Concepts on Maximizing Data Return for a Potential Europa Lander Using Direct-to-Earth Communications

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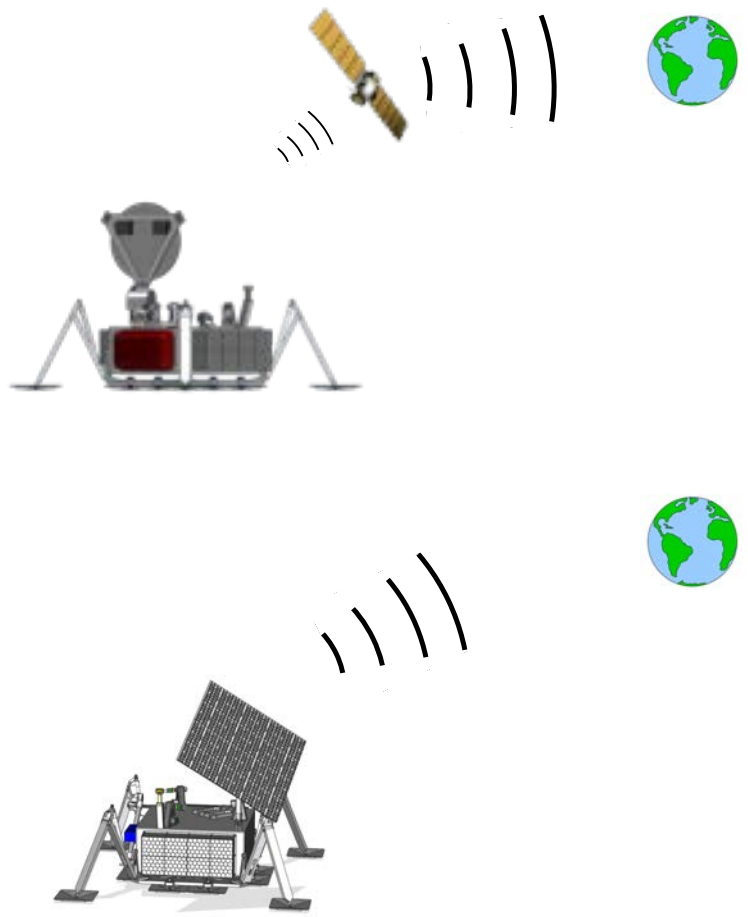
Europa Lander Mission Concept Shift

- At the June 2017 Mission Concept Review (MCR), the Carrier spacecraft also was a relay spacecraft for communications for Lander Surface Mission

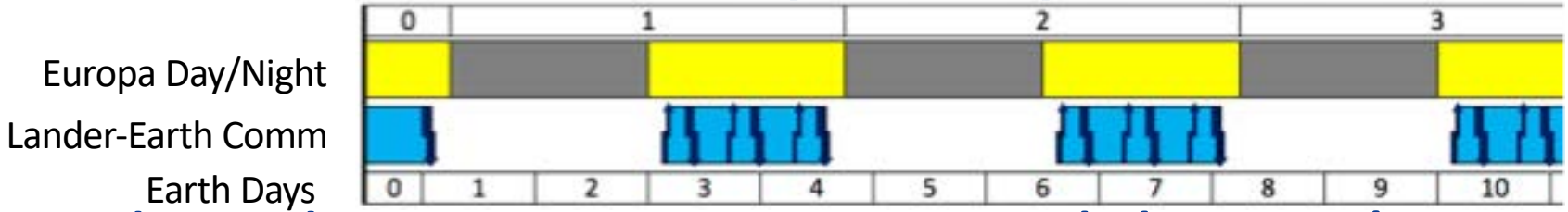
- For cost reasons, architecture has shifted a Direct-to-Earth communications mission
  - Surface Mission to be redesigned



