Document No. FCF-PO-RPT-0004
Revision Initial Release

Fluids and Combustion Facility Document

FCF/FIR/delta-CIR Critical Design Review Board Report

Date: January 10, 2003

Approved by William E. Taylor, Chairperson, FCF/FIR/delta-CIR CDR Review Board

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Change Record

Rev.	Effective Date	Description
Initial Release	1/10/03	Initial Release

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1.0 INTRODUCTION

The Fluids and Combustion Facility (FCF) Fluids Integration Rack (FIR) Critical Design Review (CDR), and Combustion Integrated Rack (CIR) delta-CDR were held December 9 to December 13, 2002 at the Ohio Aerospace Institute (OAI) facility near the Glenn Research Center (GRC) in Cleveland, Ohio. The review was performed in a presentation mode, with presentations on various appropriate topics being given by members of the NASA GRC FCF Project Office, and the Microgravity Research, Development, and Operations Contract (MRDOC) Contractor and their sub-contractors. Preceding the review was an intensive period of documentation review and discussion by members of the NASA community, including NASA Johnson Space Center (JSC), Marshall Space Flight Center (MSFC), Kennedy Space Center (KSC), and of course the GRC. Various members of the Science Team also participated in these reviews.

Membership on the review board was established by Letters of Appointment by the GRC Microgravity Science Division (see Appendices A.1 and A.2), and included the following:

Chairperson	William E. Taylor (Consultant QSS, Inc.)
Safety/ Product Assurance	Kenneth Adams (GRC)
Fluids Science	Yasuhiro Kamotani (Case Western Reserve University)
Combustion Science	Mun Young Choi (Drexel University)
Systems Engineering	Daniel Gauntner (GRC)
Engineering	John Taylor (GRC)
Crew/Human Factors	Janet Kavandi (JSC)
Operations/Integration	Jay Onken (MSFC)
ISS Technical	Michael Miller (JSC)
Systems Management Office	Harvey Schabes (GRC)
FCF Project	Robert Corban (GRC)

The scope of the reviews as contained in the aforementioned appointment letters included:

- FCF System design (flight system and ground infrastructure) and the detailed designs of FCF common hardware use for the FIR and the CIR. Since FCF common hardware was reviewed in detail at the CIR CDR, the focus of FCF common hardware review at this CDR will be on any design changes to FCF common hardware since the May CDR and the adequacy of common hardware to meet FIR and fluids science requirements.
- Fluids Integrated Rack (FIR) detailed design. In addition to a review of the detailed design of the FIR flight system, a review of FIR ground hardware (i.e., ground integration unit, engineering development unit, and crew training equipment) and FIR flight/ground support equipment are within the scope of this CDR.
- Combustion Integrated Rack (CIR) detailed design. It is planned that only the changes to the Combustion Integrated Rack (CIR) detailed design since the May 2002 CDR and the completion of open work since the CDR will be reviewed as part of the delta-CDR for CIR. This will include a review of the results of CIR engineering model testing completed since May 2002, CIR diagnostics packages not reviewed in May and the status of Requests For Action (RFAs), Review Item Discrepancies (RIDs), and any other open work from the prior review.

Areas not within scope were:

- Detailed review of FCF software. A separate Peer Review of FCF software will be held prior to this CDR, covering all aspects of FCF flight and ground software design. A summary of the results of this software review will be provided.

- Detailed design reviews of the Passive Rack Isolation System (PaRIS) and the Active Rack Isolation System (ARIS), except in relationship to their interfaces and integrated rack design with the CIR and the FIR, respectively.
- Detailed review of FIR and CIR Verification and Test Readiness. Separate Verification and Test Reviews (V&TRs) for the FIR and the CIR are planned following the CDR.

The Review Board's charter, also contained in the appointment letters was specified as:

- Establish that the science requirements are met by the FIR and FCF common hardware designs. In particular, evaluate the capabilities of the FIR to accommodate the initial payloads that are planned to operate in it (i.e., the Light Microscopy Module, the Granular Flow Module and the Microgravity Observations of Bubble Interactions Experiment).
- Establish that the FIR and FCF common hardware detailed designs meet, with acceptable risk, the design requirements defined in governing specifications, unless waivers or exceptions have been approved. For the CIR, design compliance should be assessed for any changes to the CIR and FCF common hardware designs since the CIR CDR.
- Review the results of FIR and FCF common hardware engineering model system and package tests, and establish that any impacts on the flight or end item hardware specifications or designs have been addressed. For the CIR, engineering model testing conducted since the CIR CDR should be assessed.
- Establish interface compatibility between the FIR and the CIR, the International Space Station (ISS), the Main Pressurized Logistics Module (MPLM), payload equipment to be operated in the FIR, FCF ground systems, the FCF operations control center (i.e., GRC Telescience Support Center) and other interfacing items.
- Review the predicted performance of the hardware, including reliability.
- Review the adequacy of the packaging of all FIR packages/subsystems, including FCF common hardware items.
- Evaluate FIR compliance with appropriate safety requirements, and ensure that safety hazard controls have been identified (satisfied by previously held Phase II Flight Safety Reviews).
- Evaluate compliance with appropriate quality requirements.
- Evaluate the prime Contractor's flight drawing completion status, fabrication/acquisition plans and readiness to construct the FIR, CIR and FCF common hardware items.
- Evaluate the adequacy of the prime Contractor's approach and overarching plans for FIR, CIR, and FCF common hardware qualification, verification, and test (recognizing that detailed review of verification methods, plans and requirements will occur at separate V&TRs).

The Review Board findings are summarized in Section 2.0 – Executive Summary. Details of the findings, as referenced to the Review Board's charter, are included in Section 3.0 – FCF FIR CDR report and Section 4.0 – FCF CIR delta CDR report. Appendices A through E contain referenced materials, Requests For Action (RFAs) from the review, open RFAs from the FCF CIR CDR held in May of 2002, and Review Item Discrepancies (RIDs) from this review.

1.1 Applicable Documents

Document Number	Document Title
GRC-W6000.002	GRC Work Instruction, Project Implementation Reviews

2.0 EXECUTIVE SUMMARY

The FCF FIR CDR, and the CIR delta-CDR, were both well done, generally complete, and comprehensive. The work that has gone into the Program since the redefinition of the contract based on ECP-2 was clearly evident, in that this was a much better review, of much more complete and definitive information.

The design definition of the FIR is nearing completion, and meets design requirements (with noted exceptions). It will be both operationally flexible and a viable research tool. Likewise the CIR design is also nearing completion, and while adjudged to be more complex, and therefore more challenging, it also meets requirements (again with noted exceptions), and will enable valuable research on board the ISS.

Within the body of the report, in Sections 3.0 and 4.0, the Review Board has identified a number of findings, including RFAs and Recommendations. The Review Board recognizes and appreciates the fact that at this time several technical issues and concerns are being worked; as always we recommend focused attention on the most pressing (e.g. acoustics environment, optical bench seal, radiation testing etc.), but agree that this is a program/project management challenge to be resolved jointly between the GRC and the contractor in the near future. We are especially concerned about the fact that the Configuration Management (CM) Plan is still not agreed to, nor baselined, which may directly affect the quality of flight hardware and software now being produced.

