Telerobotics & the Deep Space Gateway

Remote operations from Earth and Space

Terry Fong

Senior Scientist for Autonomous Systems
NASA Space Technology Mission Directorate

Chief Roboticist
NASA Ames Research Center

terry.fong@nasa.gov

State-of-the-Art in Space Telerobotics

Human Exploration Telerobotics

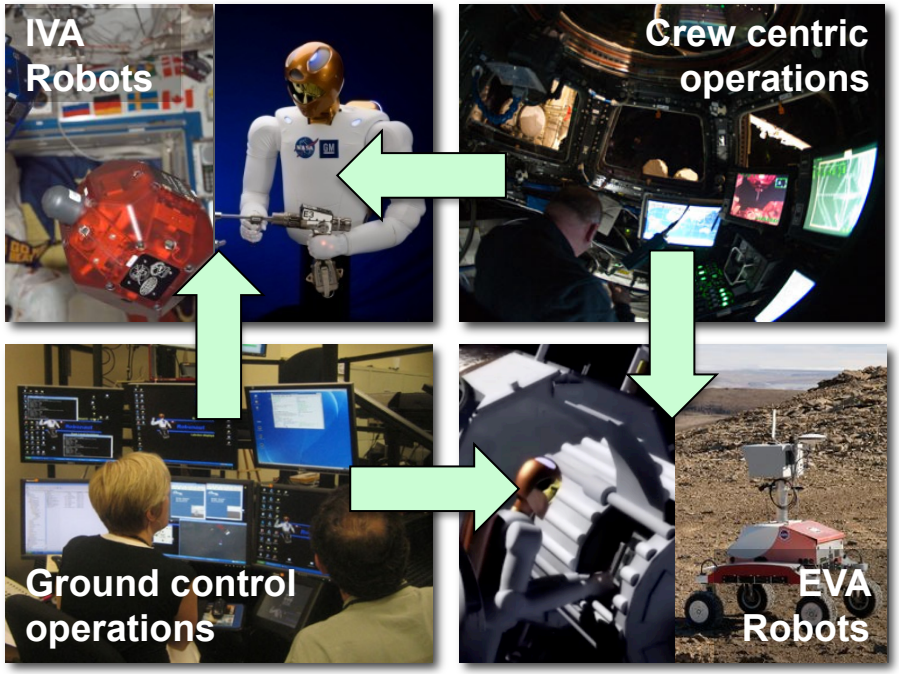
- NASA STMD (2010 – present)
- Mature space telerobotics technology to TRL 7
- Use ISS for testing