Concept Illustration

Challenges of Direct-to-Earth (DTE) Only

1. Earth in view for ~36 hrs every 3.5 days



2. Increased Lander communication capability can't match relay

At MCR:	Carrier Relay to Earth	Lander to Carrier
Data Rate to Earth	80 kbps	1 Mbps
HGA dia	3 m	0.4 m
Transmitter	50 W	25 W
Energy to transmit	650 W/8 hr	300 W/15 min

0.05 kWh/Gbit on Lander

DTE Design to increase size of antenna, amplifier, battery but can't match

Approach to Maximizing Data Return:

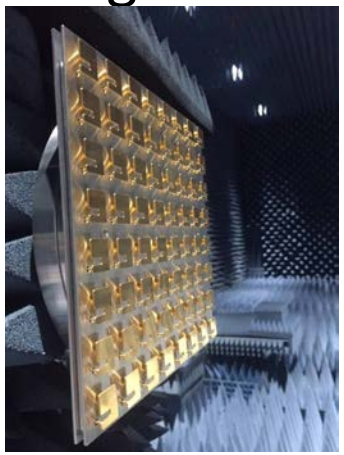
Increase current design capability while reducing overall data requirement

Enhancing Capability

Maximizing Capability: Flight System

- Telecom (X-band Design)

Larger Antenna

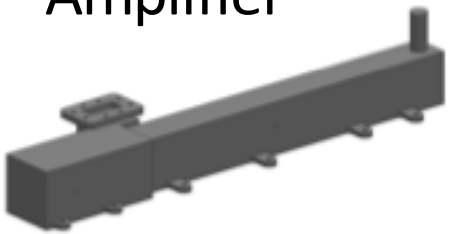


Above: 0.2 m Prototype antenna in test

0.8m gimballed, high aperture efficiency,

High Gain Antenna (HGA)

Larger Amplifier



100 W Travelling Wave Tube Amplifier (TWTA)

replaces 25W Solid State Power Amplifier (SSPA)

Dual Band Radio

Courtesy: Solar Probe Plus

Frontier Radio augmented with

capability to transmit & receive to Earth

and to Europa Spacecraft

- Energy

Increased Battery

33% more capable

Enhancing Capability (2)

Maximizing Capability: Ground System

X-band Downlink Data Rate Performance

DSN Configuration	Array Gain (dB)	Numeric Ratio	32 x 32 Element HGA, 100W Data Rate (kbps)**
1 34 m DSN			9
2 34m DSN	2.71	1.87	17
3 34m DSN	4.47	2.80	25
4 34m DSN	5.72	3.73	34
1 70m DSN			47
1 70 + 1 34m	0.42	1.10	52
1 70 + 2 34m	1.03	1.27	60
1 70 + 3 34m	1.55	1.43	68
1 70 + 4 34m	2.01	1.59	76

