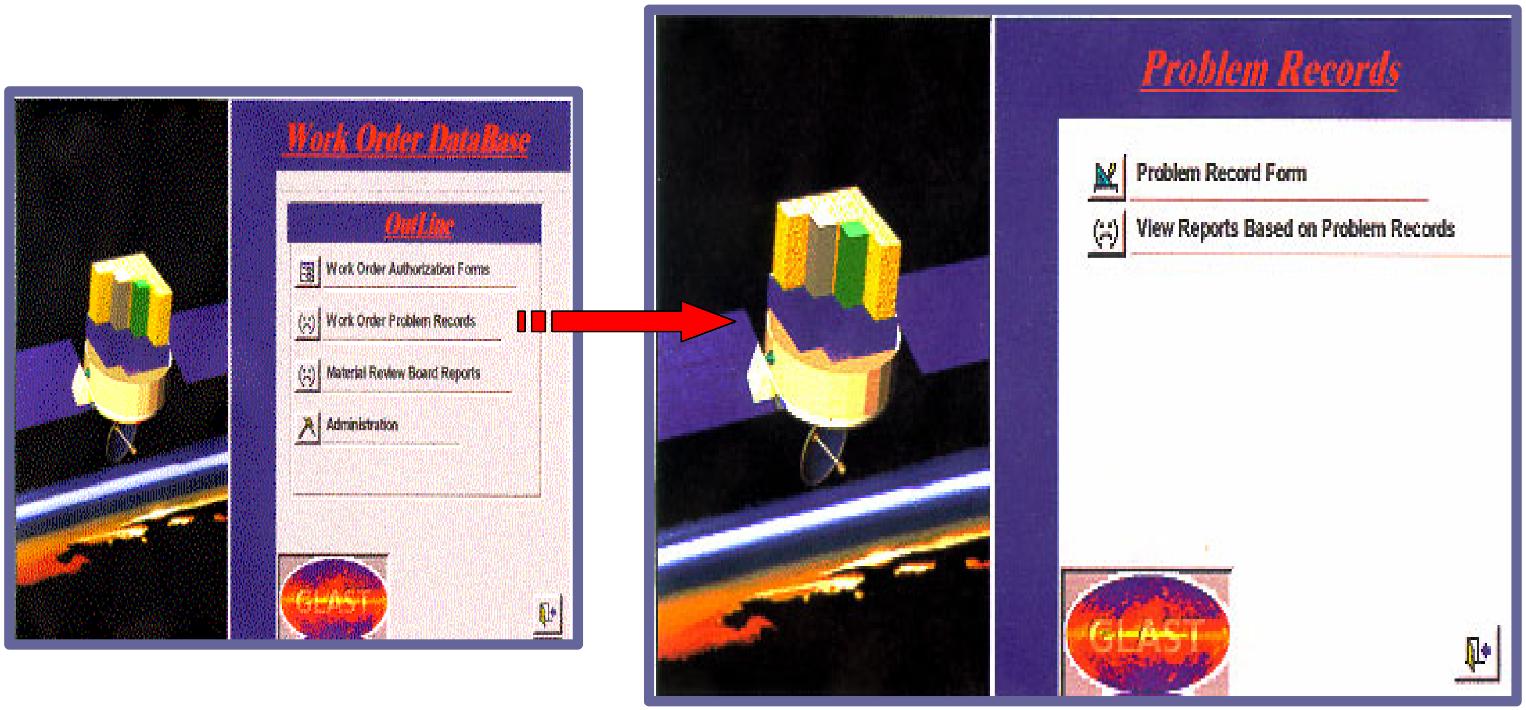
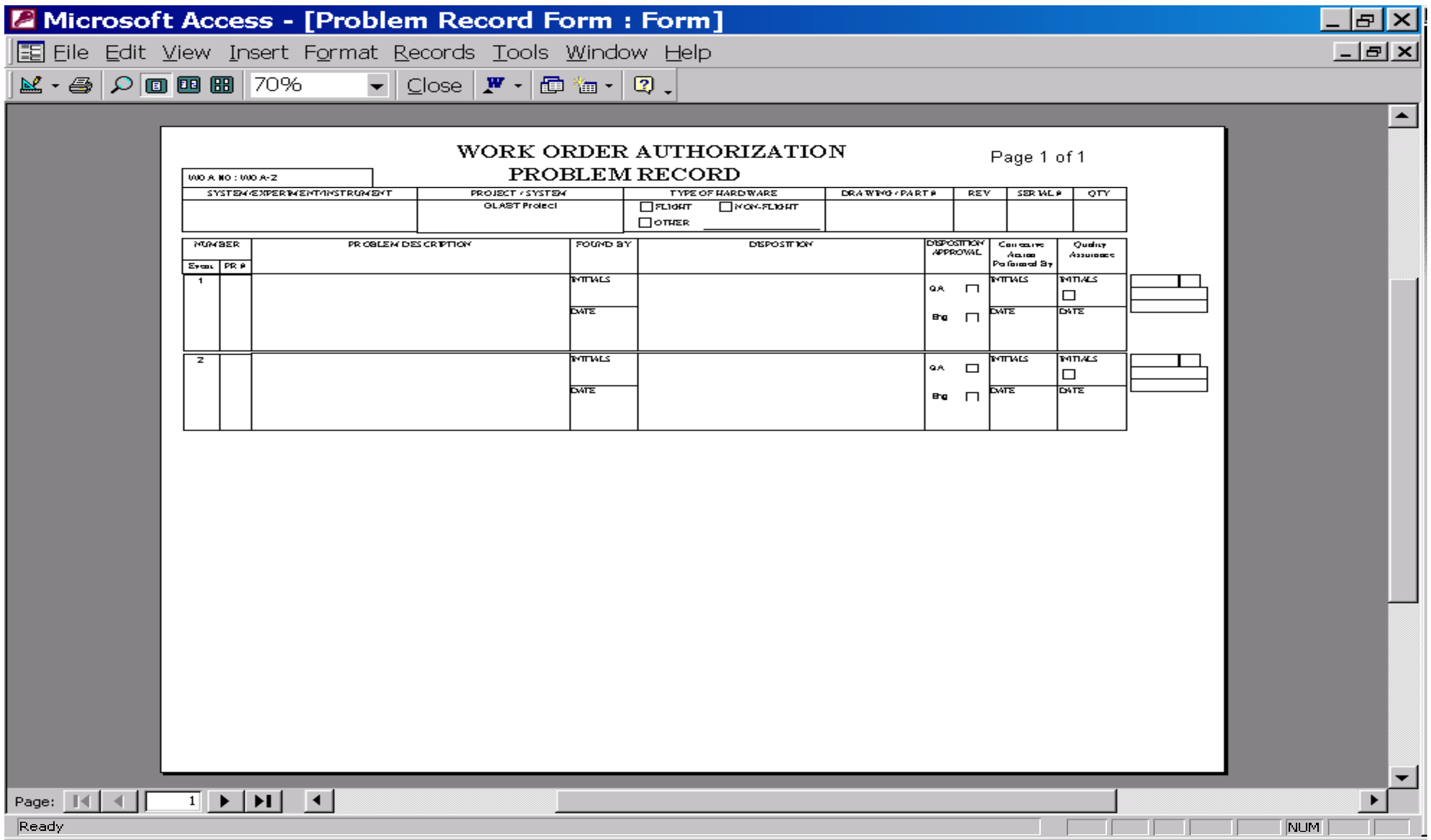