Ground control ops

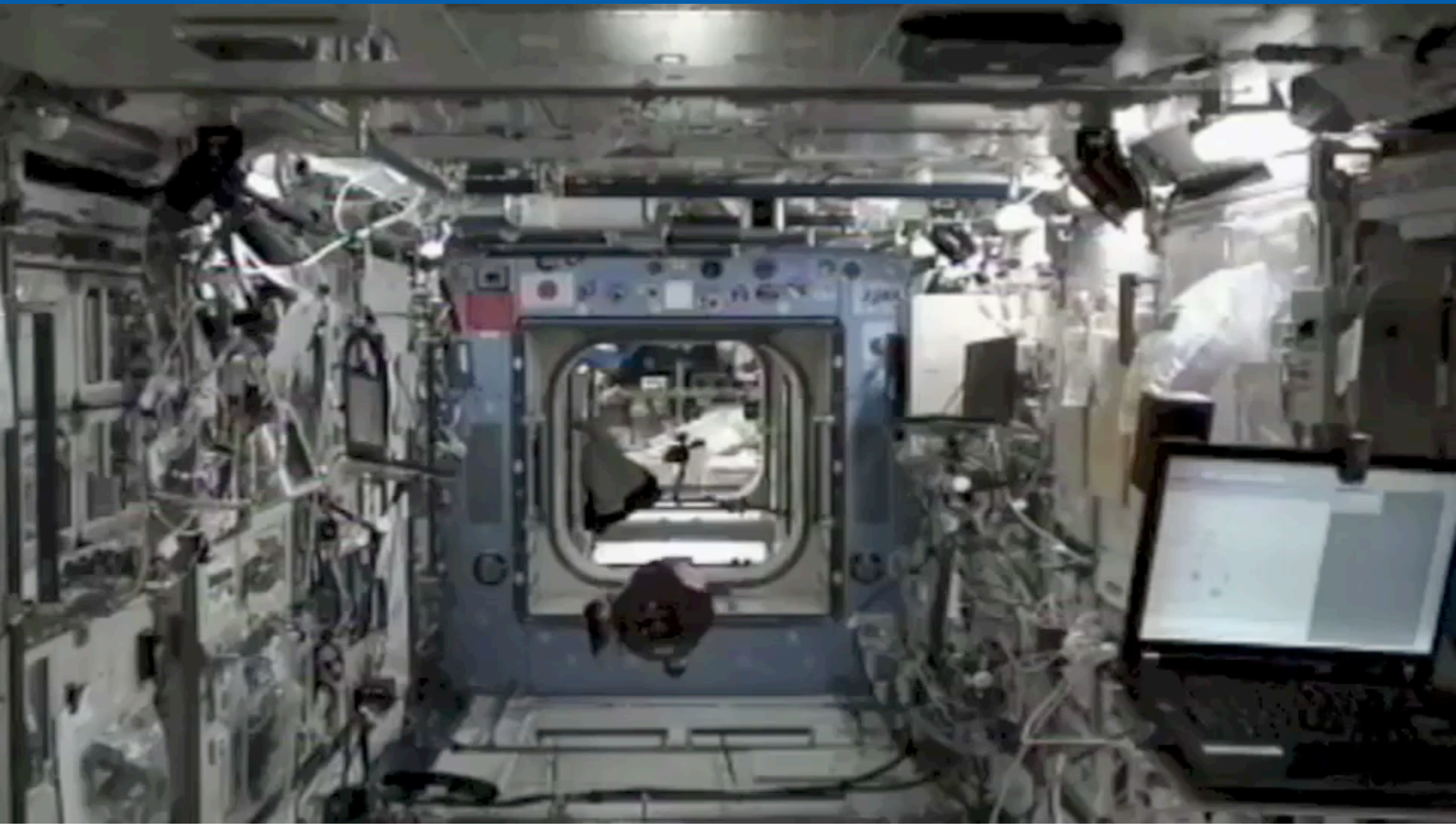
- Mission control remotely operates robot on ISS
- Off-load routine & tedious work from crew to ground control
- In-flight maintenance, repetitive tasks, remote monitoring

Crew centric ops

- Astronauts remotely operate planetary rovers from inside ISS
- Survey, deployment, inspection