The Program recognizes now, as at the CIR CDR in May, that the CIR schedule presents the most difficult challenge facing the CIR Project. At this point, having only 5 days of slack is not acceptable, and multiple shifts may recover only a portion of the slack needed. With its known technical challenges, and unknown risks and threats, it will be very difficult to: 1) get appropriate slack in the schedule; and 2) maintain a positive slack position, especially if multi-shifting is already being used to achieve slack. For this reason, the Review Board is recommending evaluating a change of manifest posture (i.e., FIR be evaluated as the first launch for the FCF Program, not CIR). While its science priorities may not be as "high," it appears that FIR can meet the required Launch Readiness Date (LRD), considering its design maturity and progress to date. While the science to be flown/utilized in FIR may not be ready, a FIR flight would: 1) hold the manifested slot; 2) allow time for FIR installation and preparations; and 3) allow the program to meet its commitments!

A final point regarding this program is worth noting here -- that is the lack of apparent "teaming" of the Contractor(s), and GRC Civil Servant/Support Contractors. It would appear prudent that the GRC adopt a posture more as a team player, than "insight/oversight" for this program. GRC will be responsible for the FCF over a long period of time, and that responsibility also requires more than management. By the nature of the contract, contractor personnel will be leaving the program over time, yet design, development, upgrade, problem resolution etc., decisions will be necessary. It is incumbent upon the GRC to have in place the capability to make appropriate decisions in lieu of contractor personnel, or perhaps in support of these individuals, in the near future. (Note: If the GRC were to adopt this approach, a considered plan, with appropriate responsibilities, duties, tasks etc., would have to be defined, and care exercised that this does not infringe upon the Contractor's responsibilities, especially as it pertains to "award fee" payments.)

The Review Board wishes to thank all who helped to make the review a success, including the presenters, support staff, facility staff, management and the design team. We consider it a "job well done."

3.0 REVIEW BOARD REPORT FCF FIR CDR

The following report is structured closely, if not identically, to the Review Board Charter contained in GRC memo 6700 (08-03A), subject: Appointment of Review Board for the Critical Design Review (CDR) of the Fluids and Combustion Facility (FCF) Fluids Integrated Rack and delta-CDR of the FCF Combustion Integrated Rack (08-03A). Each of the major topics were evaluated by the full Board, and the report attempts to integrate and synthesize the often diverse inputs into a cohesive report content. Clearly this is not always possible, and where extremely different opinions existed, the Chairperson exercised his prerogative in attempting to establish the Board's position. Where requested, a minority position is included in the Report. The report follows a format of restating the Charter criteria item, numbered from 1 to 14 for convenience of referencing, followed by Board findings including strengths and weaknesses, recommendations, RFAs (Appendix C), and RIDs identified, (Appendix E). RFAs do not cover all recommendations cited in this report. The FCF Project may elect to transition Recommendations to Actions if appropriate. Please note that there has been minor restructuring of one Charter item, i.e. "Evaluate the prime Contractor's flight drawing completion status, fabrication/acquisition plans and readiness to construct the FIR, CIR and FCF common hardware items" into two parts. The first element of this criterion was merged with other programmatic items as part of Criteria 11; the second part became a new Criteria item 14, since the Board felt it warranted special attention.

1. **Establish that the science requirements are met by the FIR and FCF common hardware designs. In particular, evaluate the capabilities of the FIR to accommodate the initial payloads that are planned to operate in it (i.e., the Light Microscopy Module, the Granular Flow Module and the Microgravity Observations of Bubble Interactions Experiment).**

   The contractor at the designer level seems to have a good working knowledge of fluid science requirements. One concern in meeting science requirements is in the area of thermal control stability. The Fluid Science Facility Scientist indicated that the current design would be good enough, but improvements would be greatly desired. The Contractor must complete the thermal analysis and testing to determine the degree of non-compliance. A second concern remains in the microgravity requirements where the ergometer "spikes" at about 3 Hz remains an issue, as well as exceedances in the range >10 Hz. While it is acknowledged that there are no known basis experiments which require the microgravity requirement be met above the 10 Hz regime, the Project should be extremely cautious in deleting, or requesting deletion of the requirement. until more information on future experiments is available.

   The FIR and Light Microscopy Module (LMM) teams have been working together over the past year or so to identify potential issues with meeting LMM's stringent requirements. Combined natural frequency is very low and will most likely require modifications to LMM and FIR. Not all requirements for GFM have been met. Data handling is a significant issue for LMM, with the Mass Data Storage Unit (MDSU) significantly trailing FIR development.

2. **Establish that the FIR and FCF common hardware detailed designs meet, with acceptable risk, the design requirements defined in governing specifications, unless waivers or exceptions have been approved.**

   Fundamentally, the design presented at the CDR is very good. Through the test program on EMs, at the integrated FIR level, and by way of analyses, the contractor has identified areas where the design does not meet requirements. Major areas showing lack of compliance include microgravity, acoustics noise, and Electromagnetic Interference (EMI)/Electromagnetic Compatibility (EMC). While most governing documentation is complete (i.e. B-Spec signed, and C-Specs submitted), there are several areas, primarily diagnostics packages, where final specifications are not complete, and require added work. This effort, including complete population of the Dynamic Object Oriented Requirements System (DOORS) database, and flow-down of requirements, should proceed

expeditiously to ensure that all requirements are known and addresses before committing to hardware build.

The Project appears to have spent significant effort in establishing a process for waiver/deviation tracking and approval. It was not clear exactly what the mechanism is to get items onto the list in the first place; however, this could be just a matter of coordination and communication between the Contractor and the GRC. The Review Board still sensed a reliance on waivers/deviations being approved as a rationalization for not pursuing technical solutions; this should be avoided, as it is not known, even by ISS personnel, whether seemingly acceptable waivers/deviations today will be acceptable in the future.

Finally, the late development of the MDSU places the Project at risk. Significant effort will be required to ensure that it fulfills requirements, and that it can be accommodated as necessary, without problems being encountered in the late integration.

3. Review the results of FIR and FCF common hardware engineering model system and package tests, and establish that any impacts on the flight or end item hardware specifications or designs have been addressed.

Good use has been made of EM hardware, both at the component/black box level and as an integrated rack. The Project is to be commended for its insistence on testing to qualification levels, as a means of early problem identification. It is clear from this testing, however, that EMI/EMC remains an issue requiring attention in the near future, as design changes in this area can have significant schedule impacts, especially if several iterations are required (Ref. RFA FCF-CDR-007). Efforts should also be expended in completing outstanding diagnostics packages testing.

4. Establish interface compatibility between the FIR and the CIR, the International Space Station (ISS), the MPLM, payload equipment to be operated in the FIR, FCF ground systems, the FCF operations control center (i.e., GRC TSC) and other interfacing items.