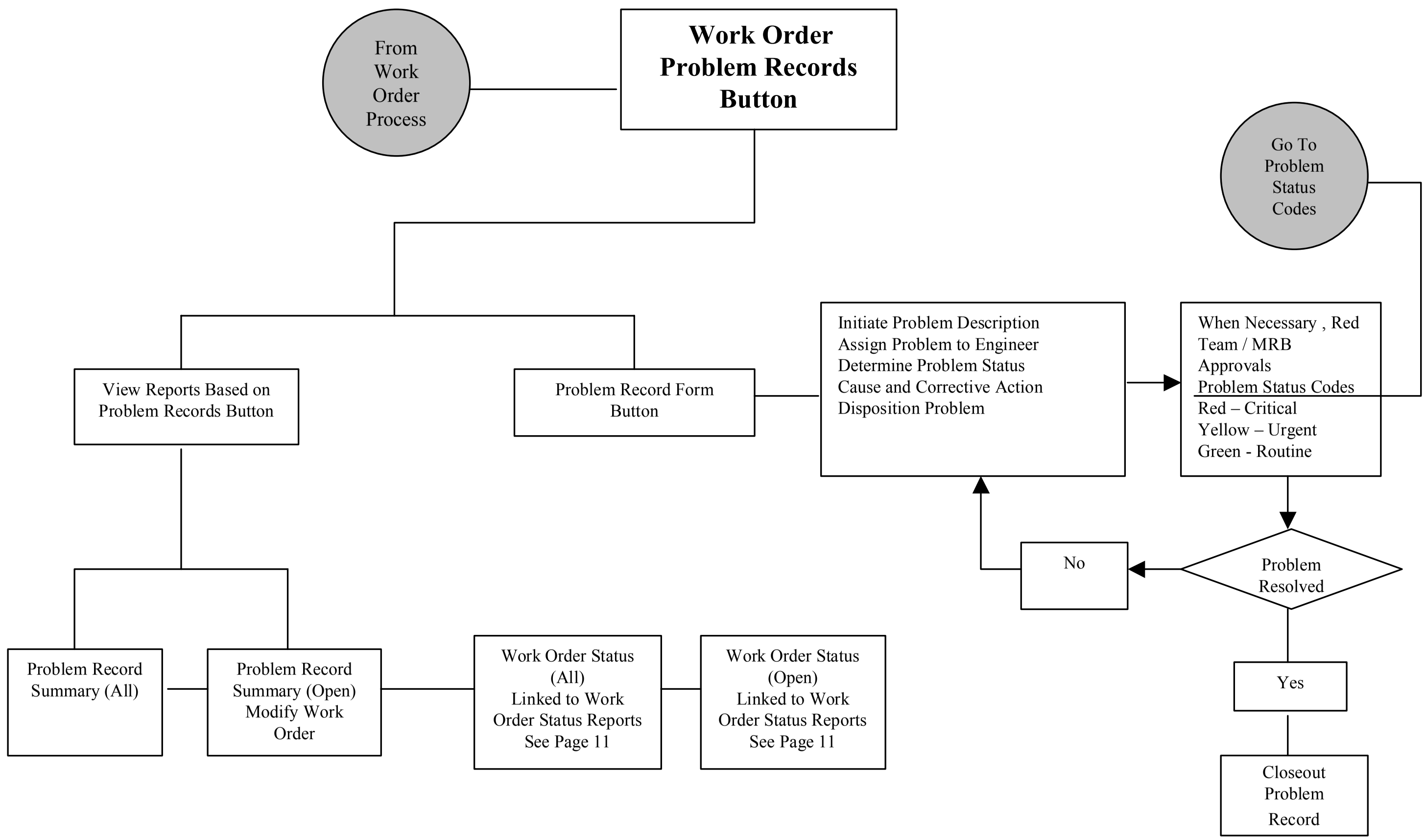


