MULTIPURPOSE END-TO-END ROBOTICS OPERATIONS NETWORK (METERON)

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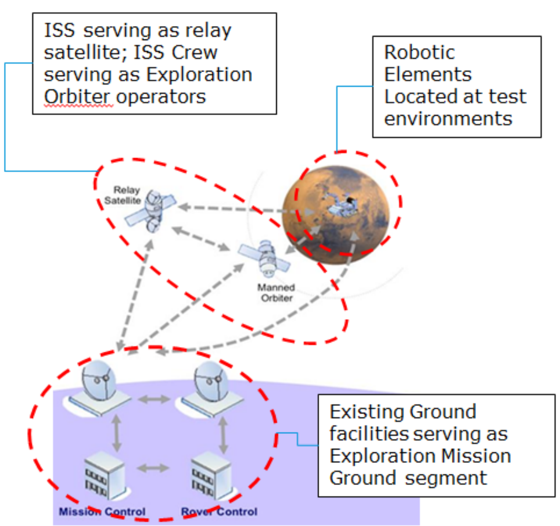
CONTEXT: INITIAL THOUGHTS

1. Future exploration architecture study teams have made assumptions about how crew can remotely perform work on a planetary surface, and more specifically operate surface robot from orbit when circumstances (contingency, etc.) preclude Earth control

(NASA GSFC)

2. Assumptions
    1. Maturity of crew-controlled tele-robotics
    2. Existing technology gaps (and how these can be bridged)
    3. Operational risks (proficiency, performance, failure modes)

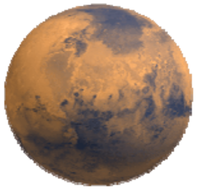
Simulated Exploration Mission Architecture

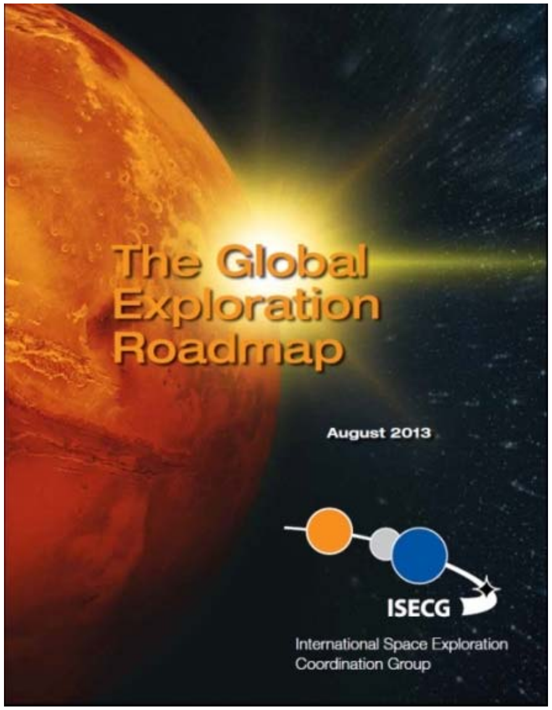


3. ESA-led study in 2009 showed that it is feasible to implement an infrastructure, encompassing the ISS, that could be used for Ground Simulations, In-Orbit Demos and their combination.

