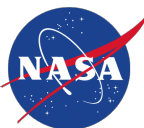




Mission Planning for Robotic and Human Exploration

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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

<http://appel.nasa.gov/2009/03/01/plan-train-and-fly-mission-operations-from-apollo-to-shuttle/>

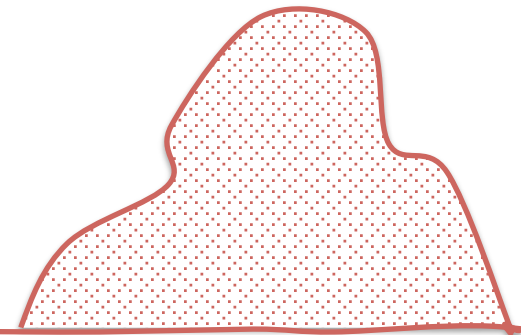
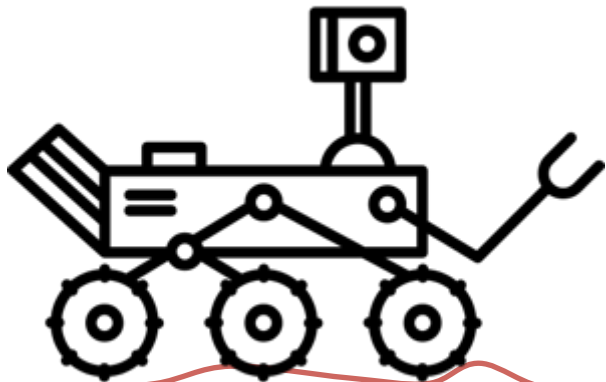
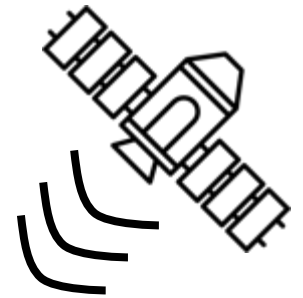
Types of Mission Planning



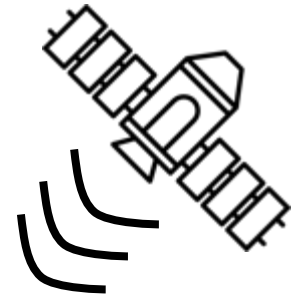
- Strategic: focuses on identifying goals & coordinating with major events.
- Tactical: focuses on how to achieve goals with the given resources.
- Operational: exact implementation of plan.
- Both robotic & human spaceflight missions follow this process.
 - Difference: Implementation of operational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

Mission Planning 101

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

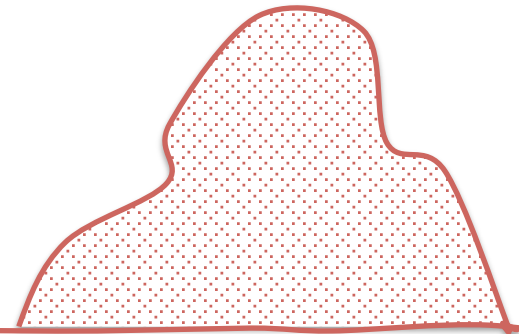
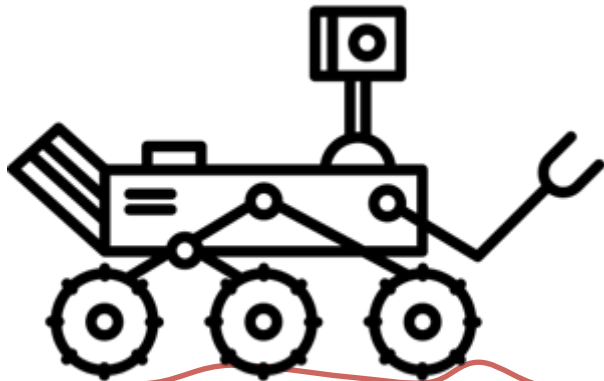


Mission Planning 101

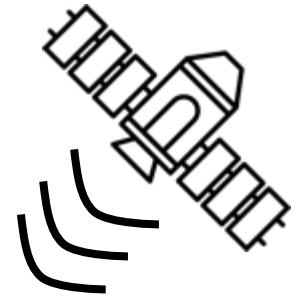


Strategic: Allocate three days for rock analysis

- ✧ Drive to rock
- ✧ Sample rock
- ✧ Analyze rock
- ✧ Send analysis results back to Earth

