SINPLEX - Small Integrated Navigator for PLanetary EXploration

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ADCSS 2012

SINPLEX

cosine measurement systems

TNO innovation for life

SystematIC design

ÅAC Microtec

DLR

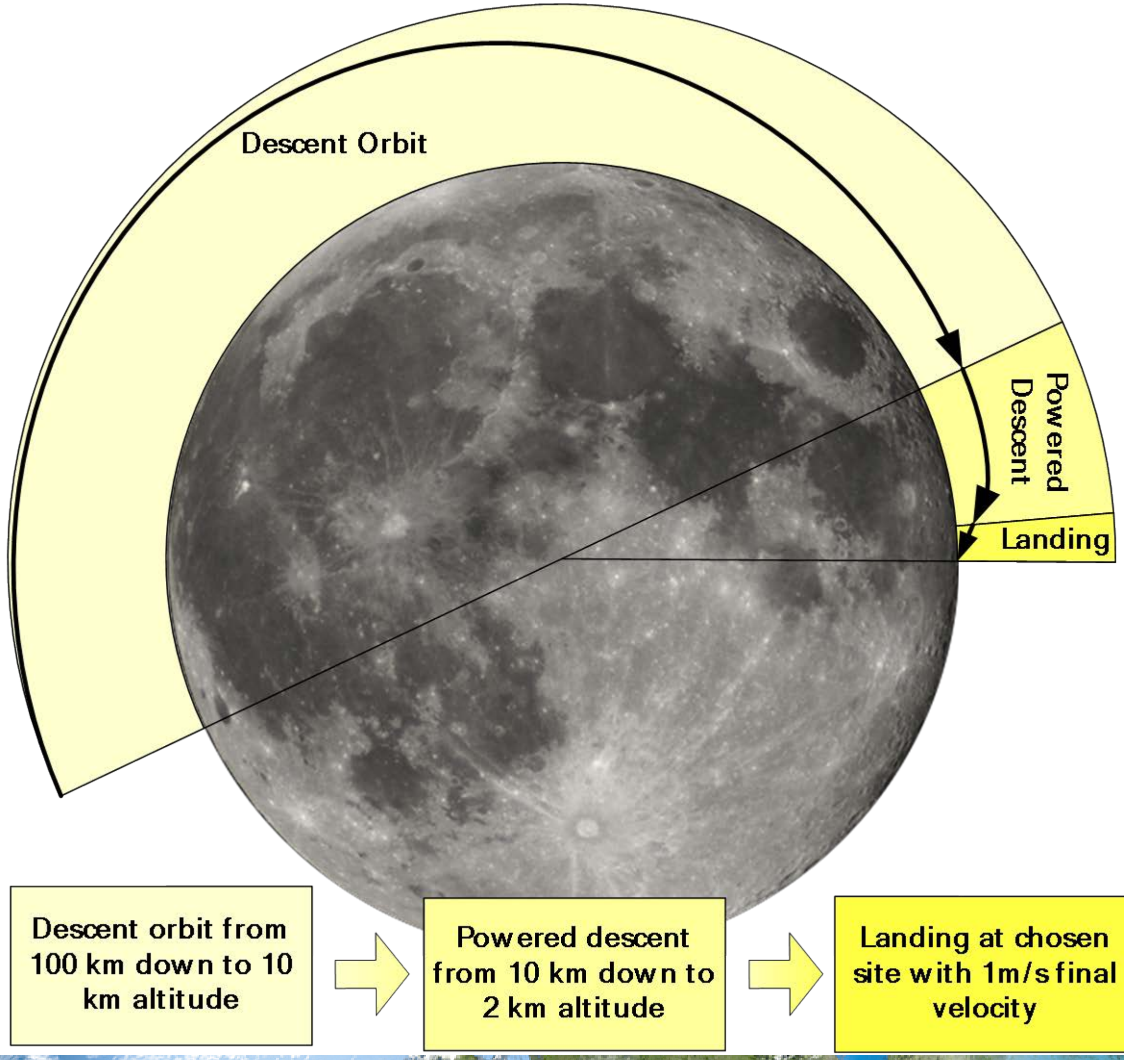
SINPLEX Project Description

- EC funded research and development project (FP7) – 2 years
- Future space exploration missions target asteroids, comets, planets and planetary moons.
- Mass is one of the most critical factors for launch cost, scientific return and mission capabilities
- Main goal is to develop an innovative, low mass navigation system for planetary exploration missions
- Mass is reduced through functional integration and electronics miniturization while still allowing good navigation performance
- Also use sensor hybridization approaches to improve the performance of the complete navigation subsystem.
- The project objectives are:
    - develop a navigation subsystem architecture
    - produce a breadboard system
    - demonstrate the system’s performance