4. Multipurpose End-to-End Robotics Operations Network

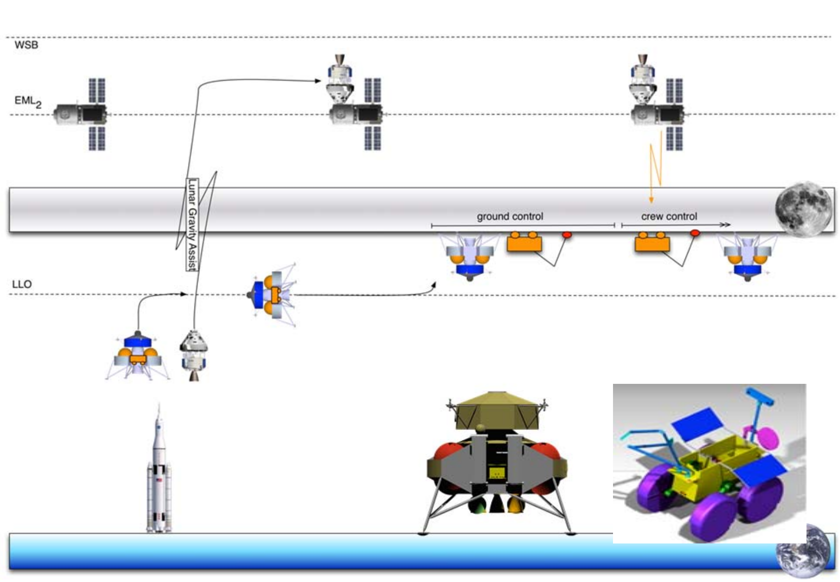
CONTEXT: International Plans for Human Exploration (ISECG, Global Exploration Roadmap)