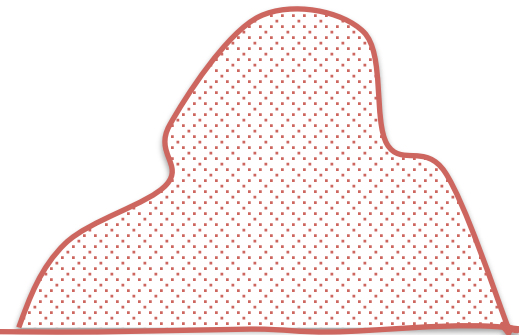
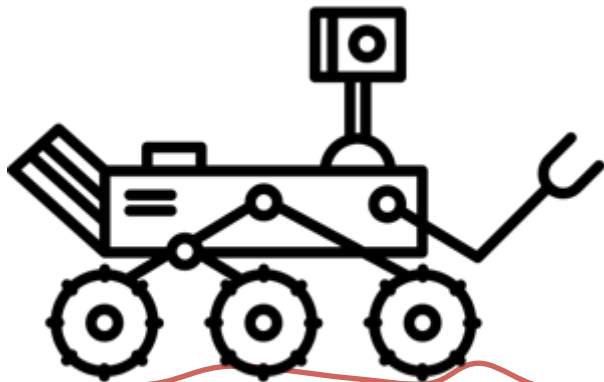