Exhibit Of Problem Record Form



Work Order Problem Records Process Flow



Work Order Problem Record
Form Fields

WOA No. – the sequential number assigned to the associated work order activity that the current problem record refers to, generated by the database system.

System / Experiment / Instrument – the name of the system corresponding to the current problem record.

Project / System - the name of the project corresponding to the current problem record.

Type of Hardware - check all that apply to the hardware status level for the work to be performed.

Drawing / Part # - the number assigned to the associated specification drawing or parts for the work order activity.

Revision – current updated revision number assigned to the referred drawing specification.

Serial # - the serial numbers of the associated parts referred to by the current problem record.

Quantity – the amount of the associated parts referred to by the current problem record.

Work Order Problem Record
Form Fields (cont'd)

Number - the sequential problem record number, assigned by the user, to identify each individual problem record.

- Event Number - refers to the event of the corresponding work order step.
- PR # - sequential number of problem records that refer to the corresponding event number.

Problem Description – A detailed description of the occurrence of the problem involved in the corresponding work order activity.

Found By – initials and date (mm/dd/yyyy) of the person who discovered the problem described. Must be inputted at the same time the problem description is created.

Disposition – a solution described in detail, to the problem referred to in the current problem record.

Disposition Approval – checked by the QA and Eng. personnel who must approve the recommended disposition.

Corrective Action Performed By – initials and date of the person responsible for performing the corrective action on the problem described in the current problem record.

Work Order Problem Record
Form Fields (cont'd)

Quality Assurance – checked by the QA person responsible for approving the work required for the completion of the current problem record and to close to the current problem record.

1st Pull Down Menu – choose the problem code associated with the current problem record.

2nd Pull Down Menu – choose the person in which the associated work order activity is assigned to.

3rd Pull Down Menu – choose the subsystem associated with the current problem record.