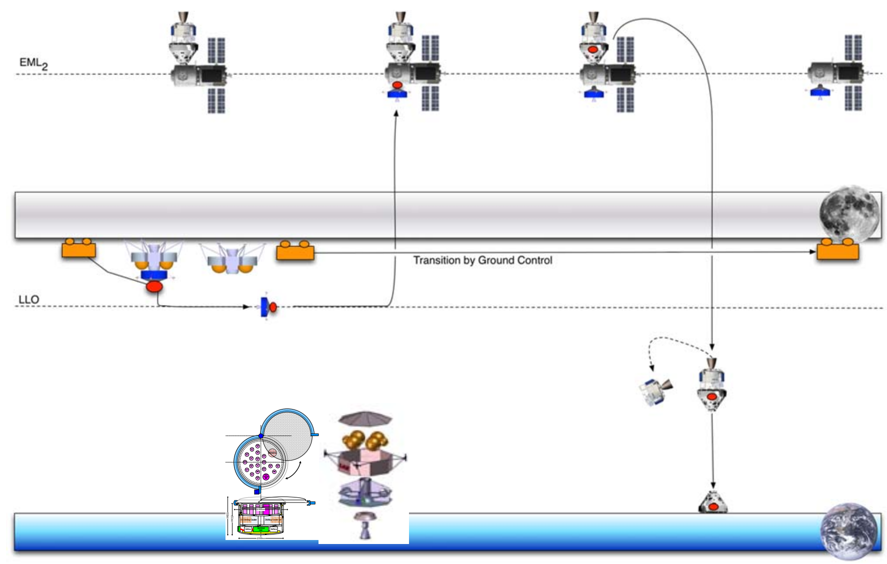




LUNAR SURFACE OPERATIONS – HERACLES MISSION

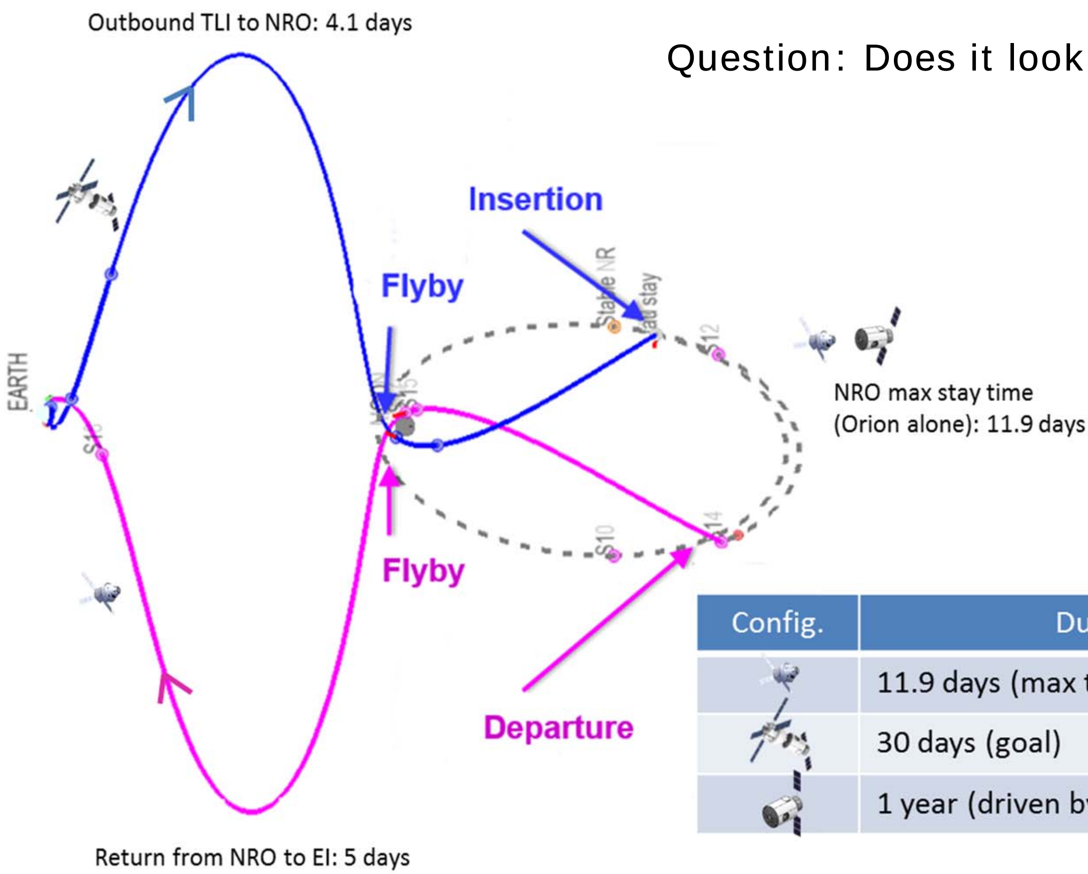
- Mission definition by ESA and International Partners
- Early human exploration mission
- New destinations (lunar far side, polar regions) new approaches (tele-operations) and new knowledge and opportunities for science (darkness, large range mobility, volatiles, operations)
- Recurrent global access through re-usability
- Preparation and risk reduction for human missions and Mars Sample Return