Scenario 1: Moon Landing

- Based on ATON, ALHAT, VBRNAV, NEXT Lunar Lander

- 100m landing accuracy

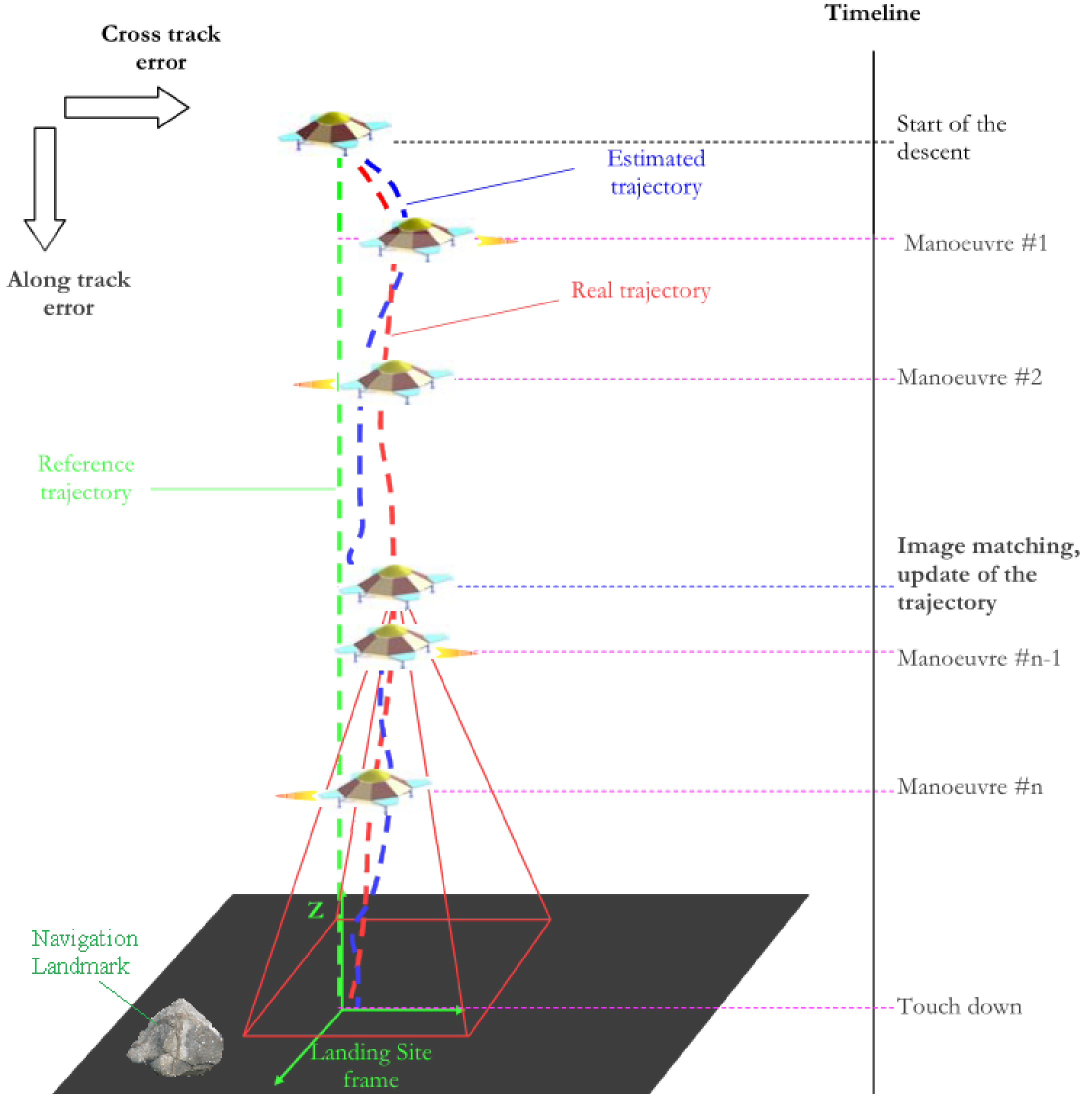


Scenario 2: Asteroid Landing

- Based on Marco Polo and Hayabusa

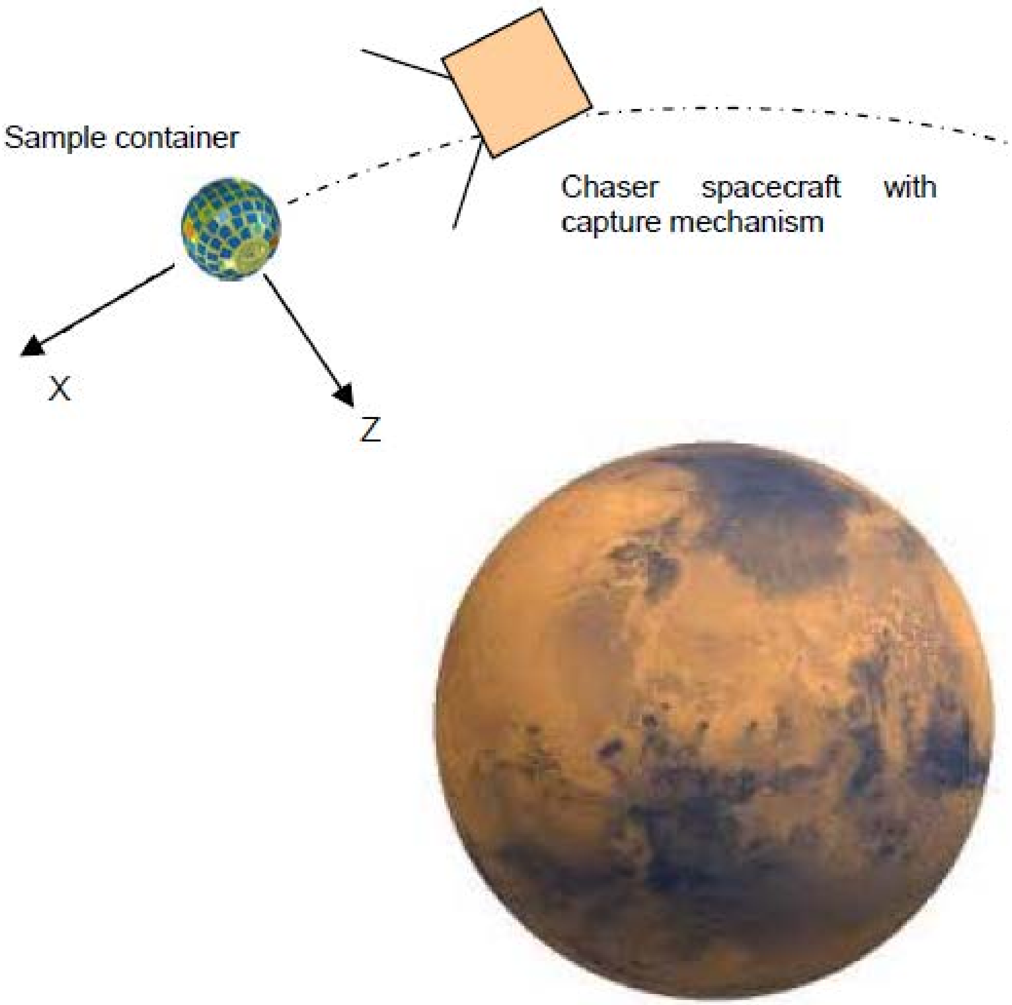