Mission Planning 101

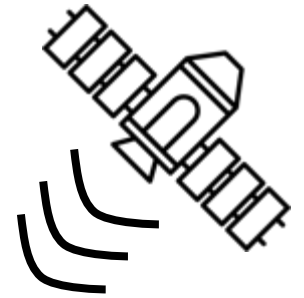


Tactical: Drive to rock

- ✧ 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

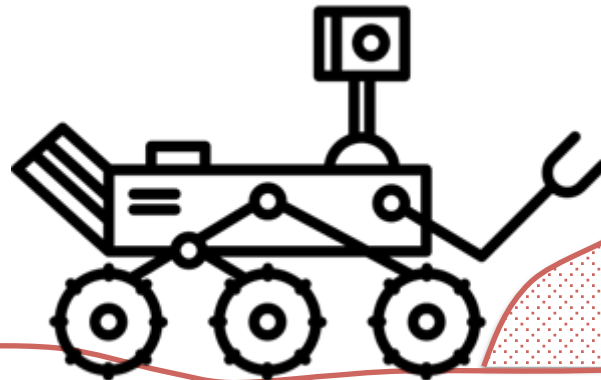


Tactical: Sample rock

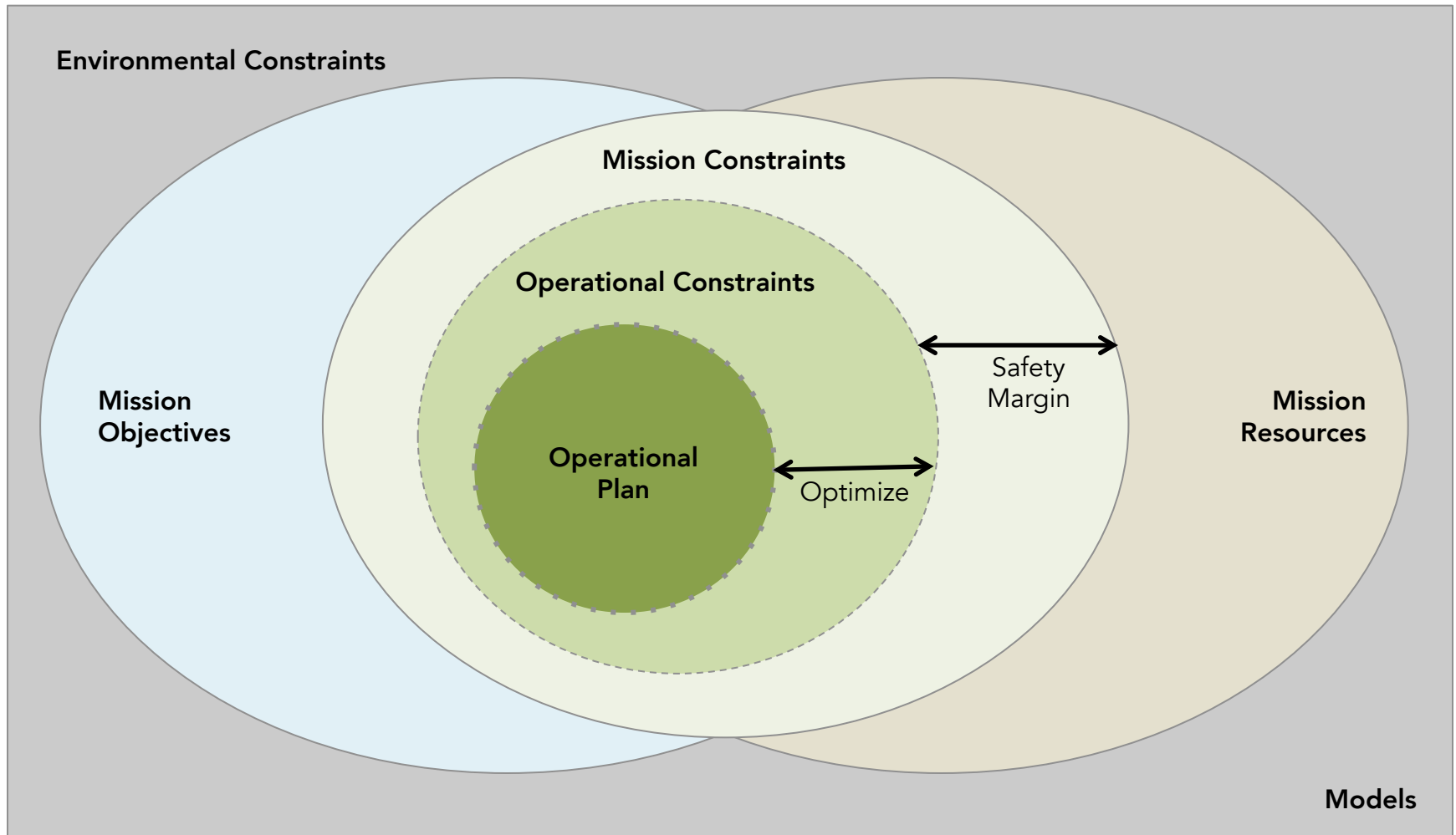
- ✧ Can rover sample rock? Is rover driving?
- ✧ How move rover arm to right sample area?
- ✧ Does the rover have enough power to sample?
- ✧ When can we send the commands to sample?
- ✧ Did the rover sample the right area?