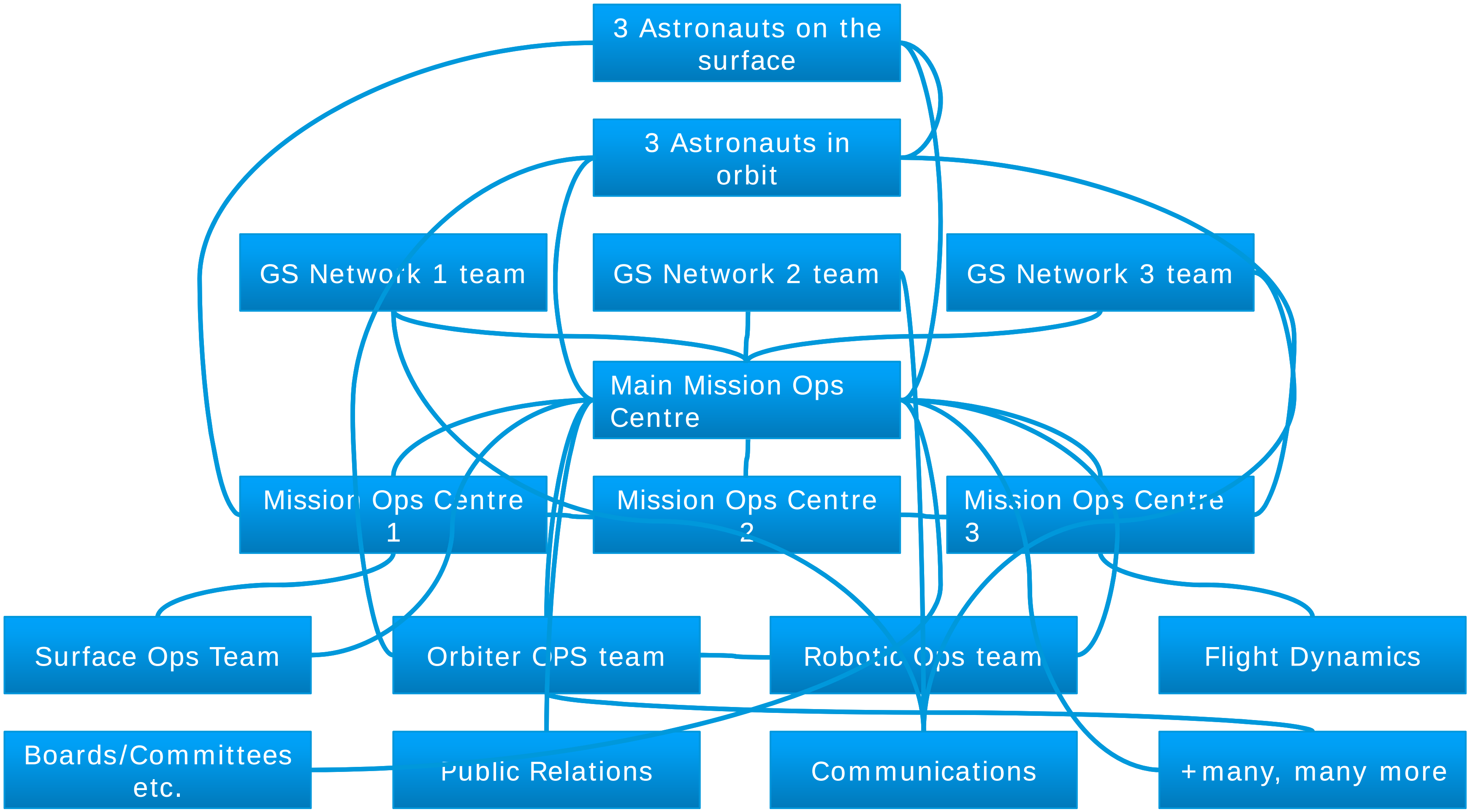
CONTEXT: CONCEPTUAL CIS-LUNAR INITIAL MISSION

Question: Does it look relatively easy at this level ?