Material Review Board Entry Screen
Behind Switchboard Button # 3

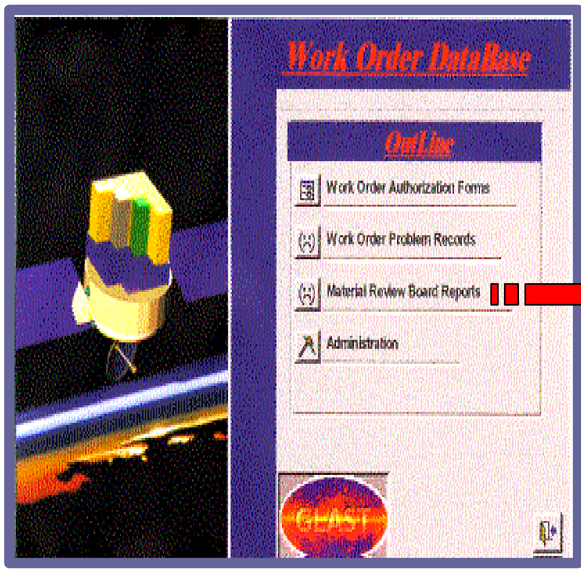
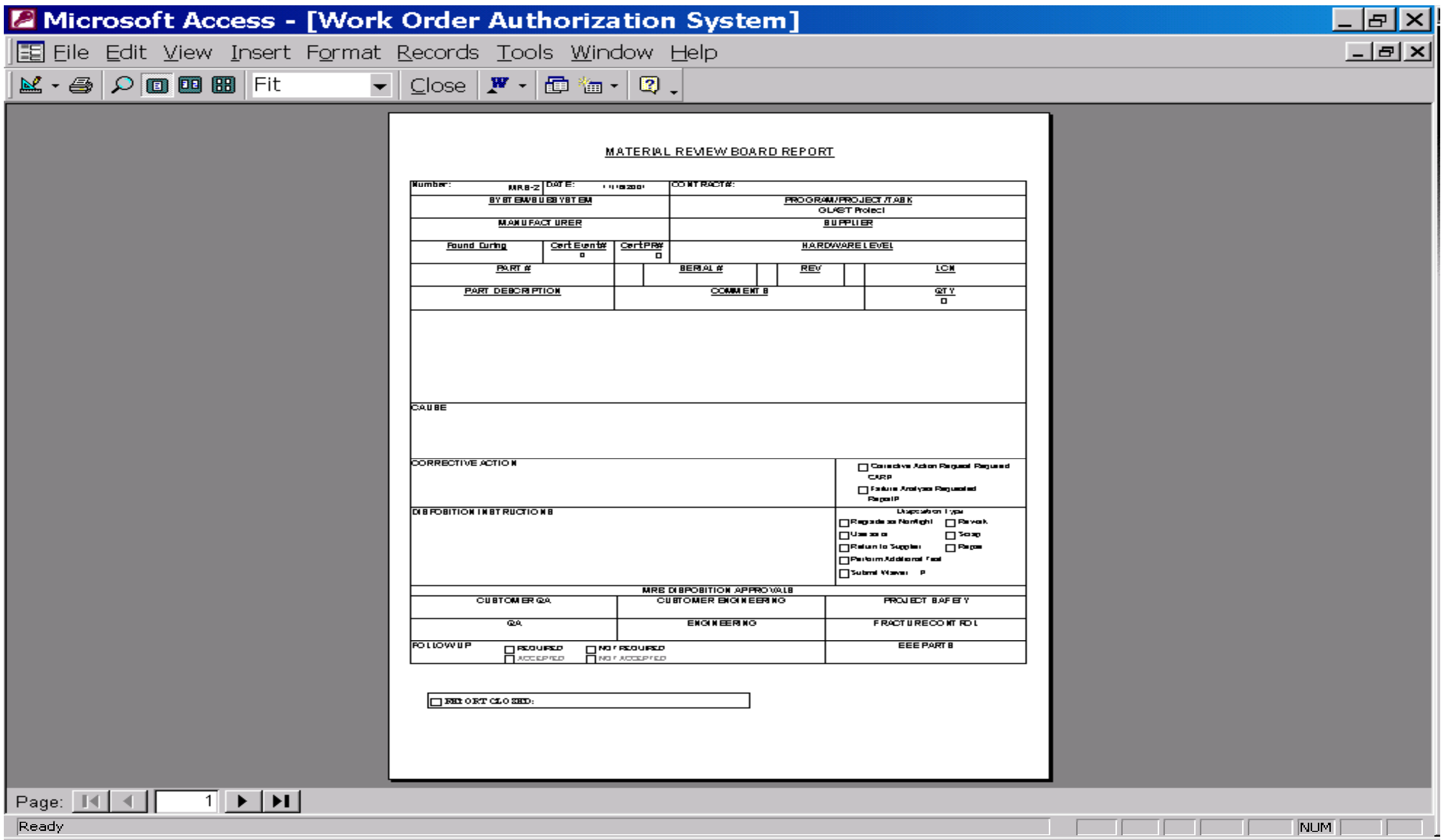
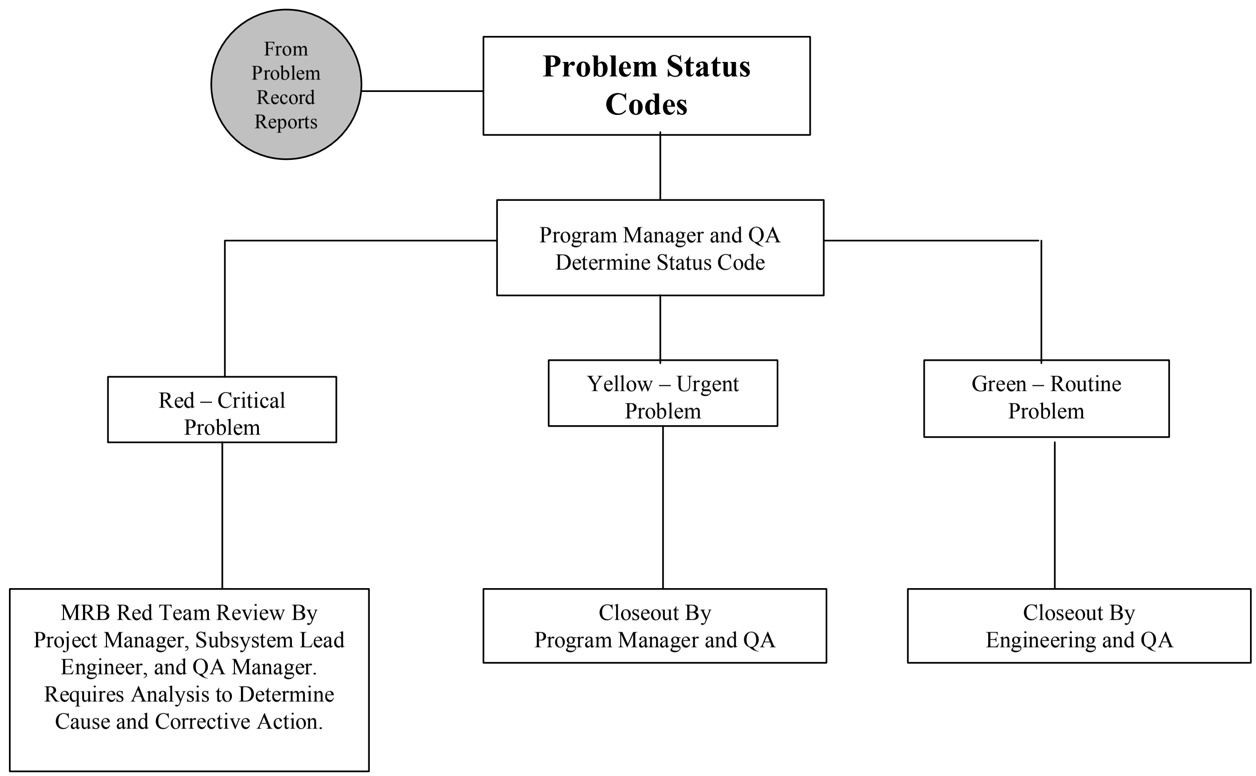