- 1km diameter asteroid

- 1m landing accuracy



Scenario 3: Sample Container Rendezvous

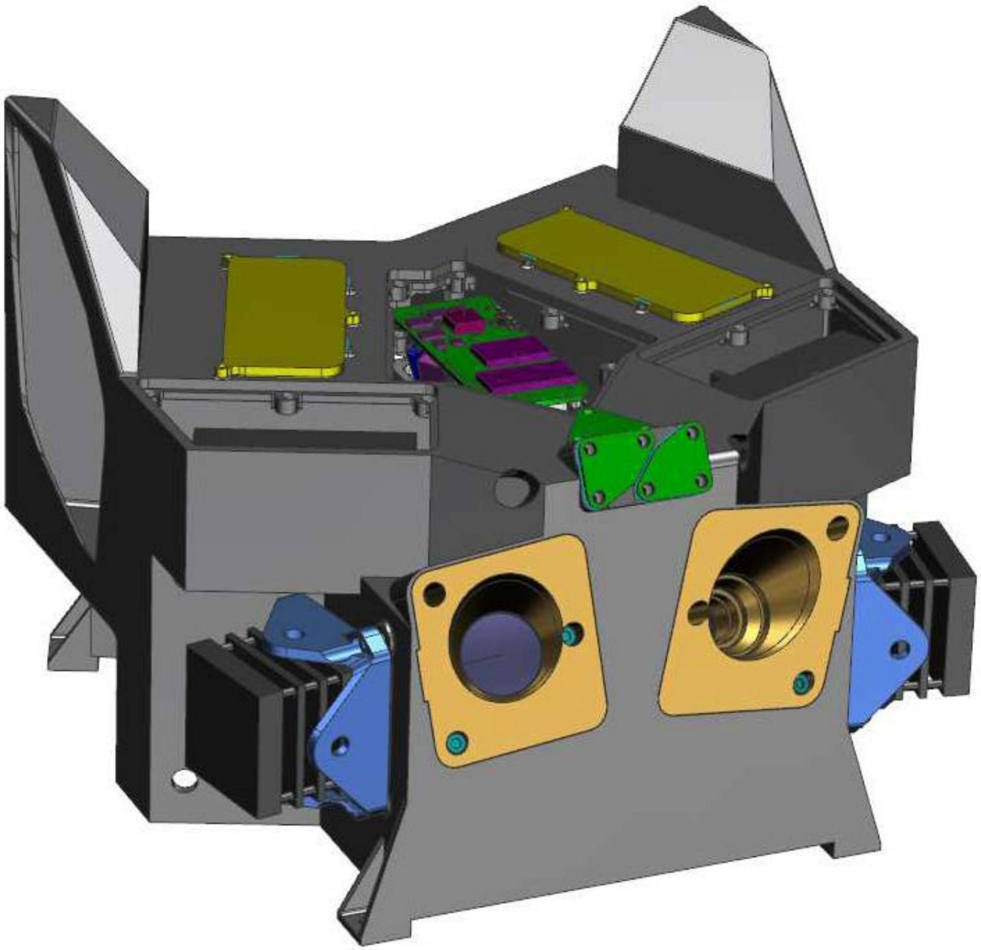
- Based on Mars Sample Return, FOSTERNAV, HARVD
- 20cm diameter container
- 10cm relative position accuracy