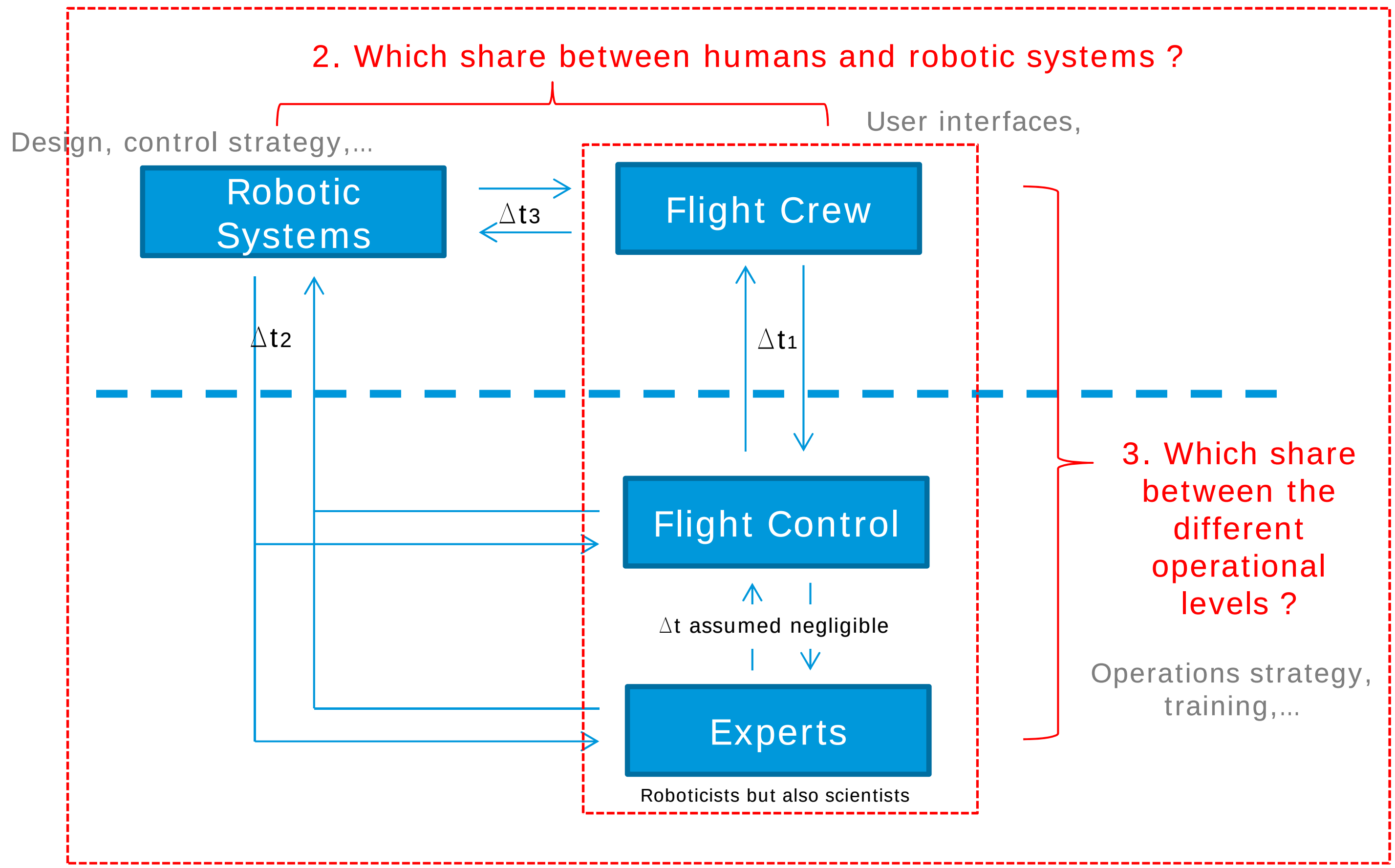
Config.	Duration
	11.9 days (max total 21 days)
	30 days (goal)
	1 year (driven by next SLS launch)

A TYPICAL OPERATIONS TEAM FOR A HUMAN EXPLORATION MISSION – A SIMPLIFIED VIEW



SOME KEY QUESTIONS

1. **Which tasks have to be performed ?** When ? By Who ?