@DTE

***At MCR**, only single 34m station planned for surface data return*

3.1 kWh/Gbit

Costs ~60x more energy to send each bit

*** assumes Factor of [2] margin in addition to 3dB required telecom margin*

Reducing Data Volume

Rescoping Science Goal: *Search for Biosignatures*

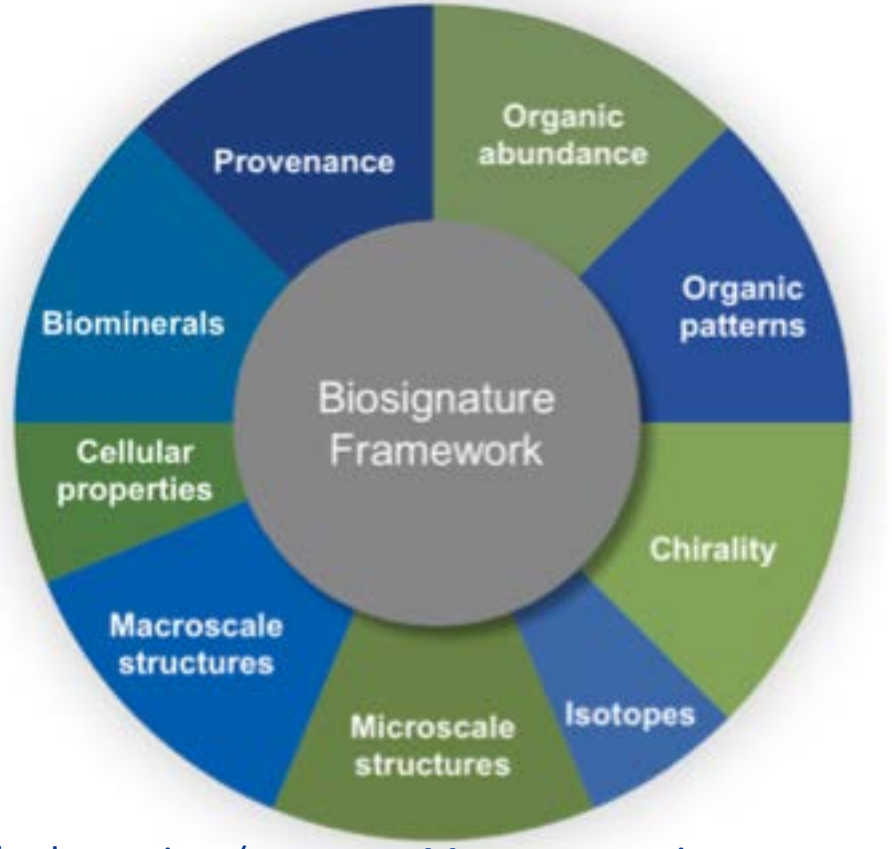
- Science Defintion Team Report Definition of 'Biosignature':
  - 'A feature or measurement interpreted as evidence of life.'

- Focusing on '**Searching for Biosignatures**' as opposed to '**Life Detection**' enables several significant operational changes, e.g., reduction in number of samples, trenches, and ground-in-the-loop opportunities.
- This minor change in focus is directly in line with the SDT Report and is also consistent with Town Hall and community feedback (e.g. OPAG).

Life Detection & Biosignatures

From Kevin Hand's Science Presentation

- **Life Detection** necessitates:
  - Multiple lines of complimentary and redundant evidence, each of which is a biosignature.
    - SDT Report Definition of biosignature: 'A feature or measurement interpreted as evidence of life.'
  - Repeated analyses of the sampled material to corroborate the validity of each line of evidence.
- **Searching for Biosignatures** has the benefit of:
  - Maintaining the capability for life detection by retaining complimentary and redundant instruments and measurements.
  - Alleviating the potentially intractable burden of life detection and the ramifications for surface operations.



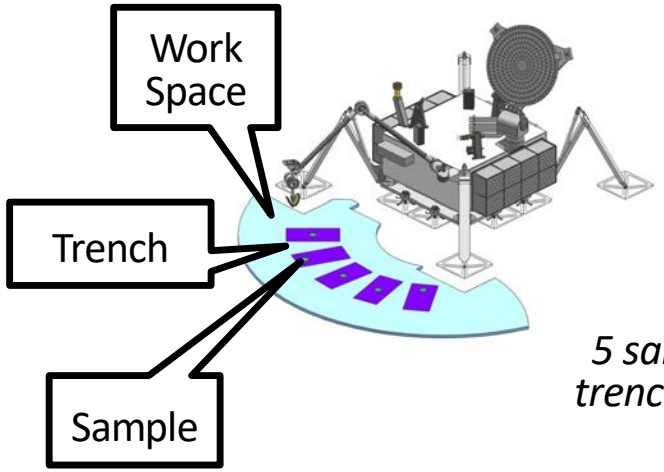
- It may take years to determine if a set of biosignatures constitutes life detection (see e.g., Mars meteorite ALH84001)
- The Viking legacy carries an unjustified, but unavoidable, burden for mission tasked with life detection.