The only interface identified between the FIR and CIR is a fiber-optic cable, which should be a relatively straightforward interface. It does require a waiver, as it is to run outside the rack envelope(s).

Interfaces with the ISS/MPLM are well known and documented, although there seemed to be some residual concern about the Moderate Temperature Loop (MTL) (water cooling) and actual performance characteristics with the ARIS, including ARIS reliability. This information is easily available and should not be difficult to obtain. Numerous potential waivers/deviations have been identified; as has been previously stated, these must be diligently pursued to keep them from becoming issues of cost and schedule. Of concern is the lack of testing of the data and communications links. While this is not expected to be a major issue, it should be completed as soon as possible so that early problem identification and resolution can be executed.

The definition of interfaces with the FCF ground systems is proceeding; however, there wasn't a great deal of information provided at this CDR. While this is generally a normal situation at CDR, it still requires attention so that there are no planned operations functions which end up being incapable of operations by the control system at the GRC TSC or Huntsville Operations Support Center (HOSC). It was suggested that Project personnel would benefit from early exposure to real problems being encountered daily on ISS Payloads by the current on-orbit payloads, as this would help them to understand what realities of operations they could expect to encounter.

No Ground Support Equipment (GSE) drawings were available for review. Therefore, a separate review with the appropriate GRC personnel is recommended once the drawings are available (Ref. RFA FCF-CDR-010).

5. Review the predicted performance of the hardware, including reliability.

The Project is to be commended on having a well-structured approach to evaluating, and supporting, this area of the design. Several items of concern have been raised as a part of our evaluation, however, and it is not clear exactly what the Project intends to do in theses areas. The following areas of concern are:

- The low reliability prediction for the CIR of .1998. The White Light drives this, but even without this item, reliability will probably be in the .5 to .6 range. Is there anything being done to improve these numbers?
- Reliability predictions do not include Government Furnished Equipment (GFE).
- On the FIR, availability is estimated at 92.5% versus a requirement of 91.4%. Overall availability of the FCF is estimated at 81.0% versus a requirement of 83%. Both numbers indicate a design and serviceability, which are considered quite good at this point. However the availability numbers do not take into account "drift" of sensitive devices. Recalibration on a periodic basis is not planned (Ref. RFA FCF-CDR-005).
- Of continuing concern is the effect of radiation, causing either damage or Single Event Upsets (SEUs). It was not clear what the extent of the total test program was to be, or what was to be done with the results!
- It is also not clear that all planned uploading/downloading of spares and consumables is within the capability/resource allocation of the FCF Project. A "reality check" of a typical re-supply mission could well indicate that planned re-supply is not achievable within allocations. (Ref. RFA FCF-CDR-008).

Recommendation: Allocate sufficient resources to accomplish radiation testing of all identified sensitive parts. Update system availability assessment to account for radiation upsets. Identify required operational workarounds and access impact on science. Identify calibration needs for diagnostics and assess feasibility of on-orbit calibration. Incorporate recalibration impacts into system availability calculations.

6. Review the adequacy of the packaging of all FIR packages/subsystems, including FCF common hardware items.

Overall, the Project has done a good job in packaging. Two areas remain of concern: packaging of ARIS components, and packaging impacts because of acoustics attenuation efforts. The ARIS passive and active components were not simulated on the EM, and while their envelopes are known, mocking them up is considered a valuable design and development tool. The results of the acoustics attenuation studies are still being evaluated; however, nearly all require use of sound absorbing foam or blankets. While relatively simple in nature, added materials such as these require attention to the implementation details to preclude interferences later with FIR and/or experiment hardware.

7. Evaluate FIR compliance with appropriate safety requirements, and ensure that safety hazard controls have been identified (satisfied by previously held Phase II Flight Safety Reviews).

The Review Board is satisfied that the Project is paying proper attention to all required Flight Safety requirements, but is not properly considering the potential problems the Payload Safety Review

Panel (PSRP) may have with routing the 120 Vdc channels A&B to the same connector. While logically correct, and of potentially significant value to an experiment developer, bringing these supplies to the same connector poses a hazard, of a short via misuse or internal failure, that the Review Board considers a high risk. It is strongly recommended that the Project review this design with this in mind, and request an early evaluation by the PSRP of this proposal (Ref. RFA FCF–CDR–003)

8. Evaluate compliance with appropriate quality requirements.

Appropriate quality requirements are in place and being worked. The interface with GRC quality, through the Hernandez Engineering support contractor, is also in place and working. The response to a previous RFA regarding establishment and use of a PRACA Review Board adds assurance that an integrated problem review process has been established and is being utilized.

9. Evaluate the adequacy of the prime Contractor's approach and overarching plans for FIR, CIR, and FCF common hardware qualification, verification and test (recognizing that detailed review of verification methods, plans, and requirements will occur at separate V&TRs).

The FIR team had planned on qualifying the hardware using the FIR EM; however, they have had to modify the qualification approach. This has allowed them to perform qual level environmental testing on the Engineering Model hardware that should give a high confidence that the qualification units will pass all testing with minimal problems. Since the team recently modified their qualification approach, specific details (schedule, test dates, etc.) have not been completed.

Recommendation: Since it appears that "protoflight" level testing will be required in some cases, the Project should take steps to ensure that the Contractor and GRC are in agreement as to environments, sequences, penalty retest etc. in advance of release of environmental test plans.

While the verification and test plans look adequate, they appear to be unnecessarily serial in nature. Past experience has shown that some testing can, and should be, done in parallel. A specific concern is that no ARIS power-on testing would be done at the GRC. This is considered an unnecessary risk, and should be reevaluated (Ref. RFA FCF-CDR-001).

10. Evaluate the operability of the proposed design and compliance with applicable human factors requirements. Evaluate the adequacy of the FCF ground infrastructure to support operations.

Ample ground control of the facility is provided, which is very good. The Project needs to make sure it gets operationally tested on the ground as much as possible. They also need to look at recalibration requirements and how those can be accomplished on-orbit if possible. Finally, ARIS operations need to be addressed, including possible failure scenarios, and how those can be mitigated or impacts minimized (Ref. RFA FCF-RFA-011).

The area of human factors, including involvement by the flight crew office, remains a strong point by the design and development team. No major issues are apparent, and minor concerns are being worked as normal business.

The original dedicated trainer was de-scoped from the contract with the use of the Engineering Design Unit (EDU) for initial ops. Modifications for this function need to be determined (Ref. RFA FCF-CDR-012).

The Contractor provided very limited data on the GSE, usage, and interface verification. The lack of "qualified" GSE could possibly lead to serious integration issues.

Finally, plans for the build of the Ground Integration Unit (GIU), and its use, as well as continuing use of the EM hardware, are well underway and considered adequate. It must be clarified soon as to whether or not the GIU will have "flight ready" (i.e. qualified hardware or limited flight build hardware) in place. Use of hardware built partially to flight standards may save money in the short run, but prove expensive – and schedule prohibitive – for use as flight spares in the long term.