Tactical: Analyze rock

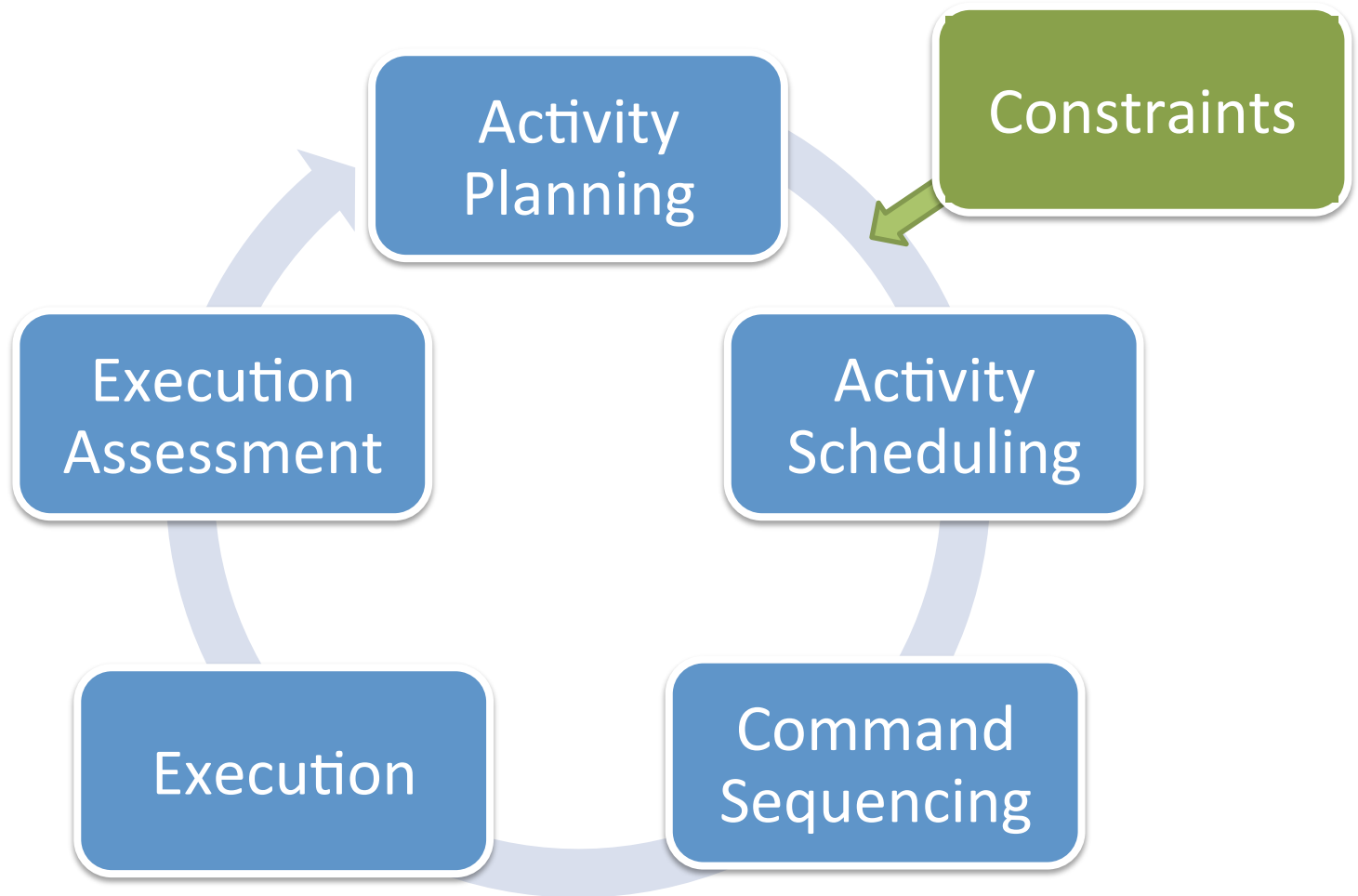
- ✧ Does the rover have enough power to analyze?
- ✧ Does the rover have enough memory for data?
- ✧ When can we send the commands to sample?
- ✧ When can we get the data?