Reducing Data Volume (2)

Concept Illustrations

Science Rescope Options:

1. Reduce number of samples, images, and seismic monitoring time.
2. Reduce trenching.

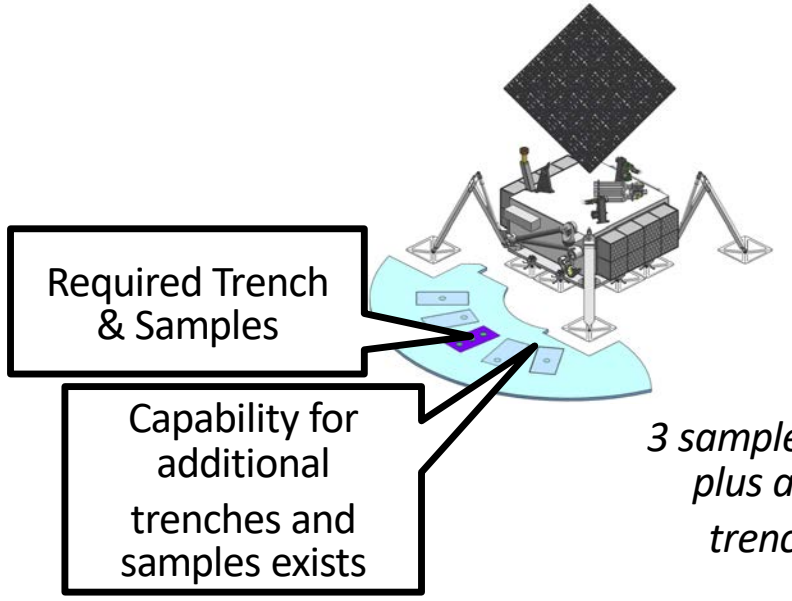


MCR

5 samples and 5 trenches required.

Project Requirements

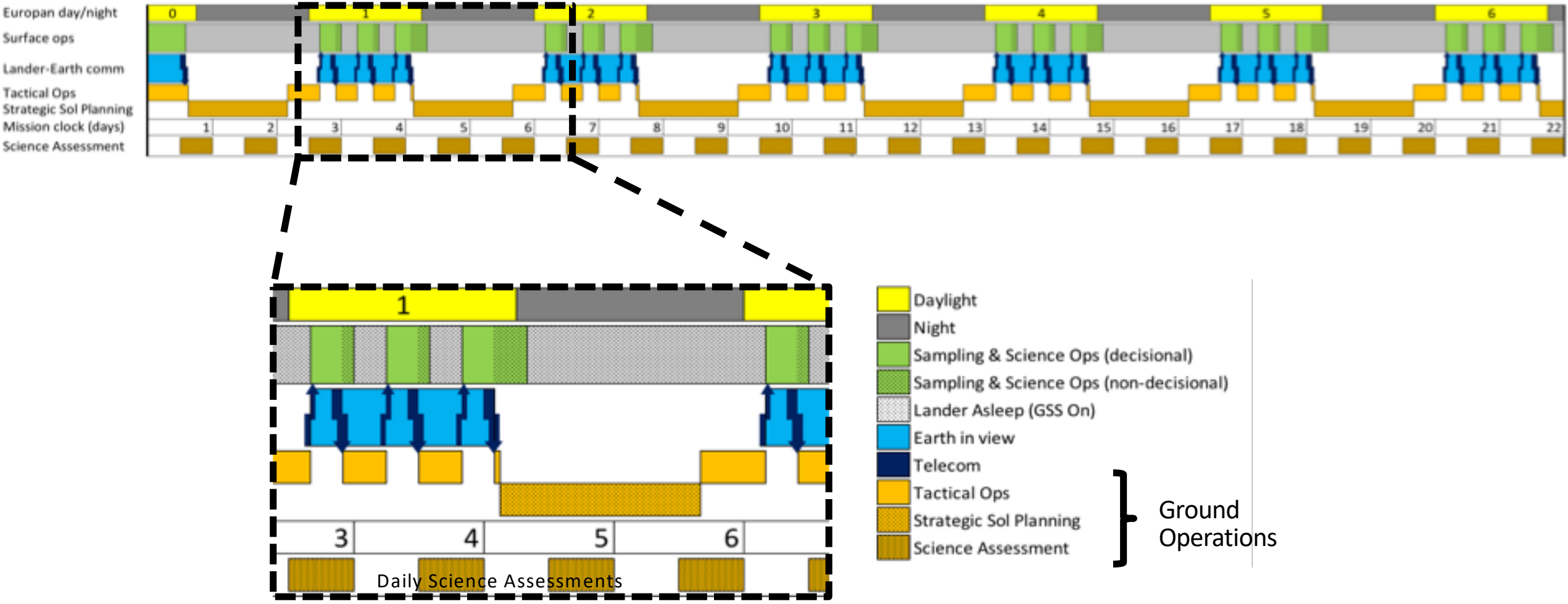
	MCR	DTE
Number of Trenches	5	1
Number of Samples	5	3
Science Data Returned (Gb)	5	1.5