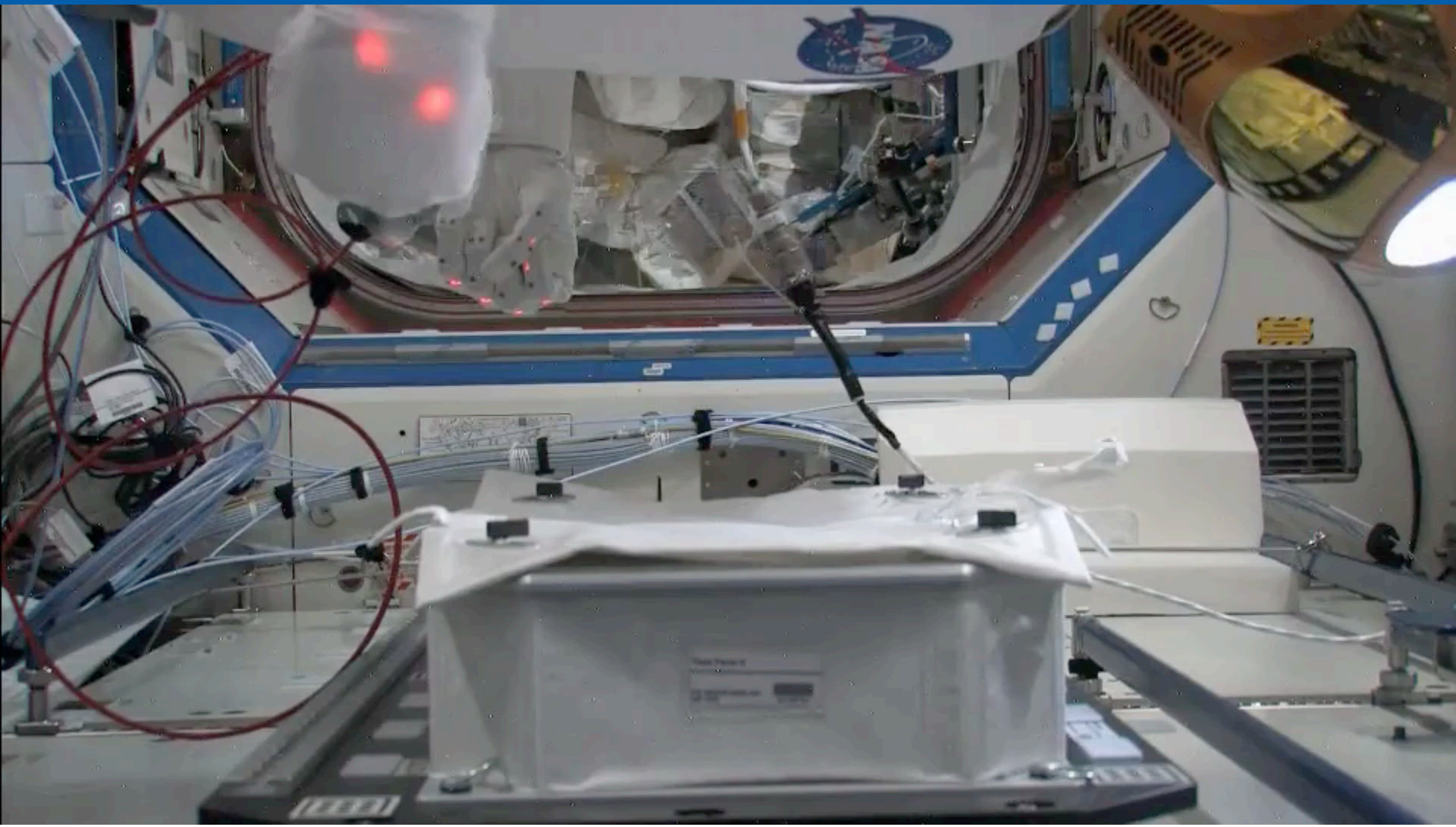
Ground Control of an IVA Free-Flyer



SmartSPHERES in ISS Kibo Laboratory (12 December 2012)