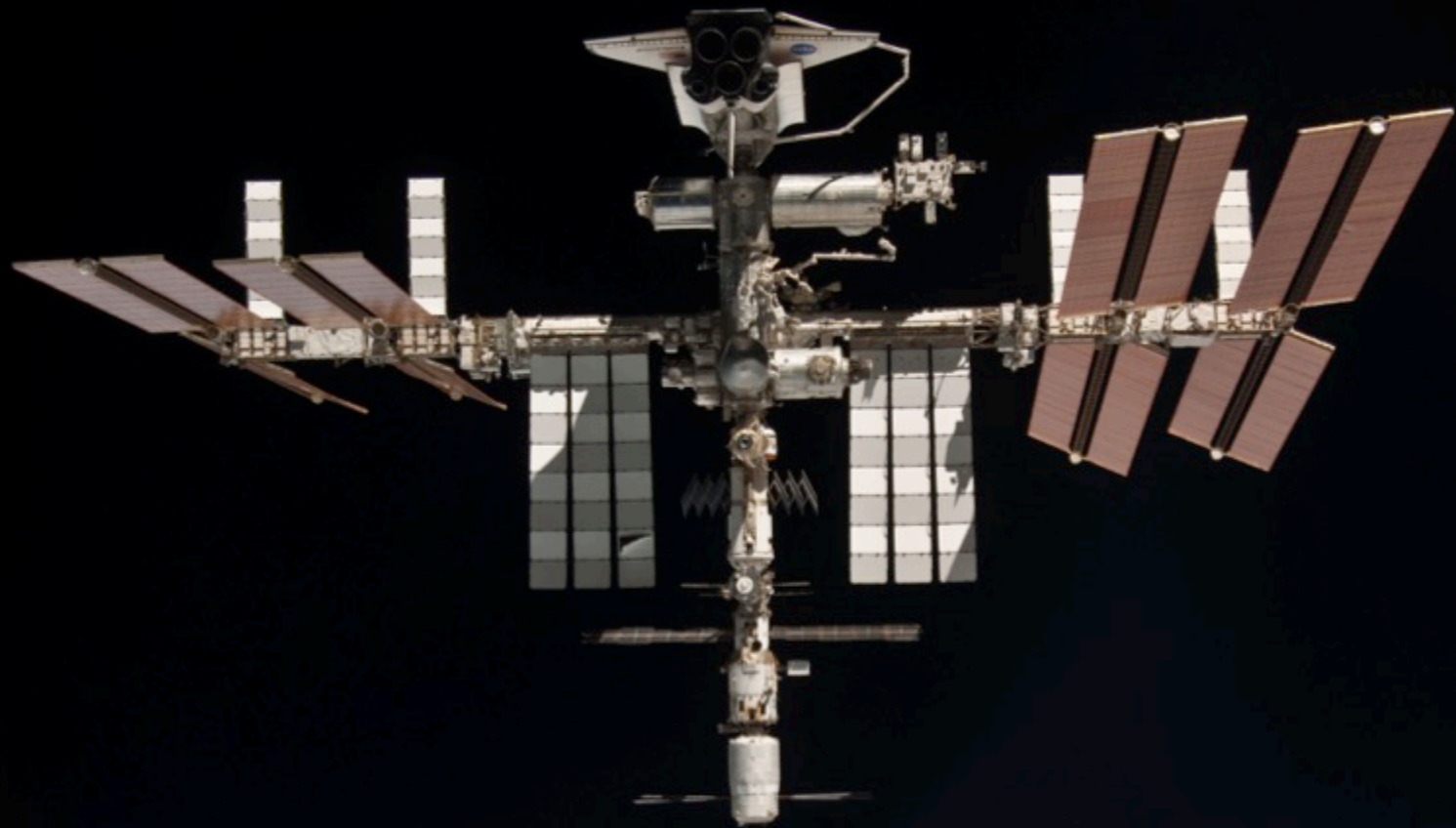


Mission Constraints



Tactical & Ops Planning Flow





Can you imagine all the constraints, resources,
and activities required for the International
Space Station?!

SPIFe: Scheduling & Planning InterFace

Mars Rovers

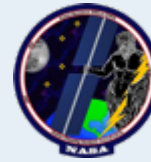


MSLICE
Mars Science Laboratory Interface



Mars Exploration Rover:
Maestro & MAGPEN

International Space Station



Power Planning
& Analysis Tool



Score



APEX

2003

2009

2010

2011

2012

2013

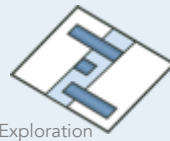
2014

2015



Phoenix
Science Interface

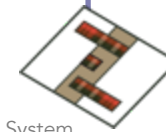
SPIFe
Scheduling & Planning Interface for Exploration



