Mission Planning for Robotic and Human Exploration

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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.
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
ario 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?!
SPIFe: Scheduling & Planning InterFace

Mars Rovers

- MSLICE: Mars Science Laboratory Interface
  - Mars Exploration Rover: Maestro & MAGPEN

International Space Station

- ISS: International Space Station
  - Score
  - APEX
  - Power Planning & Analysis Tool

- LASS: LADEE Activity Scheduling System
- Assisted Replanning
- Analog Mission Self-Scheduling
- ISS Self-Scheduling

Playbook

Phoenix Lander

- Phoenix Lander
  - SPIFe: Scheduling & Planning Interface for Exploration
  - Science Interface
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?
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