Mission Planning for Robotic and Human Exploration

Jessica J. Marquez, Ph.D.
NASA Ames Research Center
Outline

• What is Mission Planning?
• Why is planning for space missions hard?
• Highlight of specialized mission planning software tools
• Future mission planning tools: Analogs and Mars
Spaceflight Mission Operations

Plan-Train-Fly Model

Types of Mission Planning

- **Strategic**: focuses on identifying goals & coordinating with major events.
- **Tactical**: focuses on how to achieve goals with the given resources.
- **Operational**: exact implementation of plan.
- Both robotic & human spaceflight missions follow this process.
  - Difference: Implementation of operational planning.
Mission Planning 101

Goal: Analyze composition of Martian rock for scientists back on Earth.
Mission Planning 101

**Strategic:** Allocate three days for rock analysis
- Drive to rock
- Sample rock
- Analyze rock
- Send analysis results back to Earth
Mission Planning 101

**Tactical:** Drive to rock
- How far is the rover?
- Does the rover have enough power to drive there?
- When can we send the commands to drive?
- Has the rover arrived to the right location?
Mission Planning 101

**Tactical:** Sample rock
- Can rover sample rock? Is rover driving?
- How move rover arm to right sample area?
- Does the rover have enough power to sample?
- When can we send the commands to sample?
- Did the rover sample the right area?

**Tactical:** Analyze rock
- Does the rover have enough power to analyze?
- Does the rover have enough memory for data?
- When can we send the commands to sample?
- When can we get the data?
Mission Constraints

Tactical & Ops Planning Flow

Activity Planning

Constraints

Activity Scheduling

Command Sequencing

Execution

Execution Assessment
Can you imagine all the constraints, resources, and activities required for the International Space Station?!
ISS Attitude Determination & Control

APEX
- Automatic integration of input data & generation of output products
  - Significant reduction of manual entry

- Streamline planning, integrating multiple tools
- Facilitates coordination process between International Partners

Thruster Maneuvers, Reboosts
Docking Events

ISS Orbital Position & Orientation
ISS Power Planning

PLATO

- Automatic integration of input data from various flight controller disciplines
- Integration of new and legacy power analysis engines
- Facilitating power management
  - Power produced vs. power consumed
  - Scheduling powerdowns
  - Automatic generation of shared products
ISS Crew Planning & Scheduling

Score (part of OPTIMIS toolkit)

• Schedule integrates crew, ground, and payload activities alongside ISS state information (e.g., orientation, communication availability).
  – Contributions from multiple flight controller disciplines, Marshall Space Flight Center, and International Partners (Russia, Japan, European Union).

• Planning ranges from six months (1 increment) through one day (real-time planning).

• Integrates variety of external software interfaces and data; automated updates.
  – Plan Change Requests, Templates, Comm Availability calculations, Procedures.

• Flexible resource modeling and violations checking, enabling resource planning.

• Unique capabilities: real-time, simultaneous plan editing and seamless plan version control.
Score: Crew & Ground Planning
Integration of Planning SW Tools
Integrated Replanning: HTV
Preparing for Future Needs
Earth Analogs: BASALT

- Simulating Mars operations: low bandwidth & communication latency
- Evaluating different technological capabilities
Future Mission Planning Challenges

Integrated Human-Robotic Planning with teams of diverse agents, requiring geospatial planning

Support for Planning Execution & Crew-centric Re-Planning

Tighter & More Integrated Planning Process
Questions?
Jessica.J.Marquez@nasa.gov