Phoenix Lander

LASS

LADEE Activity Scheduling System



Assisted
Replanning



Analog Mission
Self-Scheduling



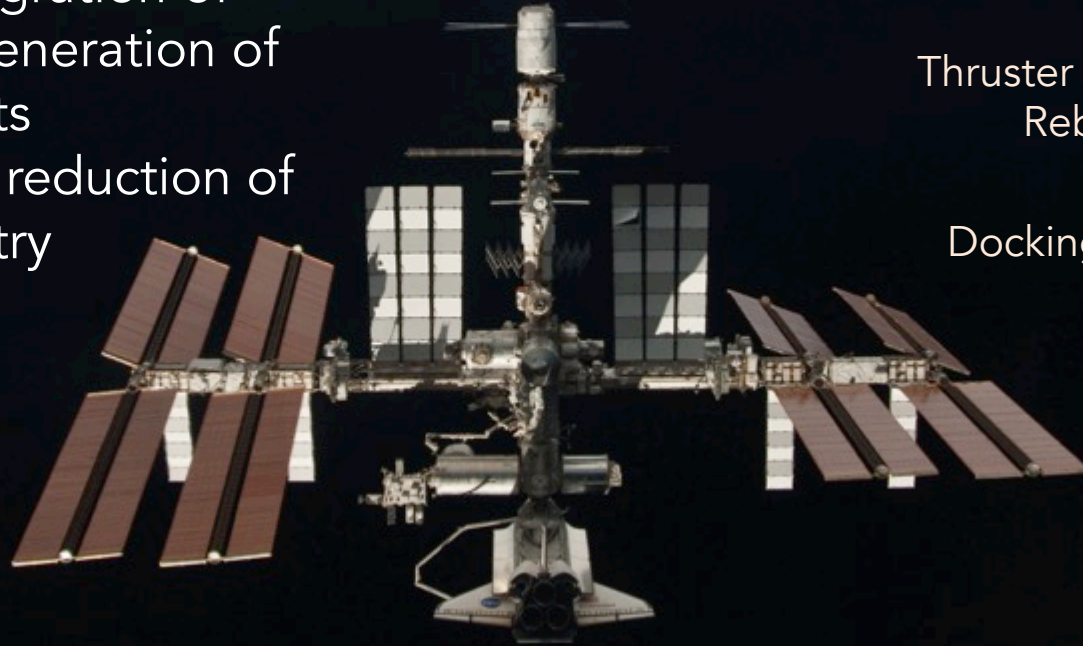
ISS
Self-Scheduling

Playbook

ISS Attitude Determination & Control

APEX

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



Thruster Maneuvers,
Reboosts

Docking Events

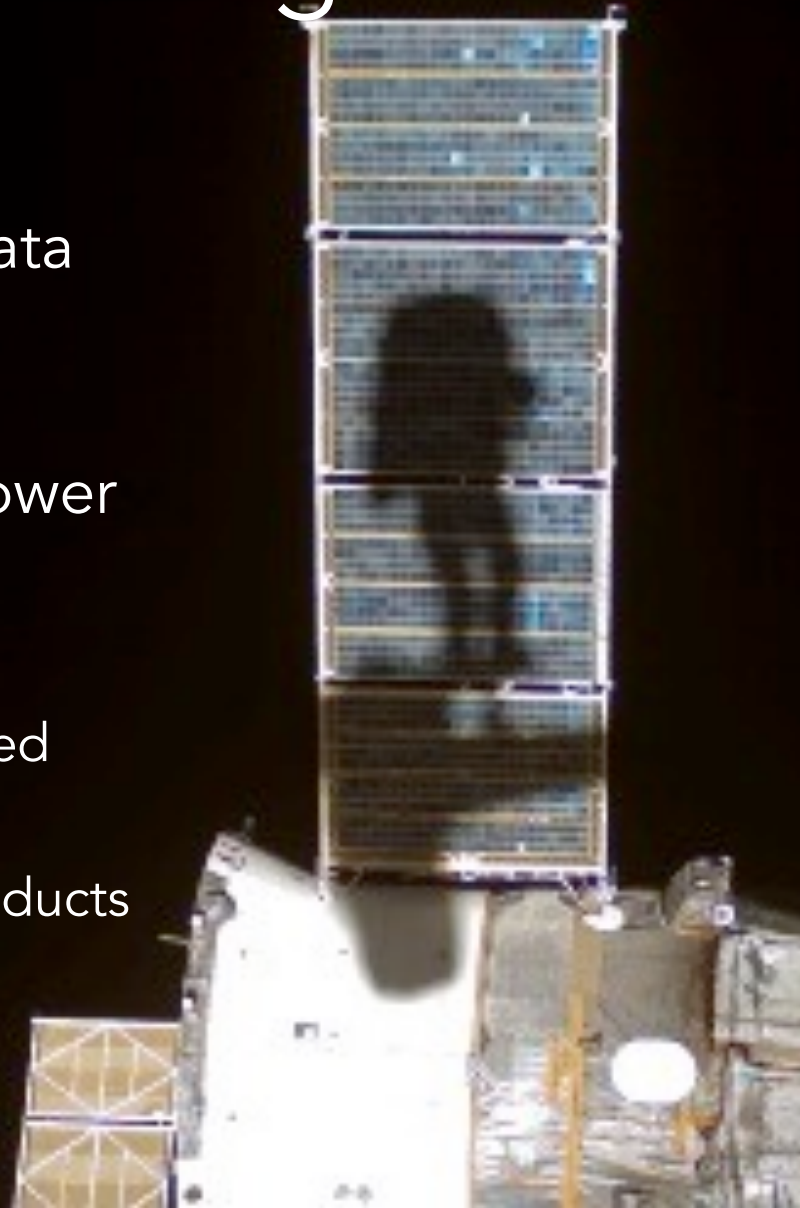
- Streamline planning, integrating multiple tools
- Facilitates coordination process between International Partners

