Reduce Operations Costs with Multimission Sequencing

David Bliss
Jet Propulsion Laboratory / California Institute of Technology
4800 Oak Grove Dr.
M/S 301-250D
Pasadena, California
(818) 354-7638

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ABSTRACT

Multimission sequencing operations offers great opportunities to reduce high quality space mission costs. Generalized tools and processes form a baseline for the development of standard, non-standard, and real-time command sequences. These tools and processes can then be modified to incorporate each mission's unique requirements. This paper presents a multimission sequencing operations strategy which applies multimission tools and processes according to mission complexity and modifies these tools according to unique mission requirements.

In general, missions employ the following four sequence development steps:

1) **Skeletal timeline development** produces the backbone upon which subsequent science observations and engineering events are placed. Tools such as APGEN lay DSN passes and critical engineering and navigation events on a timeline according to a skeleton timeline development operations process.

2) **Science observation generation** then uses science observation generation and constraint checking software such as POINTER, PDT, SIRPASS, and SEQGEN to produce and integrate science observations into the skeleton timeline. These tasks are executed according to a multi-mission science generation .

3) **Sequence integration** uses multimission integration software such as SEQGEN, SLINC, and SEQTRAN to merge science observations and engineering events into a complete sequence, translate the sequence into spacecraft-readable command packets, perform constraint checks and memory management, and produce sequence review products. These tasks are executed according to a multi-mission sequence integration process.

4) **Real-time commanding** uses multimission command generation software such as the Automated Sequence Processor (ASP) to generate real-time commands and real-time command mini-sequences for transmission to the spacecraft according to a multi-mission real-time command process.

Mission sequencing operations complexity is driven by spacecraft pointing requirements, navigation requirements, unique observing requirements, spacecraft landing requirements (if any), environmental constraints, and new spacecraft technology. These factors determine whether sequencing complexity can be classified as standard, involved, or complex.

1) For **standard sequencing complexity**, missions do not have tight pointing requirements, do not employ new technology on critical subsystems, and have no lander or "target contact" aspects to the mission. Operations are oftentimes repetitive (such as a mapping mission). For standard missions, sequence development steps 1 and 2 can be much reduced and often times eliminated, with science and engineering teams delivering straight to the sequence team for sequence integration. Remaining operations processes and multi-mission tools can be employed with relatively small adaptations.

2) For **involved sequencing complexity**, missions can have precise pointing requirements but probably not motion compensation. They can have new technology on one critical subsystem which is well-tested and well-modeled. Involved missions can have non-repetitive operations and can involve "distant" target contact such as firing at a target to analyze ejecta or touching a target surface with a sample arm. For involved operations, one or both sequence development steps 1 and 2 can be eliminated with the other step(s) existing on a much reduced level. Remaining operations processes and multi-mission tools can be employed with moderate adaptations.

3) For **complex** sequencing, missions have precise pointing requirements with motion compensation. They can have new technology on one or more critical subsystems. They can have multiple, unique observation designs. The main spacecraft body may be a lander. For complex missions, all of the above sequence development steps are likely to be required. Operations processes and multi-mission tools can be employed with extensive adaptations and tests.

This paper will analyze process and tool similarities among past JPL missions of varying complexity and show how these similarities enable the creation of standard multimission sequencing capability. This paper concludes with examples of how JPL's Mission Management Office Mission Planning and Sequencing Team (MPST) has successfully used baseline processes and tools for the operations of the Mars Global Surveyor (MGS), Stardust, Genesis, Mars Odyssey, and Space Infrared Telescope Facility (SIRTF) missions.