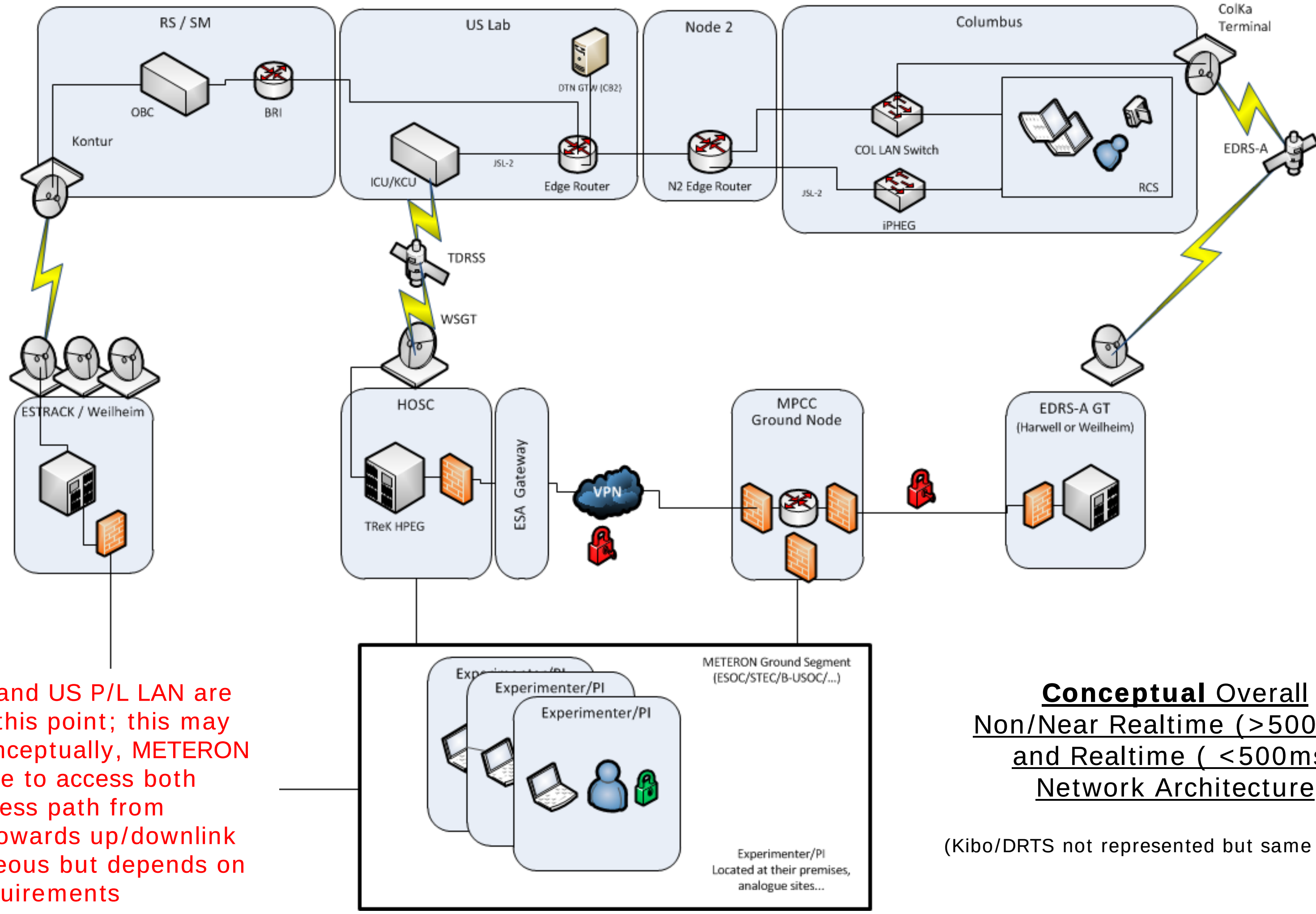


→ Helping getting answers to these questions is a the core of the METERON project

METERON AT A GLANCE

- Objectives
  - Demo **<u>communications</u>** concepts and technologies
  - Test **<u>operations</u>** concepts and technologies
  - Evaluate **<u>robotics</u>** technologies and operations
- Key questions:
  - Control from Earth or from close-by?
  - Supervisory control or low latency tele-ops?
  - Comms and ground segment - how to run such ops?
- Approach
  - Ground Simulations / Utilise the ISS when needed
  - Build upon existing infrastructure(s)
- Implementation
  - Set-up of a simulation environment
    - Goal is “plug and play”
  - Operators and Astronaut(s) on Ground/ISS
  - Various robotic assets on Earth
  - Gradually increase complexity
  - Risk reduction through gradual steps