Recommendation: Evaluate the GSE that will interface with flight hardware and perform analysis/test to minimize any potential risk of damage to the flight hardware by GSE (Ref. RFA FCF–CDR–006). Also, establish the requirements for the use of the EDU as a trainer.

11. Review the technical, schedule and cost risks of the FCF project.

The Contractor has defined and implemented a revised Work Breakdown Structure (WBS) and management approach from that shown at the CIR CDR. The lack of names in key positions, the seeming lack of coordination between design and development and integration and operations, and recent changes in subcontractor responsibilities are all indicators, however, of a plan still in flux. While the overall WBS and management plan seems acceptable, it is clear that there are fragmented teams, accountability issues, and lack of overall system engineering. The contractor team had a hard time knowing who could (or should) answer a question when the speaker did not know the answer and nobody seemed to step up and say they knew the answer. The fragmentation or lack of ownership has led to various areas that appear to not be covered at the system level adequately, such as GFE (ARIS, EPCU, etc.) and common hardware. This situation can lead to a lack of complete schedules, technical understanding, and unnecessary risks.

Of immediate concern is the need to quickly establish the key positions and staffing required for the Integration and Test (I&T) and Operations phases. As the Project nears "roll-off" of personnel, they will become more uncertain of their future, and will begin migrating to other jobs. This could be a serious risk to the Project if not mitigated soon.

Recommendation: Institute an immediate long-term staffing plan, and notify personnel as appropriate. Consider use of GRC personnel as backups for key positions.

Configuration management (CM) remains a concern of the Review Board, in spite of a good presentation during the review. The major concern is the lack of an agreed-to and signed CM Plan. It is extremely difficult to see what could possibly be holding up such an agreement on a fundamentally simple system. While staffing appears to be increased significantly, and drawing releases by CM happening without significant delay, some elements of the CM Plan must be in disagreement, and this implies risk to the Project as flight hardware begins its' manufacturing and procurement/test process (Ref. RFA FCF-CDR-013). The CM plan should be examined to ascertain what is keeping it from being approved. Any item which represents a risk to the flight hardware design, development, test or use, should be resolved prior to instituting flight hardware build. With the significant mismatch in the number of drawings released from Engineering versus released from Configuration Management, it is expected that a number of latent drawing errors remain, which could impact manufacturing. Diligence must be given to assure that drawing checking is not sacrificed in an attempt to optimize drawing release rates at the expense of manufacturing.

Cost and schedule information presented would indicate this is not a problem area for the FIR Project. While detailed schedule info was not presented, the top-level schedule has significant slack, and while perhaps not optimized, no risk was apparent in it. The concerns about the management plan and WBS expressed previously would indicate there is risk from what is not included, or inadequately covered because of an assumption that it's part of "someone else's" WBS.

This is especially apparent in the GFE area, and attention should be given to this to ensure all appropriate tasks are covered.

Except for the MDSU, which is a late addition to the Project, no significant concerns are apparent in the fabrication or acquisition area. Required need dates are identified, and planning appears consistent with the needs. There is some risk in proceeding with procurement of electronic parts and assemblies, however, until radiation susceptibility testing is completed. The obvious concern is susceptibility to damage, which cannot be corrected for by power resets etc.

In general, the Project has demonstrated their identification and mitigation process for risks, and is implementing this as a coordinated team. It is both acceptable and reasonable for the Contractor to have differing lists of risks; however, each should understand the rationale for all risks, and where appropriate, be working as a team to mitigate these in a timely manner.

12. (Not evaluated – specific to CIR.)

13. Evaluate other, past review action item responses and dispositions (i.e., Requests for Action from the FCF PDR pertaining to FIR, Review Item Discrepancies, etc.).

The Contractor, working with the GRC Project Team, has developed a process for closure and tracking of past RIDs, actions, and RFAs. Considering the magnitude of the task, it appears to be complete and comprehensive, as much as practical. However Review Board discussions indicate that its' implementation may be lacking, in that members RIDs and RFAs from past reviews have not had their closure coordinated with the originator! It is highly recommended that personnel be contacted and a determination made as to the disposition of "their" RIDs/RFAs as a test of the closure/tracking system.

14. Evaluate the prime Contractor's readiness to construct the FIR, (CIR) and FCF common hardware items.

The Prime Contractor is considered ready to construct flight hardware pending closure of RFA FCF–CDR–013 (See item 11 above).

4.0 FCF COMBUSTION INTEGRATED RACK DELTA CDR

This portion of the report is directed toward the information provided on the CIR Project, and its' progress since the original CDR held May 28 - 31, 2002. Once again, the format is focused on the Review Board Charter, as contained in memo 6700 (08-03A), and dated November 22, 2002. For this evaluation, the Review Board limited its' review to only certain items which either by the Charter, or by our interpretation, were pertinent to a delta-CDR. The original 14 items have retained the same numbers as used on the FIR CDR; however 6, 7, and 8 were not evaluated, and only applicable portions of items 4 and 9 were considered. All other items focused on the CIR itself, and did not cover common hardware, operations, management, or other common functions, as these were evaluated as part of the FIR CDR, and reported on in Section 3.

1. Establish that the science requirements are met by the CIR (and FCF common hardware) designs. In particular, evaluate the capabilities of the CIR to accommodate the initial payloads that are planned to operate in it.

The majority of the science requirements are met. There are, however, still some unresolved questions regarding the diagnostics. A critical component is the backlight source. Since the CDR (held in May 2002), the engineers decided to use diode lasers operating below the lasing threshold.

The uniformity of the beam (which affects the signal to noise ratio) and the short-term and long-term stability must be tested and verified that it meets the science requirement.

As mentioned in the CDR, there needs to be more interaction of the design team with the Principal Investigators (PI) and Project Scientists (PS) in choosing components and procedures to ensure that the scientific objectives are met. The input from the PI and PS is also critical in determining the necessary tradeoffs. A case in point is in selecting the liquid crystal tunable filters (with a low-end cutoff at 650 nm) to image laser (emission at 635 nm) transmission. A logical trade-off would have been to choose a fixed wavelength filter at 635 nm.

2. **Establish that the FIR and FCF common hardware detailed designs meet, with acceptable risk, the design requirements defined in governing specifications, unless waivers or exceptions have been approved. For the CIR, design compliance should be assessed for any changes to the CIR and FCF common hardware designs since the CIR CDR.**

   The approval of governing documents (i.e., the B and C-Specs) is of significance. Again, populating the DOORS database, and flowing these requirements and specifications down to lower tier documentation is essential, and of even more importance on CIR than FIR because of its' tight schedule.

   Flight systems design changes are appropriate and acceptable. The lack of an approved and planned implementation approach for the Optical Bench seal is of concern, again because of the schedule (Ref. RFA FCF-CDR-004). On CIR, as on FIR, there are concerns about the acoustics environment, radiation testing, and EMI/EMC exceedances, which require resolution quickly. The Project has again done a good job of identifying needed waivers and exceptions; some require attention in the very near future to prevent subsequent impacts of possible non-approval. It should be noted, again, that there was a clear tendency to assume these would be approved, and this may be the message received from the GRC Project and/or the ISS Program, but it may not turn out this way as more information is gathered and evaluated.