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

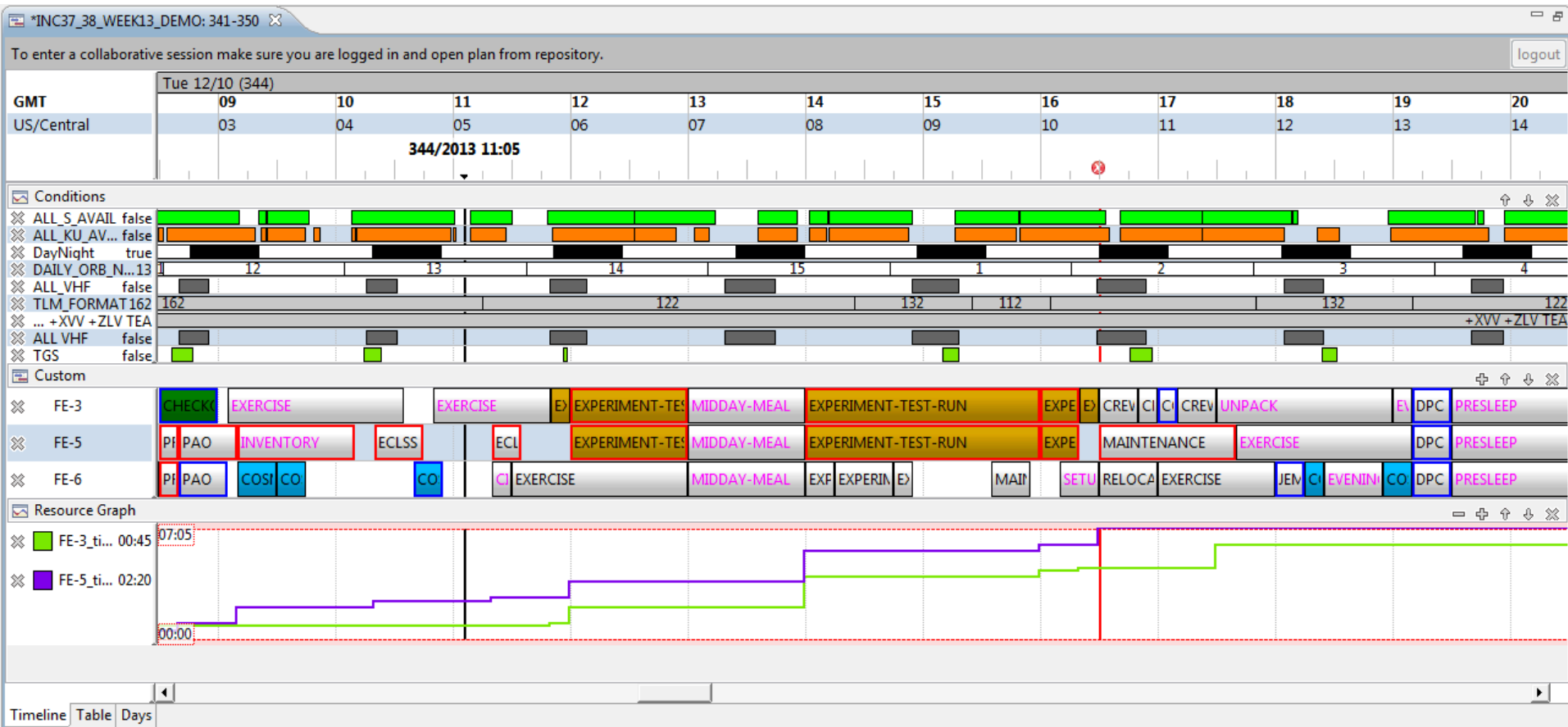


ISS Crew Planning & Scheduling

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



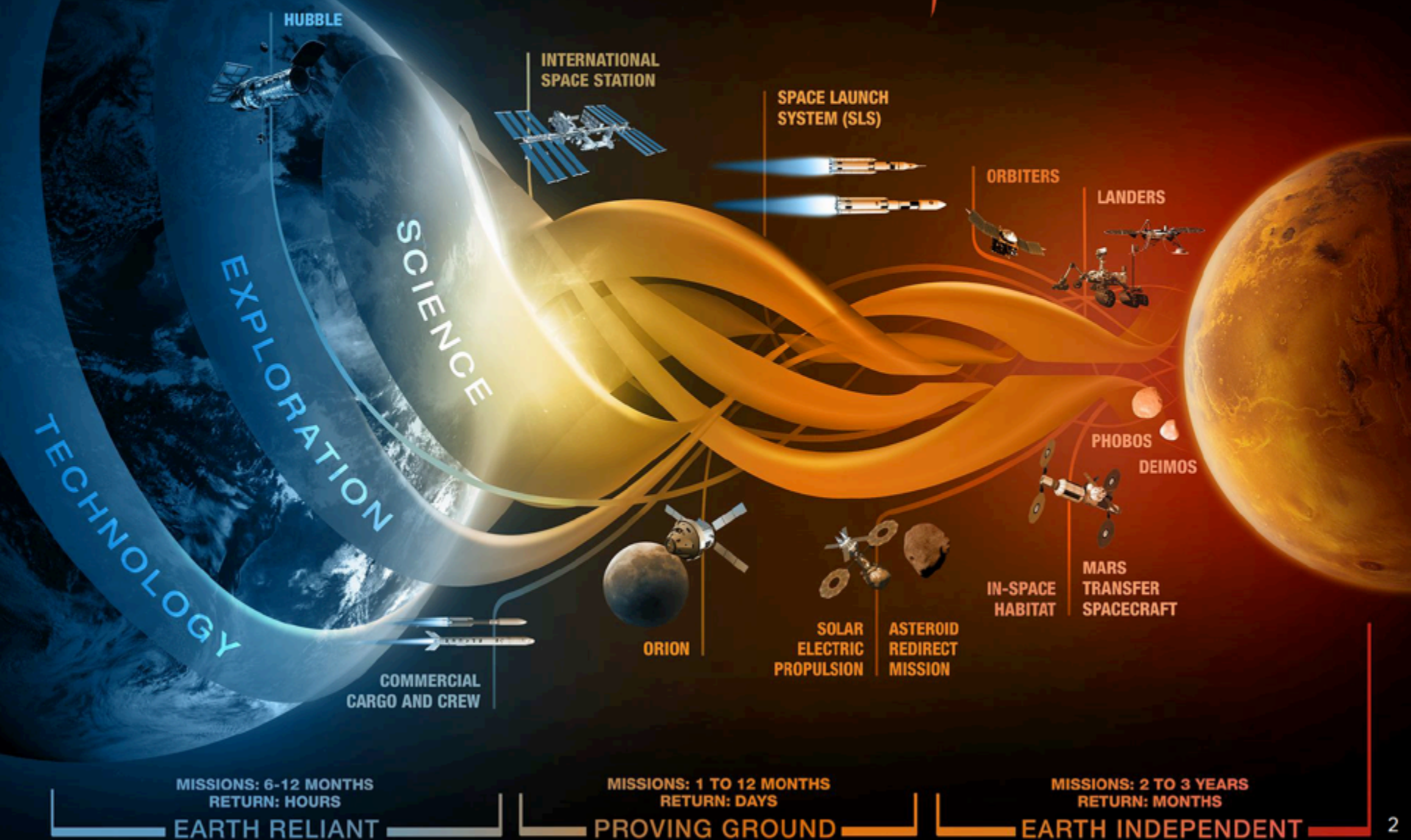
Integration of Planning SW Tools



Integrated Replanning: HTV



JOURNEY TO MARS



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





Questions?

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