DTE

3 samples and 1 trench, plus a contingency trench, required.

Reference Surface Scenario Framework



Capability of Key Timelines Studied

Metric	Science Mission Success (SMS)	Nominal Mission Case	Nominal + Contingency Case
L2 Mission Duration	[2 sols of Geophone]	6 sols	6 sols
Geo data collection duration	2 sols	6 sols	6 sols
Number of trenches attempted	1	1	3
Number of sample collection attempted	3	3	6
Number of sample analyses attempted	3	3	6
Data return	1.5 Gbits	1.8 Gbits @24 kbps	4.4 Gbits @24 kbps

Contingency examples:

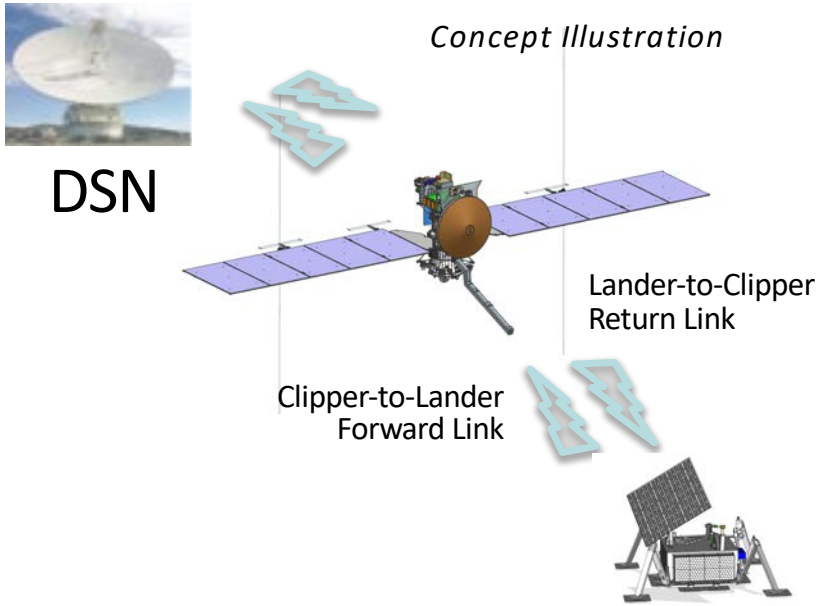
1.8 Gbits @10 kbps

3 failures, 3 successes

- Capability is added above that required for Science Mission Success, to cover contingency situations (e.g. degraded comm, sampling failures) and not for additional science

Concluding Remarks

- In addition, Lander would be compatible to relay with Clipper spacecraft if available at time of surface mission



While the design provides overall lower data return, a Direct-to-Earth communications would provide for a robust surface science mission

Questions?