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Presented to

Symposium on Planning and Scheduling

Prepared for

Goddard Space Flight Center
Mission Operations & Data Systems Directorate
Code 520

Prepared by

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What We Were Asked to Do

- Document planning and scheduling lessons learned
- Provide recommendations
- Relate lessons learned to mission characteristics

What We Did

- Conducted, documented, and validated 32 interviews
  - Missions included were: COBE, ERBS, EP/EUVE, HST, LANDSAT, SME, SMM, STS
  - Institutional facilities included were: CMF, FDF, MSOCC, NASCOM, NCC
  - Persons interviewed included: Scientists, operations personnel, managers, software engineers
- Identified lessons learned from raw data collected in interviews
- Analyzed lessons learned across missions and facilities
- Identified relevant mission characteristics and analyzed their relationships to the lessons learned
- Developed/formulated recommendations that address the lessons learned perceived as having a major impact on the planning and scheduling process

Major Recommendations

- Operational concepts are introduced much too late in the mission cycle.

1. **Develop end-to-end planning and scheduling operations concepts by mission class and ensure their consideration in system life cycle documentation.**

Background - Recommendation 1

- Persons interviewed consistently expressed the need for considering operational implications early in mission life cycle
- Systems Instrumentation Requirements Document (SIRD) frequently developed before the Mission Operations Concept Document
- Detailed analysis of operational factors might have avoided subsequent planning and scheduling problems (e.g., inability of NCC to support cross-support required by HST)

Details - Recommendation 1

- Develop mission operations concepts to include non nominal sequences
- Develop guidelines/document outlines and timelines for system documentation
- Require traceability between system documentation and the mission operations concept

- The lack of an adequate end-to-end planning-and scheduling systems engineering approach has resulted in fragmentation in mission planning and scheduling.

2. Create an organizational infrastructure at the Code 500 level, supported by a Directorate-level steering committee with project representation, responsible for systems engineering of end-to-end planning and scheduling systems.

- Planning and scheduling systems are developed in disjoint pieces
- Excessive verbal communication and iteration are required to compensate for system engineering deficiencies
- Fragmentation transcends MO&DSD to divisions, flight projects, and users

Details - Recommendation 2

- Include technical committee representing all divisions, Advanced Missions Analysis Office, and each project in the flight Projects Directorate
- Analyze and coordinate technical decisions that transcend individual divisions within MO&DSD
- Ensure that systems are specified and developed within the framework of an end-to-end information flow analysis
- Support interactions with other organizations (e.g., Flight Projects Directorate) concerning planning and scheduling implications of high level decisions (e.g., spacecraft design and operations concept)
- Oversee development of a strategy for integration of all MO&DSD planning and scheduling elements
- Ensure operational user evaluation

Major Recommendations

- Problems in mission planning and scheduling systems are exacerbated, but not created by, identifiable mission characteristics that are established in the Phase A timeframe of a mission's life cycle.

3. Develop and refine mission modeling capabilities to assess impacts of early mission design decisions on planning and scheduling.

Background - Recommendation 3

- Mission characteristics related to spacecraft design and the mission operations concept can exacerbate planning and scheduling problems
- Discrepancies can exist between flight project and MO&DSD regarding expected availabilities and capabilities of institutional resources (e.g., TDRSS)
- Difficulty in capturing and analyzing dynamic relationships using traditional methods for specifying operations concepts (e.g., text & block diagrams)

Details - Recommendation 3

- Assess impacts of early mission design decisions on planning and scheduling, particularly space-to-ground communications requirements
- Facilitate analysis of dynamic aspects of mission concept
- Support consistency and traceability between the Mission Operations Concept Document and subsequent specifications

Major Recommendation 4

- The current approach to scheduling, both within the NCC and in most missions, does not provide sufficient flexibility and is a major factor in the rescheduling problem.

4. Emphasize operational flexibility in the development of the Advanced Space Network, other institutional resources, external (e.g., project) capabilities and resources, operational software and support tools.

Background - Recommendation 4

- Most planning and scheduling systems are designed to support a single operations concept
- Difficulties arise when unanticipated events force a deviation from the nominal sequence
- Variation in needs of missions are not accommodated in current systems (e.g., fixed NCC timeline)

Details - Recommendation 4

- Include service-level request disposition, extensible contacts, flexible timelines
- Institutional resources (e.g., NASCOM, FDF) should accommodate nominal and non-nominal sequences of planning and scheduling activities