Exhibit Of Material Review Board Form



MRB Problem Status Codes



MRB Report Form Fields

MRB Number & Date - sequential number and date assigned to the current MRB report, generated by the database.

Contract # - enter the contract number associated with the MRB report.

System/Subsystem – system or subsystem associated with the current MRB report. Generated by the database.

Program/Project/Task – Program, project, or task associated with the current MRB report. Generated by the database.

Manufacturer – the manufacturer of the material in which the current MRB report is being generated.

Supplier – the supplier of the material in which the current MRB report is being generated.

Part # - the part number of the material in which the current MRB report is being generated.

Serial # - the serial number of the material in which the current MRB report is being generated.

Revision – the updated revision of current MRB report.

MRB Report Form Fields (cont'd)

<u>Part Description</u> – a brief description of the material in which the current MRB report is being generated.

<u>Comments</u> – add

<u>Quantity</u> – the amount of the materials in which the current MRB report is being generated.

<u>Description of Nonconformance</u> – a description of the nonconformance in which the current MRB report is referring. Generated by the database.

<u>Cause</u> – describes the reason for the existence of the nonconformance of the material in which the current MRB report is being generated.

<u>Corrective Action</u> - describes a possible solution to the nonconformance of the material in which the current MRB report is being generated.

<u>Disposition Instructions</u> – describes the process of performing the solution to the nonconformance of the material in which the current MRB report is being generated.

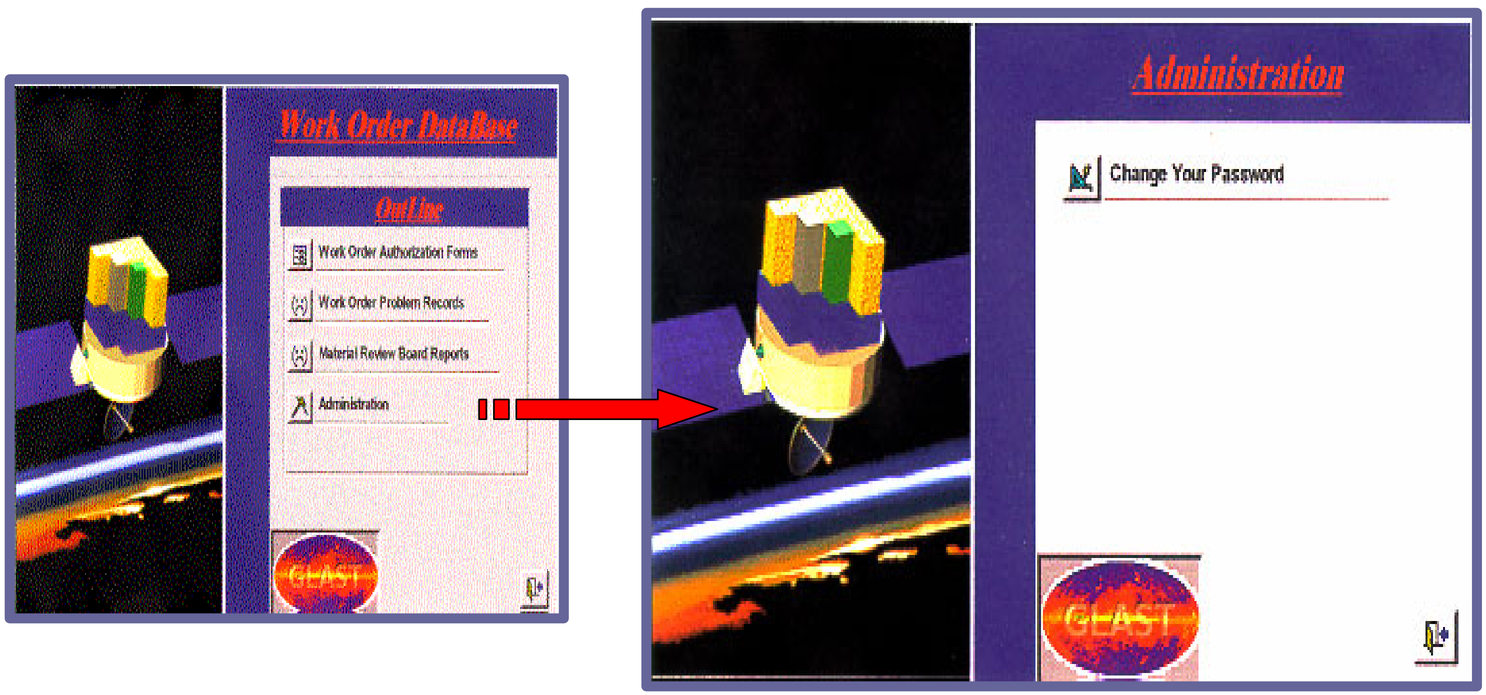
MRB Report Form Fields (cont'd)

Disposition Type – check all that apply to the disposition status level of the material in which the current MRB report is being generated.

MRB Disposition Approvals – assign a person responsible for of each of the following approval categories. The responsible person(s) must later approve the MRB report in order for the MRB report to be completed and closed.

Follow – up – check all that apply to the level of activity that must be accomplished in order to close-out the MRB report.

Administration Entry Screen
Behind Switchboard Button # 4



Administration / Database Security

The work order database has built in security that requires a password from approved users.
The user can change their password if forgotten or corrupted.