3. **Review the results of FIR and FCF common hardware engineering model system and package tests, and establish that any impacts on the flight or end item hardware specifications or designs have been addressed. For the CIR, engineering model testing conducted since the CIR CDR should be assessed.**

   Again, EM unit testing at qualification levels is a valuable risk mitigation action, and the Project is to be commended for following this approach.

   In the science area, there are still some critical elements that have not yet been tested - specifically, the UV and IR intensified array cameras. These cameras are known to go off calibration quite easily and therefore testing and characterizing their behavior on the ground before flight is imperative. The oxygen replenishment system require for Flow Enclosure Accommodating Novel Investigations in Combustion of Solids (FEANICS) experiments must be tested to ensure that the control system can reliably maintain the desired oxygen concentration throughout the burning process. The burning behavior is extremely sensitive to the oxygen concentration so that any "step–wise" introduction of oxidizer must be avoided. The end-to-end test that was presented lacked data. For example, dynamic blending needs to be verified. Testing of the droplet tracking system must include tests that deal with focusing of droplets moving in/out of the depth of field. The camera sensitivity (and therefore the camera setting) must be tested for typical illumination that is expected from a variety of flames. Otherwise, images will not produce quantitative data due to saturation or lack of resolution in gray levels.

CIR EM end-to-end systems interface tests were completed, although many changes were made and sufficient time of error-free system operation has not been demonstrated.

Recommendation: Implement needed design changes and run at least 100 hours of anomaly-free operation of the CIR rack.

4. Establish interface compatibility between...the CIR, the International Space Station (ISS), the MPLM...

The ISS & STS interfaces are mostly defined, and the Interface Control Document (ICD) is in the baselining process. Further clarification is needed in the "vented gases" area. The ISS exceptions have been identified but still need to be worked. The biggest concern is the communication and data interfaces and its compatibility with ISS since this interface has not been tested to date. The Project may wish to test the FCF Input/Output Processor (FIOP) with the ISS interface to determine hardware and software compatibility. There is some concern that the ISS interfaces are known, but the actual operating characteristics are not.

Again, No GSE drawings were available for review. Therefore, a separate review with the appropriate GRC personnel is recommended once the drawings are available.

5. Review the predicted performance of the hardware, including reliability.

In general, comments made on the FIR designs are also applicable here. Again, the lack of inclusion of GFE is particularly disturbing, and can reasonably be expected to lower the already low .5211 reliability number. Availability estimates for the CIR are 88.6% versus a requirement of 90.1%. As on the FIR, lack of consideration of the need for periodic recalibration is not defined or included. This also can reasonably be expected to lower the availability number, and perhaps require additional spares if on-board recalibration is not an option. Finally, and again, radiation effects could affect reliability, availability, and resultant sparing of components.

6. Not evaluated.

7. Not evaluated.

8. Not evaluated.

9. Evaluate the adequacy of the prime Contractor's approach and overarching plans for...CIR... qualification, verification and test (recognizing that detailed review of verification methods, plans and requirements will occur at separate V&TRs).

The use of EM hardware in tests at qual levels gives good assurance that the equipment under test, the facilities, and the test procedures are well planned. However, the CIR also intends to do some qualification testing using a protoflight approach, and again should work closely with the GRC personnel to ensure the resulting tests and test level qualify the hardware, including spares, for flight.

The verification and test approach are consistent with that planned on the FIR, and appear to be acceptable. Again, the serial nature is a problem, and should be evaluated, especially in light of the very tight schedule.

10. Evaluate the operability of the proposed design and compliance with applicable human factors requirements.

The general evaluation of the CIR follows closely that of the FIR, and will not be repeated. Specifically, the CIR design has taken into consideration the long-term operational ability of the hardware to minimize crew time, provide science flexibility, and allow quick change-out of diagnostics. The CIR has held a couple of Crew Reviews with the Crew Office for CIR and common hardware. Many of the comments and feedback have been factored into the design. While not all the human factors requirements have been met, attempts are still being made to meet most of them. Acoustics work is commendable. Some design modification may still be required for access to remove the launch strut behind the combustion chamber.

11. Review the technical, schedule and cost risks of the (CIR) project.

While not a specific charter item, the Review Board performed an evaluation of this area also. Comments regarding the management approach, staffing and responsibilities were made in the FIR section of this report. Specifically, however, the schedule for CIR completion appears at high risk, if not un-doable. The absence of slack, little ability to generate slack other than multi-shifting (which is NOT 100% effective), serial planning of tasks, new aspects of the I&T function etc., all lead the Review Board to conclude that this is the highest risk area of the CIR Project. While personnel can be shifted from the FIR Project, probably without significant impact to its' launch date, only so many people can work on a rack at one time. Therefore, use of FIR personnel will not solve this concern. The Review Board recommended at the CIR CDR that the work effort to complete the CIR be defined, slack added, and that should be allowed to define the Launch Readiness Date (LRD). While this was not done, for reasons not requiring explanation, the resultant position the CIR finds itself in is one of attempting to do the improbable – and soon to become the impossible – unless major breakthroughs are discovered and implemented.

Recommendation: Perform a realistic assessment of the ability of CIR to meet the LRD. Do not commit to a date that is not achievable with minimum to moderate risk at this time. Consider requesting a "swap" of first FCF flight opportunity with the FIR, which is in much better schedule position, and has fewer risks.

12. Specific to the CIR, review areas that had shortfalls at the CIR CDR, technical changes since the CIR CDR and progress on Request for Action (RFA) responses/closeout.

The Review Board reviewed all RFAs that were submitted for closure at the time of the CIR delta-CDR. Three RFAs remain open, from the viewpoint of the Review Board, as follows:

- RFA CIR-CDR-002 - Adverse effects of radiation. Open pending definition of the extent of radiation testing to be concluded.
- RFA CIR-CDR-009 - On-orbit Stowage. Open pending definition and evaluation of complete FCF Stowage requirements and planning, including feasibility.
- RFA CIR-CDR-011 - Configuration Management and Control. Open pending signoff on the Configuration Management Plan.

13. Evaluate other, past review action item responses and dispositions (i.e., Requests for Action from the FCF PDR pertaining to FIR, Review Item Discrepancies, etc.).

No added comments are provided beyond what was included for the FIR.

14. Evaluate the prime Contractor's readiness to construct the FIR, CIR and FCF common hardware items.

The Prime Contractor is ready to proceed to construct the CIR, pending response to RFA FCF–CDR–013 on Configuration Management.

