Independent Analysis of CMG to FSE Interface Capability

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BACKGROUND

In May of 2004, the NASA Engineering Safety Center (NESC) was requested by the Space Shuttle Program Flight Operations and Integration Office (SSP MO) to provide an independent analysis of the Control Moment Gyroscope (CMG) to Flight Support Equipment (FSE) interface capability. The replacement CMG for station is mounted in the aft part of the payload bay of the shuttle on a piece of FSE for launch (and landing in the event of an early mission termination), Figure 1 and 2.

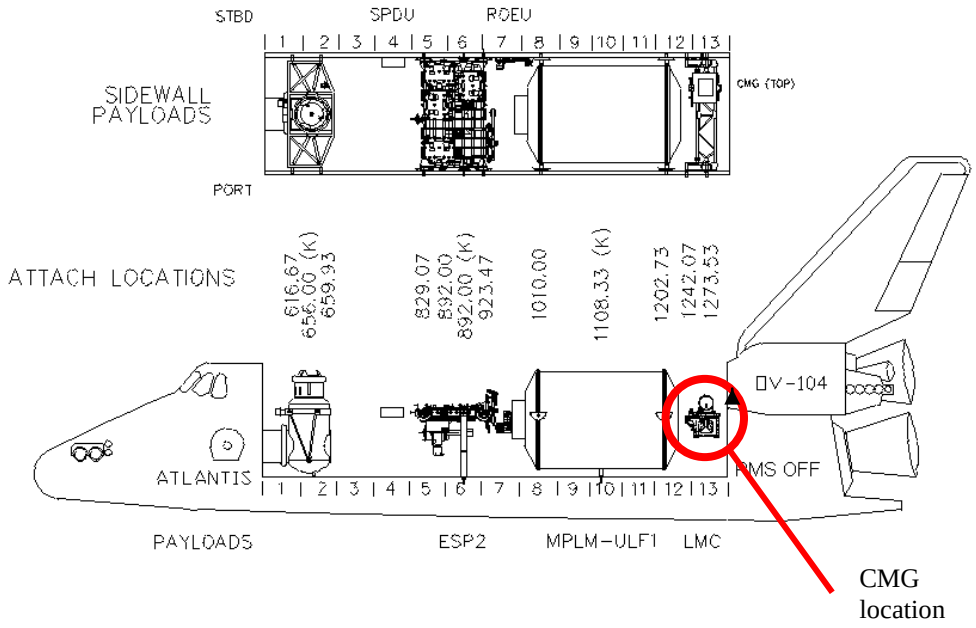

Figure 1: Location of aft payload carrier where CMG is mounted for launch and landing.

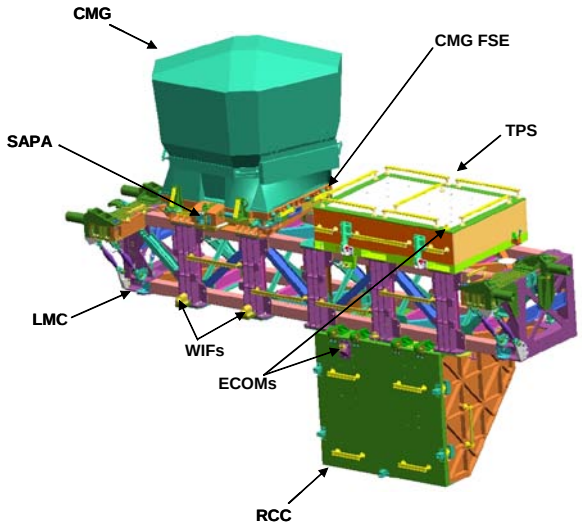

Figure 2: CMG mounted via the FSE to the payload carrier (LMC)

This hardware is scheduled to fly on the Return-To-Flight (RTF) Shuttle mission and is critical for meeting the needs of the International Space Station (ISS) program. Initial NESC assessment of the problem indicated that the contractor, Boeing, was having some problems clearing the FSE for flight loads[1]. They had significant negative margins for landing loads at the attach bolts between the CMG and the FSE. The program wanted some independent evaluation of the strategy which Boeing was pursuing due to the criticality of this hardware.

REVIEW

As a part of this activity, additional technical information was requested by the NESC for review. This information included historical briefings, and a summary of the analysis activities to date. The contractor was attempting to refine their analysis and resulting margins with the following processes:

A. Application of time consistent loads
B. Increasing model fidelity for representing joint stiffness
C. Non-linear analysis
D. Evaluation of uncertainty factors and factors of safety

[1] SSP MO Briefing, DRAFT, "STS-114 (LF1) CMG/FSE Integrated Assembly Nominal Landing Loads Status", J. Sills, 4/30/2004

Based on a review of the information provided, it was the opinion of the Mechanical Analysis NESC Discipline Expert (NDE) and JSC Chief Engineer that the contractor and program were following the appropriate, standard processes for resolution of this type of analytical issue.

It was recommended to the requester and at the NESC Review Board (NRB), in June of 2004, that the NESC provide expertise to monitor the progress of the resolution of this margin issue and follow any recommendations for reduction in factors of safety. This strategy was accepted by both the initiator and the NRB. Because of her familiarity with shuttle payload certification and her location at JSC, the NESC NDE for Mechanical Analysis was assigned to follow this activity directly.

Assessment follow-on activities included fact finding & dialogue with key stakeholders, including the Johnson Space Center (JSC) Structures Working Group, the in-line engineering directorate support at JSC to ISS, Shuttle Integration (MO) personnel, ISS Launch Package Manager, and the Boeing analysis personnel responsible for the analytical products.

The contractor was able to make significant improvement in the margins of safety through the use of non-linear analysis techniques, improvements in model stiffness representations, some minimal relief in dynamic uncertainty factors and a reduction in factor of safety based on some limited testing. These analyses were reviewed in detail, and concurred to, by the NESC. While the contractor was able to obtain positive margins for landing, this analysis did not cover bolt out requirements (required as a part of fracture control and Extra Vehicular Activity bolt requirements), and did not provide sufficient margin to cover any increases in loads in future launch coupled loads analysis. Therefore, in July of 2004, the NESC recommended to SSP MO that the ISS program should be more aggressive in pursuing options to buy back additional margin in this hardware attach location[2]. Options included testing of actual hardware capability, and re-manifesting the hardware to a more lightly loaded configuration. This recommendation was subsequently passed from SSP MO to the ISS launch package manager, and program manager.

Based on the recommendations of Boeing, JSC engineering, SSP MO and the NESC, the ISS program decided to pursue additional testing on the capability of this hardware to determine the true, ultimate capability.

[2] Email J. Kramer White to J. Shannon, "Briefing to NESC board on CMG FSE margins", 7/13/2004, including briefing "**Control Moment Gyro to Flight Support Equipment Margins (04-045-E)**" to NESC Review Board, J. Kramer White, 7/8/2004

CONCLUSION

Analytical and testing work on this interface continued through April of 2005, where positive margins were demonstrated by the contractor for all required bolt configuration cases. These margins were accepted by the ISS and SSP and this issue is considered closed.

APPENDICES

A. Request Form (NESC-FM-03-002)
B. NESC Status Briefing, "Control Moment Gyro to Flight Support Equipment Margins (04-45-E)", J. Kramer White, 7/8/04
C. SSP MO Briefing, DRAFT, "STS-114 (LF1) CMG/FSE Integrated Assembly Nominal Landing Loads Status", J. Sills, 4/30/2004

Plan Approval and Document Revision History

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Version	Description of Revision	Author	Effective Date
1.0	Initial Release	Julie Kramer-White	6-22-05