METERON CONCEPTUAL NETWORK ARCHITECTURE

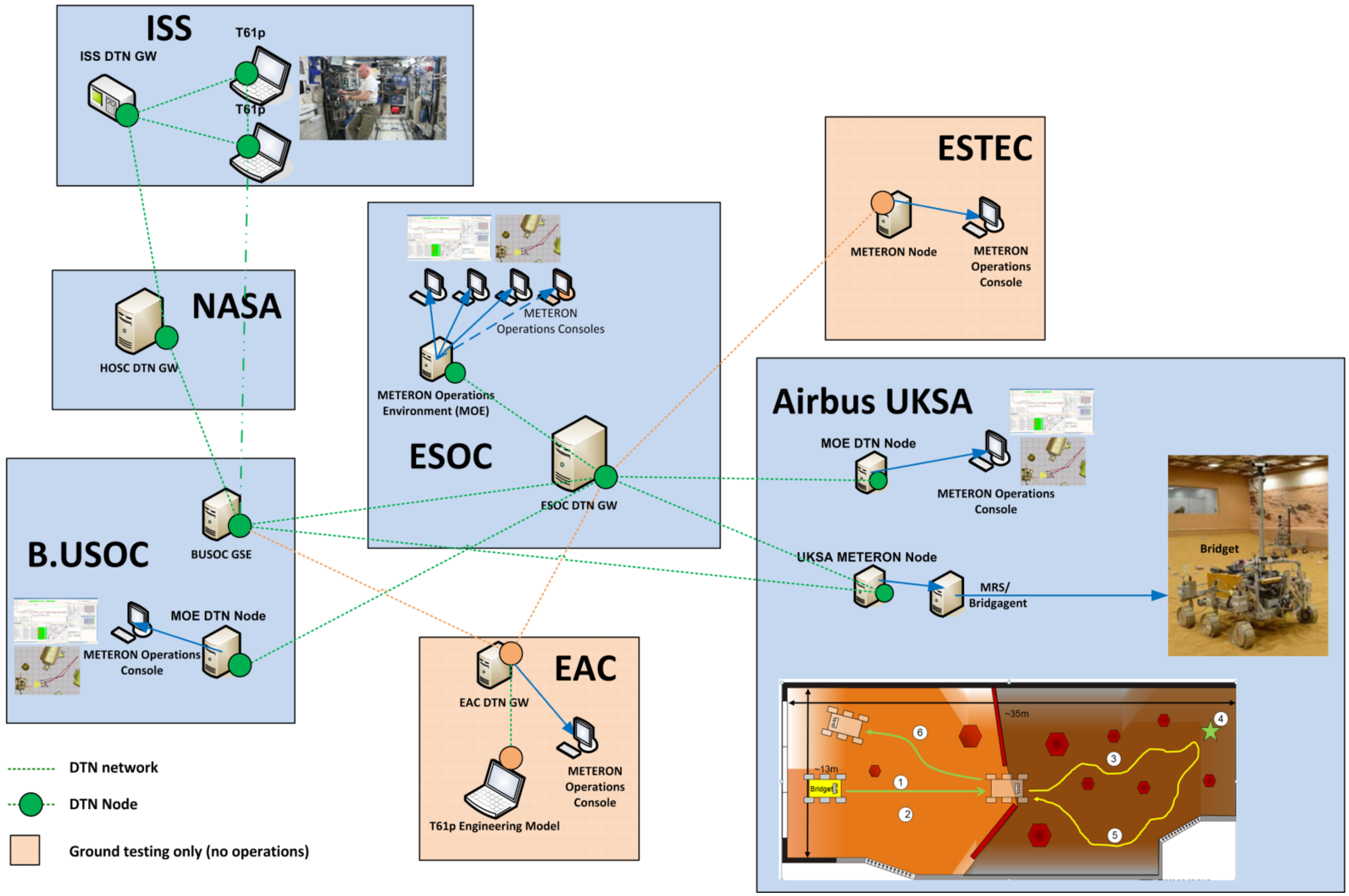


Note: Col-LAN and US P/L LAN are not bridged at this point; this may come later. Conceptually, METERON wants to be able to access both LANs. Also, access path from METERON GS towards up/downlink is not simultaneous but depends on experiment requirements

Conceptual Overall Non/Near Realtime (>500 ms) and Realtime (<500ms) Network Architecture

(Kibo/DRTS not represented but same principle)