APPENDIX A - APPOINTMENT LETTERS TO THE REVIEW BOARD

A.1 Original Letter of Appointment to the Review Board

National Aeronautics and
Space Administration

John H. Glenn Research Center
Cleveland, Ohio 44135

Reply to Attn of: 6700 (08-03) November 18, 2002

TO: Distribution

FROM: 6700/Microgravity Science Division

SUBJECT: Appointment of Review Board for the Critical Design Review (CDR) of the Fluids and Combustion Facility (FCF) Fluids Integrated Rack and delta-CDR of the FCF Combustion Integrated Rack (08-03)

The Fluids and Combustion Facility (FCF) Fluids Integrated Rack (FIR) Critical Design Review (CDR) and delta-CDR for the FCF Combustion Integrated Rack (CIR) are scheduled on December 9-13, 2002, as follows.

- FIR CDR – Monday afternoon, December 9th (starting at 1:00 P.M.) through Wednesday morning, December 11th.
- CIR delta-CDR – Wednesday afternoon, December 11th to Thursday morning, December 12th
- FCF Flight/Ground Systems CDR – Thursday, December 12th

A CDR Executive Session will be held on Friday, December 13th from 8:00 A.M. to 12:00 noon. This session is limited in attendance to the CDR Review Board and invited Program/Project participants.

The Review Board for the FCF System CDR, FIR CDR and CIR delta-CDR will consist of the following persons:

Chairman	William Taylor (Consultant)
Safety/ Product Assurance	Kenneth Adams (GRC)
Fluids Science	Yasuhiro Kamotani (CWRU)
Combustion Science	Mun Young Choi (Drexel Univ.)
Systems Engineering	Daniel Gauntner (GRC)
Engineering	John Taylor (GRC)
Crew/Human Factors	Janet Kavandi (JSC)
Operations/Integration	Jay Onken (MSFC)
ISS Technical	Michael Miller (JSC)
FCF Project	Robert Corban (GRC)

Re: 08-03
November 18, 2002

This CDR will consist of a review of the FCF System (flight and ground hardware; FCF common hardware), the FCF Fluids Integrated Rack and a delta review of the detailed design of the Combustion Integrated Rack (i.e., based on changes, open work and actions from the CIR CDR held in May 2002). The review will be conducted in accordance with Glenn Research Center (GRC) Work Instruction GRC-W6000.002, Revision B (Project Implementation Reviews).

The following are within the scope of the Critical Design Review:

- FCF System design (flight system and ground infrastructure) and the detailed designs of FCF common hardware use for the FIR and the CIR. Since FCF common hardware was reviewed in detail at the CIR CDR, the focus of FCF common hardware review at this CDR will be on any design changes to FCF common hardware since the May CDR and the adequacy of common hardware to meet FIR and fluids science requirements.
- Fluids Integrated Rack (FIR) detailed design. In addition to a review of the detailed design of the FIR flight system, a review of FIR ground hardware (i.e. ground integration unit, engineering development unit and crew training equipment) and FIR flight/ground support equipment are within the scope of this CDR.
- Combustion Integrated Rack (CIR) detailed design. It is planned that only the changes to the Combustion Integrated Rack (CIR) detailed design since the May 2002 CDR and the completion of open work since the CDR will be reviewed as part of the delta-CDR for CIR. This will include a review of the results of CIR engineering model testing completed since May 2002, CIR diagnostics packages not reviewed in May and the status of requests for action, review item discrepancies and any other open work from the prior review.

The following areas are not within the scope of the Critical Design Review.

- Detailed review of FCF software. A separate Peer Review of FCF software will be held prior to this CDR, covering all aspects of FCF flight and ground software design. A summary of the results of this software review will be provided.
- Detailed design reviews of the Passive Rack Isolation System (PaRIS) and the Active Rack Isolation System (ARIS), except in relationship to their interfaces and integrated rack design with the CIR and the FIR, respectively.
- Detailed review of FIR and CIR Verification and Test Readiness. Separate Verification and Test Reviews (V&TR) for the FIR and the CIR are planned following the CDR.

Re: 08-03
November 18, 2002

In accordance with Critical Design Review requirements in NAS3-99155 and NASA Glenn Project Implementation Review guidelines in GRC-W6000.002, Revision B, the Review Board's charter for the CDR is as follows:

- Establish that the science requirements are met by the FIR and FCF common hardware designs. In particular, evaluate the capabilities of the FIR to accommodate the initial payloads that are planned to operate in it (i.e., the Light Microscopy Module, the Granular Flow Module and the Microgravity Observations of Bubble Interactions Experiment).
- Establish that the FIR and FCF common hardware detailed designs meet, with acceptable risk, the design requirements defined in governing specifications, unless waivers or exceptions have been approved. For the CIR, design compliance should be assessed for any changes to the CIR and FCF common hardware designs since the CIR CDR.
- Review the results of FIR and FCF common hardware engineering model system and package tests, and establish that any impacts on the flight or end item hardware specifications or designs have been addressed. For the CIR, engineering model testing conducted since the CIR CDR should be assessed.
- Establish interface compatibility between the FIR and the CIR, the International Space Station (ISS), the MPLM, payload equipment to be operated in the FIR, FCF ground systems, the FCF operations control center (i.e., GRC TSC) and other interfacing items.
- Review the predicted performance of the hardware, including reliability.
- Review the adequacy of the packaging of all FIR packages/subsystems, including FCF common hardware items.
- Evaluate FIR compliance with appropriate safety requirements, and ensure that safety hazard controls have been identified (satisfied by previously held Phase II Flight Safety Reviews).
- Evaluate compliance with appropriate quality requirements.
- Evaluate the prime Contractor's flight drawing completion status, fabrication/acquisition plans and readiness to construct the FIR, CIR and FCF common hardware items.
- Evaluate the adequacy of the prime Contractor's approach and overarching plans for FIR, CIR and FCF common hardware qualification, verification and test (recognizing that detailed review of verification methods, plans and requirements will occur at separate V&TR's).

Re: 08-03
November 18, 2002

- Evaluate the operability of the proposed design and compliance with applicable human factors requirements. Evaluate the adequacy of the FCF ground infrastructure to support operations.
- Review the technical, schedule and cost risks of the FCF project.
- Specific to the CIR, review areas which had shortfalls at the CIR CDR, technical changes since the CIR CDR and progress on Request for Action (RFA) responses/closeout.
- Evaluate other, past review action item responses and dispositions (i.e., Requests for Action from the FCF PDR pertaining to FIR, Review Item Discrepancies, etc.).

The Review Board should assess the status of the FIR, CIR and FCF System in accordance with the above, and recommend whether or not the FCF Project is ready to proceed with flight hardware fabrication, integration and test. The Board should also identify any concerns in the FCF Project that should be addressed and recommend any actions that should be taken or recovery plans that should be implemented to enhance the success of the next phase of the Project.

In accordance with the above guide, the Review Board shall prepare and submit a final report of its findings within four (4) weeks following the conclusion of the review. The report should include findings on strengths and weaknesses, recommendations by the Board and Requests for Action resulting from the review.

