

Lee & Associates, LLC

Final Report

Reference: PO # H-31405D

INTRODUCTION

The primary activities of Lee & Associates during the period 7/20/99 to 12/31/99 as specified in the referenced Purchase Order has been in direct support of the Advanced Space Technology Program Office's Core Propulsion Project. An independent review to assess the program readiness to conduct component and system level testing of the FASTRAC Engine and to proceed into Fabrication has been provided. This was accomplished through the identification of program weaknesses and potential failure areas and where applicable recommended solutions were suggested to the Program Office that would mitigate technical and program risk.

The approach taken to satisfy the objectives has been for the contractor to provide a team of experts with relevant experience from past programs and a strong background of experience in the fields critical to the success of the program. The team participated in Test Planning, Test Readiness Reviews for system testing at Stennis Space Center, Anomaly Resolution Reviews, an Operations Audit, and data analysis. This approach worked well in satisfying the objectives and providing the Project Office with valuable information in real time and through monthly reports.

During the month of December 1999 the primary effort involved the participation in anomaly resolution and the detailed review of the data from the final H3 and H4 test series performed on the FASTRAC engine in the b-2 Horizontal Test Facility at Stennis. The more significant findings and recommendations from this review are presented in this report.

FINDINGS AND RECOMMENDATIONS

UNEXPLAINED ANOMALIES

Observations

There were several unexplained anomalies or conditions revealed during the review. The following examples were noted:

1. RP-1 pressure spike in the inlet line post test on H3-1.
2. Flow meter accuracy
3. MFV not fully open
4. GG Pc increase at cutoff
5. Nozzle delamination
6. Negative margins
7. Side loads
8. Post cutoff chugging
9. Impeller deformation
10. LOX purge at cutoff
11. Bearing delta pressure
12. GG hot flange bolt preload
13. Slow MOV opening during cold start
14. Slow OBV closing during cold start
15. Delay opening IFV during cold start
16. Heater operation

This list is not comprehensive, but does represent the more significant examples from the data presented. It should be noted that some of the unexplained anomalies are of more concern than others, since the program impact could be greater if gone uncorrected.

Recommendations:

1. Identify all unexplained anomalies and test conditions.
2. Determine if there is a correlation between them.
3. Develop a plan to determine cause, effect on system performance, resolution, and required corrective action.
4. For any anomaly that remains unexplained identify risk and retention rationale including risk mitigation if required.

ACTION ITEM TRACKING SYSTEM

Observations

It does not appear the project has a system or process to consolidate and integrate across disciplines, the actions generated from the data review which is maintained, tracked and closure pursued.

Recommendation

Adopt an action item tracking system.

INSTRUMENTATION/DATA ACQUISITION

Observations

The strain and dynamic data is critical to the project; these data and its validity should have been coordinated between MSFC and SSC following each individual test. Now that it is rather late in the program it may be difficult to determine the usefulness of the data and to coordinate calibration factors.

Recommendations

1. Identify all instrumentation/data acquisition anomalies
2. Develop a resolution plan for the data/instrumentation required to complete the development, certification, and flight test program including test and hardware effectivity.
3. Develop a process for dealing with instrumentation/data acquisition problems in real time.

DESIGN CHANGES

Observation

There are design changes which appear to be incompatible with flight hardware deliveries and the continuation of the development and the start of the certification testing without retrofitting.

Recommendations

1. Identify all known, pending, and potential design changes.
2. Establish classification as to mandatory, highly desirable, and nice to have.
3. Establish lead-time for development, test and fabrication.
4. Identify those that do not fit the schedule and consider a block change.
5. Stop all work on non-mandatory changes.

PRETEST PREDICTIONS

Observations:

1. In only a very few cases did the data evaluation teams compare their data to pretest predictions.

2. The engine system math model for pretest predictions and calibration is inaccurate.
3. There are cases where redline values create unnecessary premature cutoffs. They are adjusted when it is observed that a cutoff is eminent or has occurred.

Recommendations:

1. Comparing actual data to pretest predictions is a very good practice and should be adopted for all disciplines.
 2. Develop a plan to reach a posture of reliably accurate predictions and place proper emphasis to ensure its implementation.
 3. Redlines should be set to ensure hardware/personnel safety.
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TEST PLANNING

Observations:

1. It is not apparent there is a method to determine the percent complete of the development test program, therefore it is difficult to quantify the required tests remaining.
2. There does not appear to be a well defined set of ground test requirements as they relate to engine acceptance testing prior to flight.

Recommendations:

1. Prepare a test plan or matrix that includes the total test program, with emphasis on tests remaining.
2. Identify ground acceptance tests requirements for flight including number of tests and tests duration.

SUMMARY

The FASTRAC development team at MSFC did an admirable job of accumulating and presenting a massive amount of data for evaluation and should be commended for their efforts. The significance of this test series to subsequent ground and flight test planning dictates a very careful assessment of all test anomalies and absence of valid test data. It is in this context that the observations and recommendations are presented here.