850 msec round-trip latency (with TDRSS and DTN), supervisory control

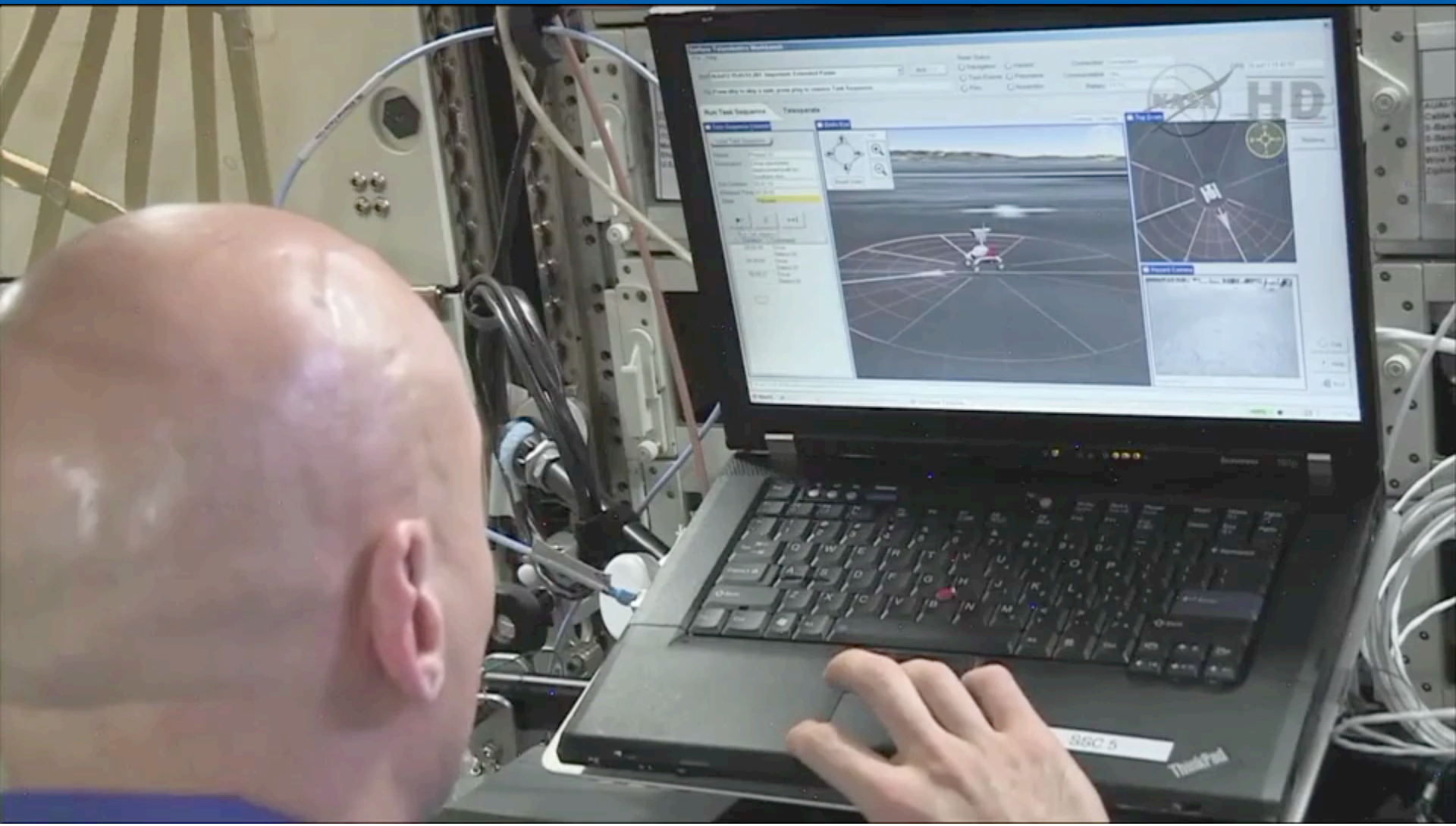
Ground Control of Dexterous Manipulator



Robonaut 2 working with soft goods (3 September 2013)

supervisory control with autonomous manipulation

Crew Control of a Planetary Rover



It is 100% FEASIBLE for crew to remotely operate a planetary rover from orbit
(depending on conops, communications, control mode, environment, risk tolerance, rover capabilities, task, training, user interface and many, many other factors …)

Telerobotics ConOps

Many ways to incorporate the Gateway into telerobotic missions

- Astronaut performs real-time, **manual control** (“joysticking” or “teleop”)
- Astronaut performs **supervisory control** (robot has some autonomy)
- Mission control performs **manual** or **supervisory control** while Astronaut performs **real-time monitoring** and/or data triage
- Astronaut and mission control **time-share** the robot
- Astronaut operates robot **while at Gateway** and Mission control operates robot **during Gateway dormant** periods
- Gateway provides **telerobotic mission support**
- **… and more …**

Many variables to consider

- Communication links (availability, bandwidth, latency)
- Mission requirements (activities, timelines, training, etc)
- Orbit (Lagrange points, halo, polar, period, amplitude range, etc.)
- System capabilities (astronauts, ground control, rover, spacecraft)
- Time phasing, schedules, etc.

Telerobotic Mission Support

The Gateway can provide infrastructure for telerobotics

- **Communications relay**: provide (or increase) link availability and bandwidth to the surface – particularly polar regions and the far side
- **"Orbital computing"** (space equivalent of "cloud computing")
  - Off-load processing from rover – potentially much higher performance
  - Off-board storage from rover – for later triage, downlink, or retrieval
- **Mapping from orbit**: provide site maps
- **Positioning** & **timing**: assist rover localization
- **Power beaming**: provide supplementary and survival energy
- **Remote sensing**: complement surface level data collection
- **Sample return cache**: intermediate location for high-grading
- … and more …

The Gateway is far more than a place for astronauts to perform "teleops"

Some Key Questions

What are the requirements for future telerobotic systems?

- Activities: field geology, volatiles prospecting, instrument deployment, etc
- Where, when, and how should humans be involved?

How can the Gateway most benefit robot missions?

- Including astronauts in robot / science operations?
- Providing enabling infrastructure and services?

Should astronauts on the Gateway operate planetary rovers?

- Constrain missions to only operate when astronauts are available?
- Would this unacceptably increase mission risk? Are there real benefits?

What additional studies, development and testing are needed?

- What data and evidence do we need to develop future missions?
- How can we best obtain and validate this information?