Original Signed by Stephen N. Simons on 11/18/02
Stephen N. Simons
Deputy Chief, Microgravity Science Division

Distribution:

Consultant/W. Taylor
NASA GRC/0500/K. Adams
Case Western Reserve University/Y. Kamotani
Drexel University/M. Choi
NASA GRC/7800/D. Gauntner
NASA GRC/7700/J. Taylor
NASA JSC/CB/J. Kavandi
NASA MSFC/FD32/J. Onken
NASA JSC/OZ/M. Miller
NASA GRC/6700/R. Corban

Re: 08-03
November 18, 2002

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NASA HQ/UG/M. King
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NASA JSC/OZ/M. Culp
NASA JSC/OZ/D. Hartman
NASA JSC/OZ/L. Roe
NASA JSC/OZ/C. Spease
NASA JSC/OZ2/USA/J. Temple
NASA MSFC/SD10/R. Henderson
NASA MSFC/SD11/W. Ramage
NASA MSFC/TBE/J. Sykes

NASA GRC/0510/G. Kelm
NASA GRC/0520/J. Regan
NASA GRC/0520/B. Patel
NASA GRC/0612/K. Brocone
NASA GRC/6700/FCF Project Office File/A. Wood
NASA GRC/6700/FCF Project Office Electronic File/D. Sedlak
NASA GRC/6700/MRDOC CM File/D. Davis
NASA GRC/6700/F. Kohl
NASA GRC/6700/H. Ross
NASA GRC/6700/J. Salzman
NASA GRC/6700/K. Schubert
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NASA GRC/6700/J. Wanhainen
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NGIT/ANLX/M. O'Toole
NGIT/ANLX/N. Bozzolo
NGIT/HEI/J. Wetherholt
NGIT/HEI/T. Johnson

A.2 Revised Letter of Appointment to the Review Board

National Aeronautics and
Space Administration

John H. Glenn Research Center
Cleveland, Ohio 44135

Reply to Attn of: 6700 (08-03A) November 22, 2002

TO: Distribution

FROM: 6700/Microgravity Science Division

SUBJECT: Appointment of Review Board for the Critical Design Review (CDR) of the Fluids and Combustion Facility (FCF) Fluids Integrated Rack and delta-CDR of the FCF Combustion Integrated Rack (08-03A)

This memo is revised to include a representative from the Glenn Research Center Systems Management Office.

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ISS Technical	Michael Miller (JSC)
Systems Management Office	Harvey Schabes (GRC)
FCF Project	Robert Corban (GRC)

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The Review Board should assess the status of the FIR, CIR and FCF System in accordance with the above, and recommend whether or not the FCF Project is ready to proceed with flight hardware fabrication, integration and test. The Board should also identify any concerns in the FCF Project that should be addressed and recommend any actions that should be taken or recovery plans that should be implemented to enhance the success of the next phase of the Project.

In accordance with the above guide, the Review Board shall prepare and submit a final report of its findings within four (4) weeks following the conclusion of the review. The report should include findings on strengths and weaknesses, recommendations by the Board and Requests for Action resulting from the review.

Stephen N. Simons
Deputy Chief, Microgravity Science Division

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NASA GRC/0107/O. Gonzalez-Sanabria
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NGIT/HEI/T. Johnson

APPENDIX B - ACRONYMS/ABBREVIATIONS

Acronym/Abbreviation	Definition
ARIS	Active Rack Isolation System
BPR	Biological and Physical Research
CDR	Critical Design Review
CIR	Combustion Integrated Rack
CM	Configuration Management
DOORS	Dynamic Object Oriented Requirements System
E&TS	Engineering and Technical Services Directorate
EDU	Engineering Design Unit
EM	Engineering Model
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
FCF	Fluids and Combustion Facility
FEANICS	Flow Enclosure Accommodating Novel Investigations in Combustion of Solids
FIOP	FCF Input/Output Processor
FIR	Fluids Integrated Rack
GFE	Government Furnished Equipment
GFM	Granular Flow Module
GIU	Ground Integration Unit
GRC	NASA Glenn Research Center
GSE	Ground Support Equipment
HOSC	Huntsville Operations Support Center
HW	Hardware
I&T	Integration and Test
ICD	Interface Control Document
ISS	International Space Station
JSC	NASA Johnson Space Center
KSC	NASA Kennedy Space Center
LMM	Light Microscopy Module
LRD	Launch Readiness Date
MDCA	Multi-User Droplet Combustion Apparatus
MDSU	Mass Data Storage Unit
MOA	Memorandum of Understanding
MOBI	Microgravity Observations of Bubble Interaction

Acronym/Abbreviation	Definition
MPLM	Main Pressurized Logistics Module
MRDOC	Microgravity Research, Development and Operations Contract
MSD	Microgravity Science Division
MSFC	NASA Marshall Space Flight Center
MTL	Moderate Temperature Loop
NGIT	Northrop Grumman Information Technology
OAI	Ohio Aerospace Institute
ORU	Orbital Replacement Unit
PaRIS	Passive Rack Isolation System
PI	Principal Investigator
PRACA	Problem Reporting and Corrective Action
PS	Project Scientist
PSRP	Payload Safety Review Panel
RFA	Request For Action
RID	Review Item Discrepancy
SEU	Single Event Upset
STS	Space Transportation System
SW	Software
TSC	Telescience Support Center
V&TR	Verification and Test Review
WBS	Work Breakdown Structure

APPENDIX C - REQUESTS FOR ACTION (RFAs)

FCF-CDR-001: ARIS functional testing with FCF-FIR

Statement of Concern

It was stated that there is no plan to have ARIS electronics powered during any functional test at GRC. First test is planned at KSC. Early functional testing of ARIS will reduce risk of finding problems late in the flow.

Recommended Action

Test ARIS as part of the flight systems test as early in the flow as practical. Specifically it should be included in any rack level EMI tests.

FCF-CDR-002: Mixed dimensional units

Statement of Concern

Throughout the CDR presentation, both English and metric units were used. Mixed dimensioning has caused serious problems on other payloads/spacecraft (notably, Mars Observer). In the case of FCF-FIR, these may be limited to form/fit impacts, but could still imply schedule risk.

Recommended Action

Define the dimensioning policy of the FCF. Identify steps being taken to preclude impacts from improperly dimensioned items.

FCF-CDR-003: 120V bus connection risk mitigation

Statement of Concern

Fourth 120 VDC, 4 amp circuit that is provided to PI is on a separate bus from the first three. Internal PI circuitry or a short could connect the two buses.

Recommended Action

Show a plan for mitigating the risk of connecting the 120 VDC, 4A buses.

FCF-CDR-004: Optics bench ATCU seal

Statement of Concern

Given the criticality of the schedule of the optics bench development to the overall CIR development, the lack of a baselined seal option and testing approach is unacceptable.

Recommended Action

Provide a plan for seal development including schedule for development and test and verification including life test.

FCF-CDR-005: Calibration of on-orbit diagnostics

Statement of Concern

The need and approach of diagnostics on-orbit was not adequately addressed. Some equipment, such as intensified array cameras, are prone to significant drift. It is not clear how an out-of-calibration condition would be detected. Calibration needs were not addressed in system reliability calculations. No provisions have been made for on-orbit calibration.