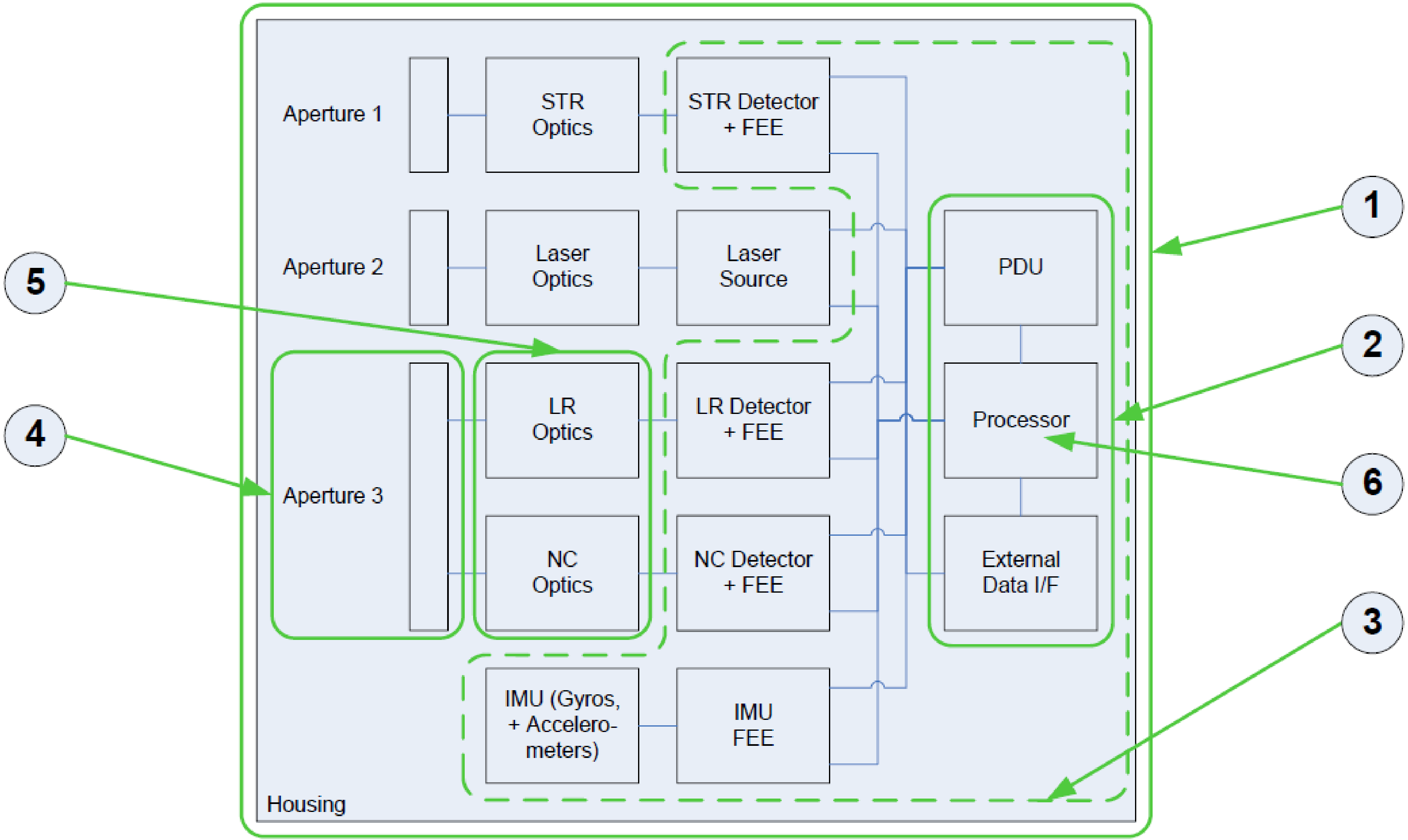
CDR Design

- Highly integrated system
- Fully redundant system includes:
  - 2x 4-axis IMUs
  - 2x Laser range finders
  - 2x Star tracker cameras and processing boards
  - 2x Navigation cameras and processing boards
