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SYSTEMS ENGINEERING PROCESS AND ORGANIZATION ASSESSMENT

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The systems engineering (SE) process for space systems is a disciplined approach used by both NASA/MSFC and its contractors to convert mission needs into a system specification, the key technical input to NASA Phase C Detail Design activities. Although only 5% of the program effort is expended during Phase A Preliminary Analysis and Phase B Definition, 85% of the program cost is determined by the end of Phase B. The responsibility for SE work at the Center during Phases A, B, and C rests primarily with two organizations: Program Development, which manages Phase A&B; Systems Analysis and Integration Lab, whose involvement begins in Phase B and continues throughout Phase C.

The purpose of this report is to briefly summarize the results of an eight week assessment of NASA/MSFC Phase A and Phase B systems engineering processes, methodologies, and activities. Specifically, fourteen inconsistencies or weaknesses were identified and recommendations for corrective action were generated. A 1.5 hour briefing on these results was given in EL51 on 8-11-92; that documentation is available from the author or either NASA Colleague.

The first group of inconsistencies or weaknesses deals with the existing approach and organizational issues to provide SE support during Phase B:

1.1 Too many system development projects at MSFC, which result in:
- Low utilization of engineering manpower to do value-adding work, because they are matrixed to too many projects (two is considered optimal);
- SE manpower focused on Phase C/D work, not Phase B.

1.2 Variable documentation at the end of Phase A and Phase B, which induces rework at the start of the next phase.

1.3 System development times too long--in some cases 20 years from start of Phase A to operations.

1.4 Phase B program risk analysis capability weak-to-non-existent.

1.5 Trade study management procedures, associated cost and effectiveness models, and decision-structuring aids appear weak-to-non-existent.

Recommendations to resolve these problems were to:

- Control release of projects into new phases in order to reduce the number of programs "active" at NASA/MSFC to better match resources available in S&E labs.
- Realign technology R&D at the Center to meet the needs of approved programs.
- Develop standards for technical documentation that Phase A and Phase B NASA/MSFC project teams must produce, regardless of who is "customer organization."
- Consider breaking Phase B Definition into two subphases, B1 System Definition and B2 Design Definition, as does the Department of Defense (DOD). Also, appoint a Chief Systems Engineer for Phase B.
- Make a concentrated, center-wide effort to reduce development times (for cost savings) and yet meet project milestones as they were originally planned during Phase A.
- Obtain maximum benefit from development of in-house prototypes.
- Develop the capability in SE to identify and make visible to management the technical risks inherent in a technology, a design solution, or an entire design concept.
- Consider developing the expertise to convert quantified technical and programmatic risks into program risk assessments, for the purpose of early, preventive action by program managers and the chief engineers.
- Commit to becoming a world-class practitioner of system engineering methodologies that permit prediction of life-cycle cost and system effectiveness based on the technical parameters and performance characteristics of a proposed product and its associated processes.
- Establish SE's role as trade study coordinator for all Phase B projects.

The second group of inconsistencies or weaknesses deals with the approach used to plan and manage in-house SE activities:

2.1 NLS Definition Phase Implementation Plan, as an example, lacks necessary details on study process flow, systems analysis and control procedures, and outlines of target documents.

2.2 A critical task during Phase B is the preparation of a Systems Engineering Management Plan (SEMP) for Phase C, because this document is the description of the Phase C technical work will be controlled. This task was omitted from the NLS planned work.

2.3 RIDs prior to release of system spec into Phase C are indicative of changes needed in Phase B responsibilities, staffing, processes and documentation.

2.4 The MSFC SE Handbook leaves some critical SE concepts, such as traceability of a requirement, baseline control, "how to" for technical risk analysis, and others unaddressed, and must be improved.

2.5 In-house projects must be forced to conform to a standardized process (with project-specific variations, of course) which included periodic screening for technical leadership, documentation, and process flow.

The missing items from the NSL Implementation Plan were classified into general descriptions, Phase B tasks, and Phase B outputs. The purposes of a SEMP were described, and a comparison of SEMP outlines suggested in MIL-STD-499A and MIL-STD-499B was prepared. The need to adopt a MSFC standardized SEMP contents, and to require preparation of a SEMP by Phase C contractors (or MSFC engineers, in the case of in-house Phase C) was emphasized. It was recommended to use the record of RIDs and their source/disposition on numerous previous programs in a type of "process diagnosis" in order to discern causes embedded in the way Phase B and the preparation of the Phase C plans are conducted. Suggestions for revisions of the SE Handbook were made.

The final set of inconsistencies and weaknesses deals with PD and S&E involvement and phasing during Phases A&B. Problems identified were:

3.1 Phase A technical documentation not well-defined in terms of content, and there is no concept of "customer needs" for the documentation.

3.2 PD has little guidance in their "Lead Engineer's Handbook" on how to conduct Phase B.

3.3 Phase A and Phase B project teams are apparently chronically understaffed.

3.4 Phase B responsibilities, staffing, study processes, and target documentation are vaguely defined in both PD and SE guidance documents.

Recommendations were to adopt the System Requirements Document (SRD) as the target technical document for Phase A Study Teams. Also, Phase A Study Teams must become much more disciplined in the way they document their sources, analyses, requirements, and design concept. Also, it was recommended that a Phase B CSE from S&E be appointed to lead systems requirements work during Phase B, placing control on all Phase B technical matters within S&E. Phase B program managers under this proposal would continue to reside in PD, and the control of all Phase B programmatic matters and customer interfaces would continue under the control of PD. Finally, it was recommended that NASA/MSFC formalize the study process flow for Phase B and that the focus of each subphase be on producing the following documents:

- Phase B1: Preliminary System Spec (System Functional Baseline)
- Phase B2: System Spec and Various Item Development Specs (System Allocated Baseline)

The figure on page II-3 summarizes the reviews, key documents, baselines, and decision authority recommended for a revised NASA/MSFC development life-cycle.

Concept for Managing MSFC In-House Development Projects