Recommended Action

Provide an assessment of calibration requirements for all diagnostics. Assess need for on-orbit calibration. Show how out-of-calibration condition will be determined for each diagnostic item. Assess impacts of out-of-calibration conditions on system reliability and availability. Show how sparing approach supports ground re-calibration.

FCF-CDR-006: Ground support equipment certification and availability

Statement of Concern

The presentation on ground support equipment (GSE) provided insight into the key and higher assemblies of equipment needed. It was not apparent that all items of GSE have been identified or planned. It was not clear that appropriate verification and qualification of GSE was planned prior to first use with flight hardware.

Recommended Action

1. Develop a document (tech letter, appendix, stand-alone spec) that provides a complete list that details all GSE, quantities of each, delivery/availability dates, and plans for verification/acceptance prior to first use with flight hardware.

2. Review of test procedure documents to assure appropriate GSE is identified for each test and assure date of first need/use is after date of first availability from No. 1 above.

FCF-CDR-007: EMI

Statement of Concern

EMI results indicate that design changes, waivers, exceedances, and retesting is necessary to meet the requirements, the impacts of which appear to not be adequately planned for.

Recommended Action

Provide a complete plan to address EMI exceedances, including a schedule that includes testing schedules, impacts to project schedule, and a process for dealing with exceptions. Consider the establishment of an EMI Review Panel, including independent experts.

FCF-CDR-008: On-orbit stowage allocation may be insufficient for proposed hardware

Statement of Concern

Based on on-orbit spares list, other maintenance hardware, acoustic foam and mufflers, tools, etc., the FIR program may exceed their on-orbit stowage allotment.

Recommended Action

Determine on-orbit stowage allocation from ISS Payloads Office. Use list of hardware dimensions with appropriate packing material to determine a realistic list of spares, and remaining space applicable for removable acoustic shielding and other hardware.

FCF-CDR-009: Mass Data Storage Unit CDR

Statement of Concern

The Mass Data Storage Unit (MDSU) was recently added to the program via ECP-2 and consequently only a conceptual design was presented at this CDR. No follow-on MDSU CDR was shown in the contractor schedules or plans.

Recommended Action

Plan and conduct an MDSU CDR at the appropriate future times involving both project and payload representations.

FCF-CDR-010: Ground Support Equipment Review

Statement of Concern

Ground Support Equipment (GSE) drawings were not available for review prior to or at the CDR.

Recommended Action

Plan and conduct a follow-on review of GSE design and test.

FCF-CDR-011: Define operations preparation activities

Statement of Concern

No clear plan and schedule for operations team mission preparation tasks.

Recommended Action

Produce an operations roadmap to launch focusing on personnel training, EHS tool development and payload integration template milestones. Identify detailed tasks for console tool development and test including ground displays and commands. Show operations team involvement in ground testing with flight hardware. Ensure that hiring profile will satisfy tasks for operations readiness.

FCF-CDR-012: Inputs of using EDU for crew training

Statement of Concern

EDU being shipped to JSC to support crew training. Impacts to project unclear due to unavailability of EDU at GRC. Also it is not clear if crew training requirements are being incorporated in the EM to EDU conversion plans.

Recommended Action

Clearly define all EDU usage requirements and assess number and duration of trips to JSC, constraints on crew training and constraints and impacts to other development/testing tasks needing the EDU. Assess any modifications to the CIR and FIR EMs to assist in performing crew training activities (e.g., CIR EDU should include the launch support strut).

FCF-CDR-013: Configuration Management (CM)

Statement of Concern

The CM plan is still not agreed to by the GRC. This implies differences of requirements or implementation, that in the worst case could affect the quality, form, fit, and/or function of the flight hardware now beginning manufacture and test.

Recommended Action

Either get the CM accepted and signed off in the very near future, or perform an analysis of differences that are precluding its' signoff, and assure that none of these differences can affect the quality, form, fit, and/or function of the flight hardware.

FCF-CDR-014: Review Item Discrepancies (RIDs)

Statement of Concern

Deficiencies were identified during detailed review of the CDR data package by the review teams. Unless corrected, the design of the FCF may not meet requirements, and data necessary for initial launch and sustaining engineering may not be available. All RIDs generated as part of this review need to be dispositioned, tracked and closed using an appropriate process.

Recommended Action

A disposition, tracking, and closure process was presented at the CDR. All RIDS identified at this CDR review (Excel spreadsheet provided as an attachment to this report) shall be documented, tracked, and closed using this process. As defined in this process, feedback shall be requested of the Initiator to assure that the disposition is appropriate. Closure of this RFA should be considered contingent upon completion of the Convening Authority's approval of all RID dispositions, and a statement in the response to this RFA that the process, as presented, will be followed.

APPENDIX D - OPEN RFAs FROM PRIOR REVIEWS

CIR-CDR-002: Adverse effects of radiation

Statement of Concern

Although identified as a risk, it is not evident that the contractor has performed sufficient analyses or developed a risk mitigation strategy for the adverse effects of radiation on the CIR's reliability, maintainability, and availability.

Recommended Action

1. Perform a risk analysis. This analysis should identify devices and assemblies (e.g., processors, memory, and programmable logic devices) susceptible to radiation damage due to single event effects and total ionizing dosage. The analysis should include an investigation of existing failures or adverse events experienced by similar products especially those flown in high inclination orbits which pass through the South Atlantic Anomaly (SAA).

2. Develop a risk mitigation strategy. This strategy should include options such as radiation testing of critical devices/assemblies, use of hardware and/or software Error Detection and Correction (EDAC), multiple buffering and comparison of commands and data before execution, arm/fire sequencing, and sparing strategy.

CIR-CDR-009: On-orbit stowage

Statement of Concern

The CIR plans to have a significant amount of on-orbit stowage. Both up-mass and volume, and on-orbit stowage space are critical elements for any payload, and it is the FCF/CIR Project's responsibility to stay within available limitations.

Recommended Action

Perform an analysis of the stowage volume required for all CIR spares, installation hardware, maintenance items, payload equipment, etc. Determine the minimum set of on-orbit hardware required with associated stowage requirements. Work with the ISS program to determine a proper phasing of these items and determine a realistic scenario for their deployment. Incorporate stowage limitations into the availability of the FCF.

CIR-CDR-011: Configuration Management and Control

Statement of Concern

Evidence at the CDR Review, including numerous RIDs, indicates that the contractor's implementation of required CM practices is deficient. Should deficiencies exist, they could seriously weaken the required integrity of flight hardware and software.

Recommended Action

Assurances shall be made that the Configuration Management system and its associated processes are properly in place, being utilized by the FCF team properly, adequate resources, and trained personnel. This shall include an audit by NASA of the CM systems. Any identified weaknesses shall be corrected as soon as possible.

APPENDIX E - REVIEW ITEM DISCREPANCIES (RIDs)

The dispositioned RIDs are supplied as an attachment to this report. RFA FCF-CDR-014 was included to assure that the RIDs actions are completed and the RIDs closed.