  - 2x On board computers
  - 2x Power distribution

- < 5kg
- 170mm x 210mm x 200mm
- 42W (nominal)



Miniaturization Through Integration



IMU

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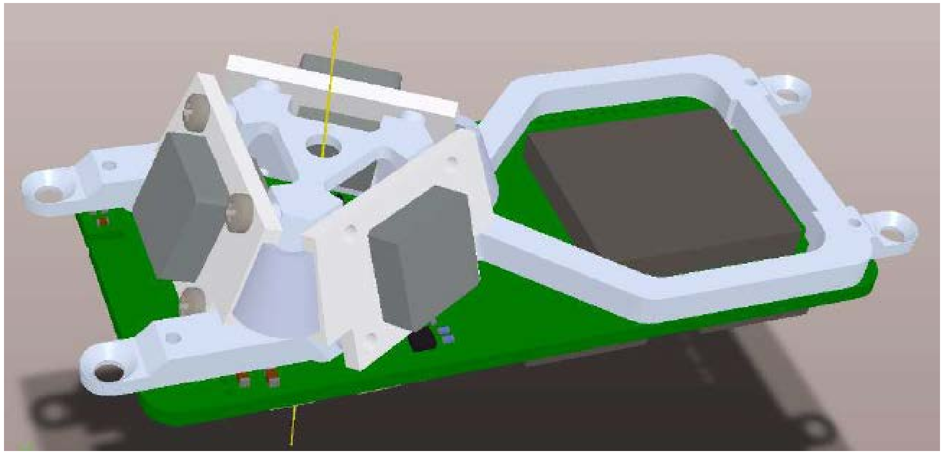
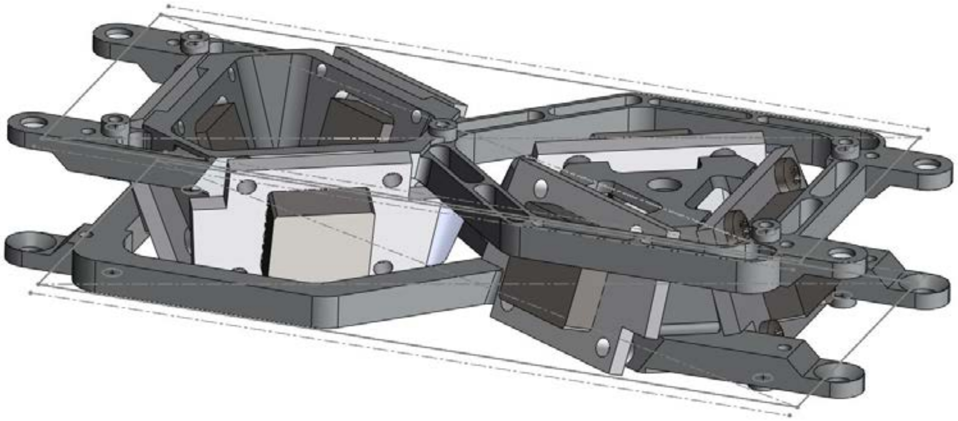