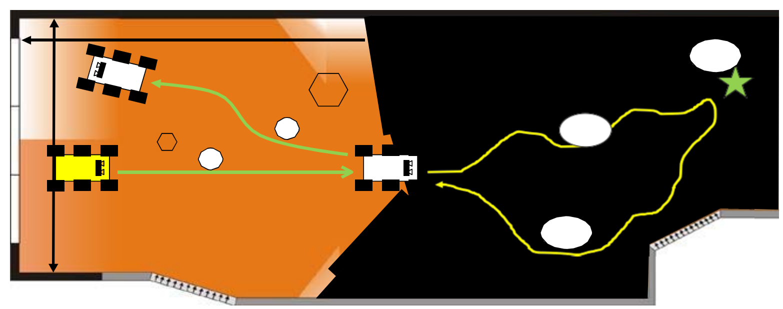
METERON NETWORK ARCHITECTURE: A SPECIFIC EXAMPLE

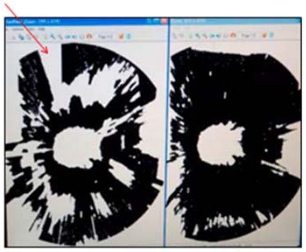


SUPVIS-M(ARSYARD)

- Operate “Bridget” in Stevenage Marsyard; Estec-ESOC-Airbus UK
- Rovers need to travel large distances in harsh light conditions
- Are people (team) better than computers in image interpretation?
- Need tele-operation for obstacle avoidance and speed under operating constraints?

Example of harsh lighting (left) vs. good lighting (right)





SUPVIS-E(UROBOT)

- Operating Eurobot at Estec, with supervisory control from ISS
- Force control loops closed locally in the robot
- 2nd rover controlled from ESOC or from ISS
- Disruption Tolerant Networking (DTN) – “space internet” – insensitive to loss of signal
- 1 or 2 laptops in ISS: TM driven graphics and real time video streams
- 1st part by A. Mogensen Sept’15 (nominal ops), **T. Peake: off-nominals**
- http://www.esa.int/spaceinvideos/Videos/2015/09/Driving_Eurobot_from_space

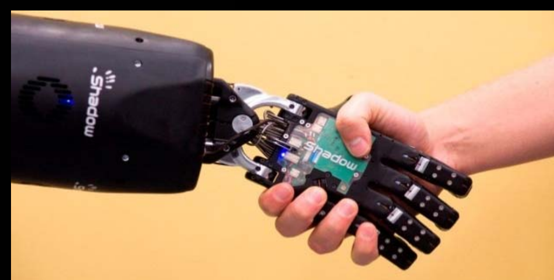
METERON - MULTI-PURPOSE ROBOTICS OPERATIONS NETWORK

EXPERIMENT SERIES FILLING COMS / ROBOT TECHNOLOGY GAPS

Short Title of Experiment	Summary Description	
OPSCOM-1	Communications set-up and first DTN flight demo	
OPSCOM-2	Validation of communications and operations systems (utilising Eurobot) via DTN, using specific ground infrastructure	
INTERACT	Haptics control of arm and rover; development of control strategies and algorithms	
SUPVIS-E	Supervisory control of Eurobot, advanced comms (part 1: no introduced errors, part 2: with errors, e.g. failed auto grasp)	
HAPTICS-1	demonstration of force-reflection to take place within a microgravity experiment	
HAPTICS-2	demonstration of a closed bilateral control loop with real-time force-reflection between the ISS and a small robotic joint located on Earth	
SUPVIS-M	Control of a rover in Stevenage Mars Yard, focusing on rover speed in automatic vs manual control, in varying lighting conditions (incl. pitch dark).	
SUPVIS-JUSTIN	Advanced Supervisory control of DLR's rover Justin	
OPSCOM-3	Use of European DTN / MPCC; Kontur; gapless handover between ground stations, analysis of European Ka-band link	

COM4HAP-1	Demonstration of ESTRACK + Kontur comms links
COM4HAP-2	Demonstration of complete comms chain
EXO-1	Exoskeleton control of a LightWeightRobot (LWR) in Estec
EXO-2	Exoskeleton control of DLR's Justin
EXO-3	Exoskeleton control of ISS-based NASA Robonaut (TBC)
ANALOG-1	End-to-end exploration scenario with Eurobot in a field test, controlled from ISS

Under Revision



THANK YOU

European Space Agency