- COTS components:
  - 4x MEMS accelerometers
  - 4x MEMS gyros
  - ÅAC Microtec's µRTU

- Custom components:
  - Sensor interface
  - Mechanical structure
  - Software



Laser Transmitter

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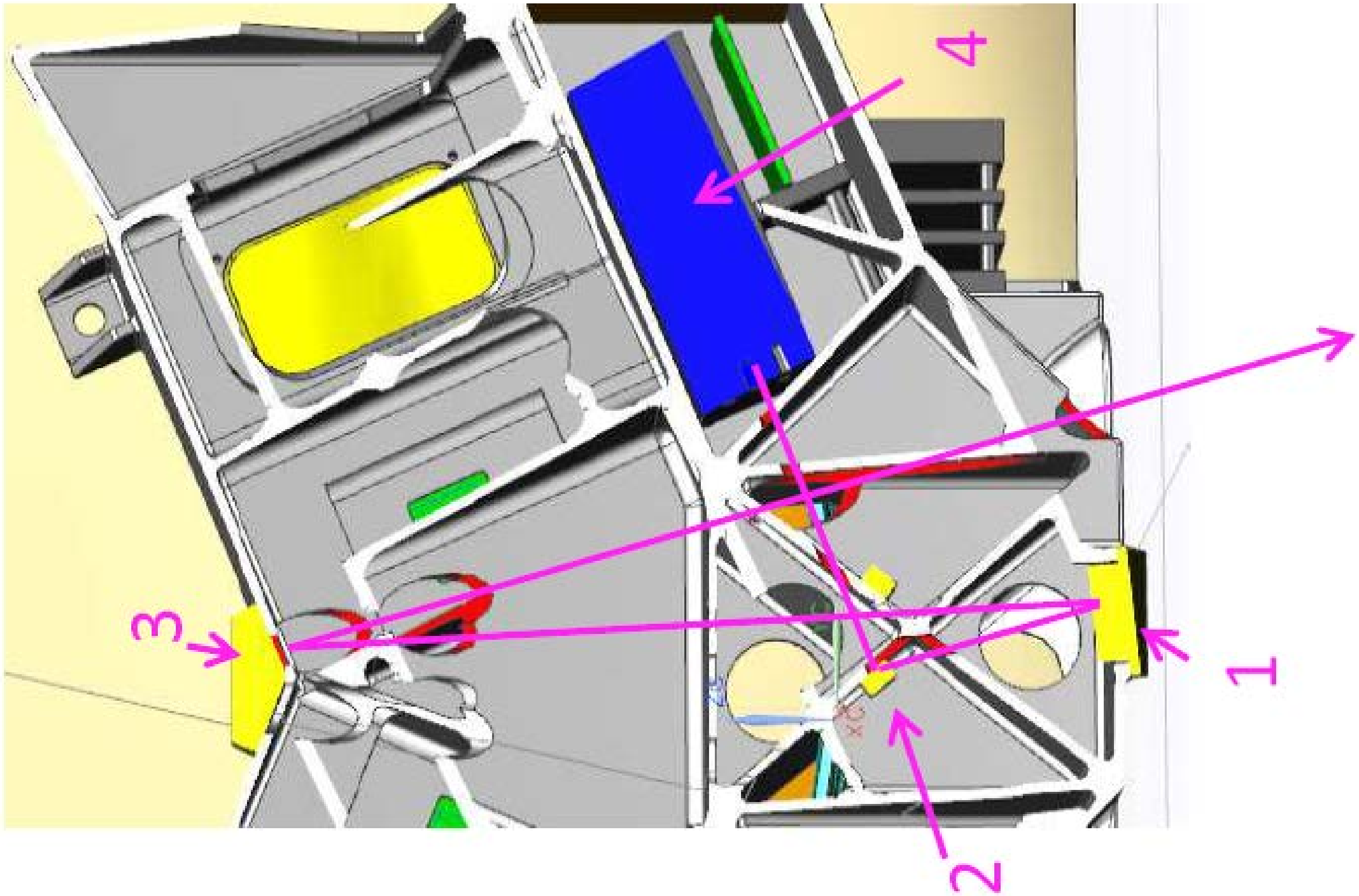

Navigation Camera/ Laser Receiver

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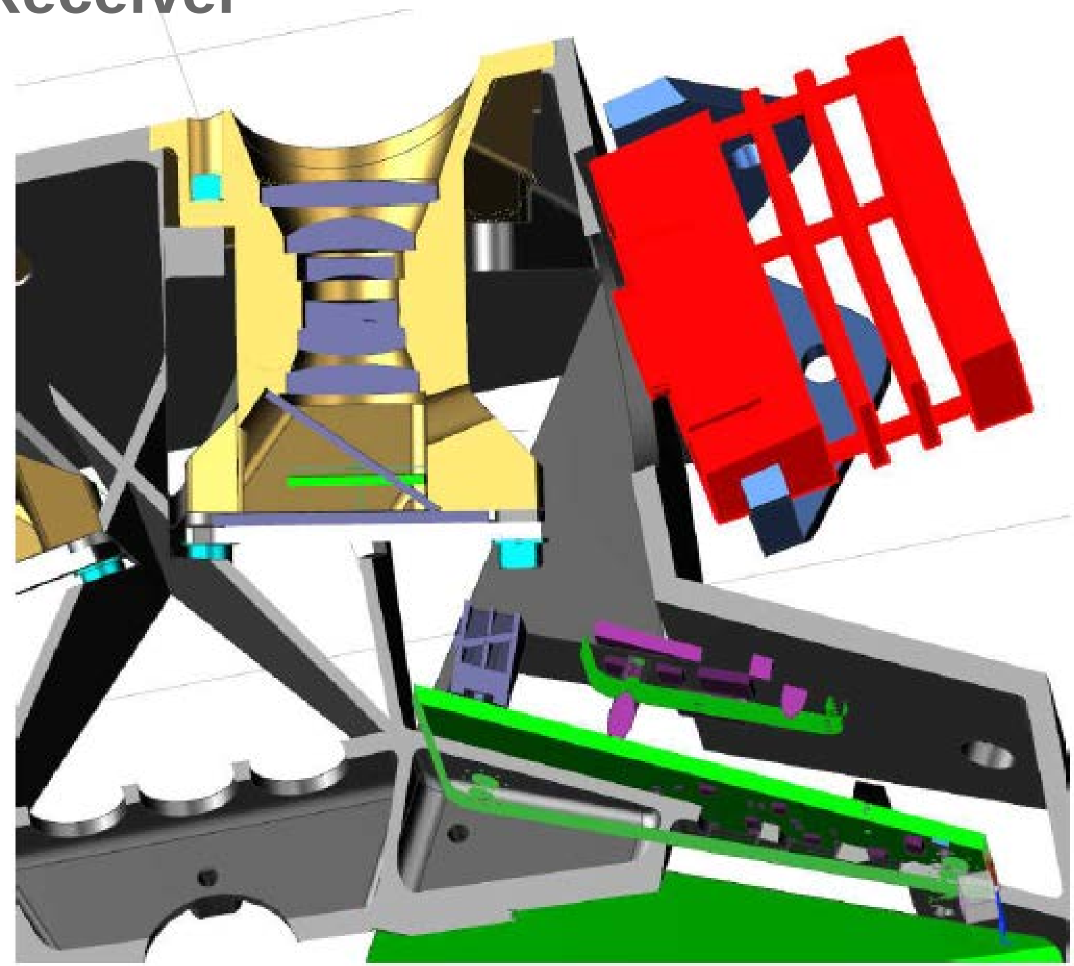

DLR

Star Tracker

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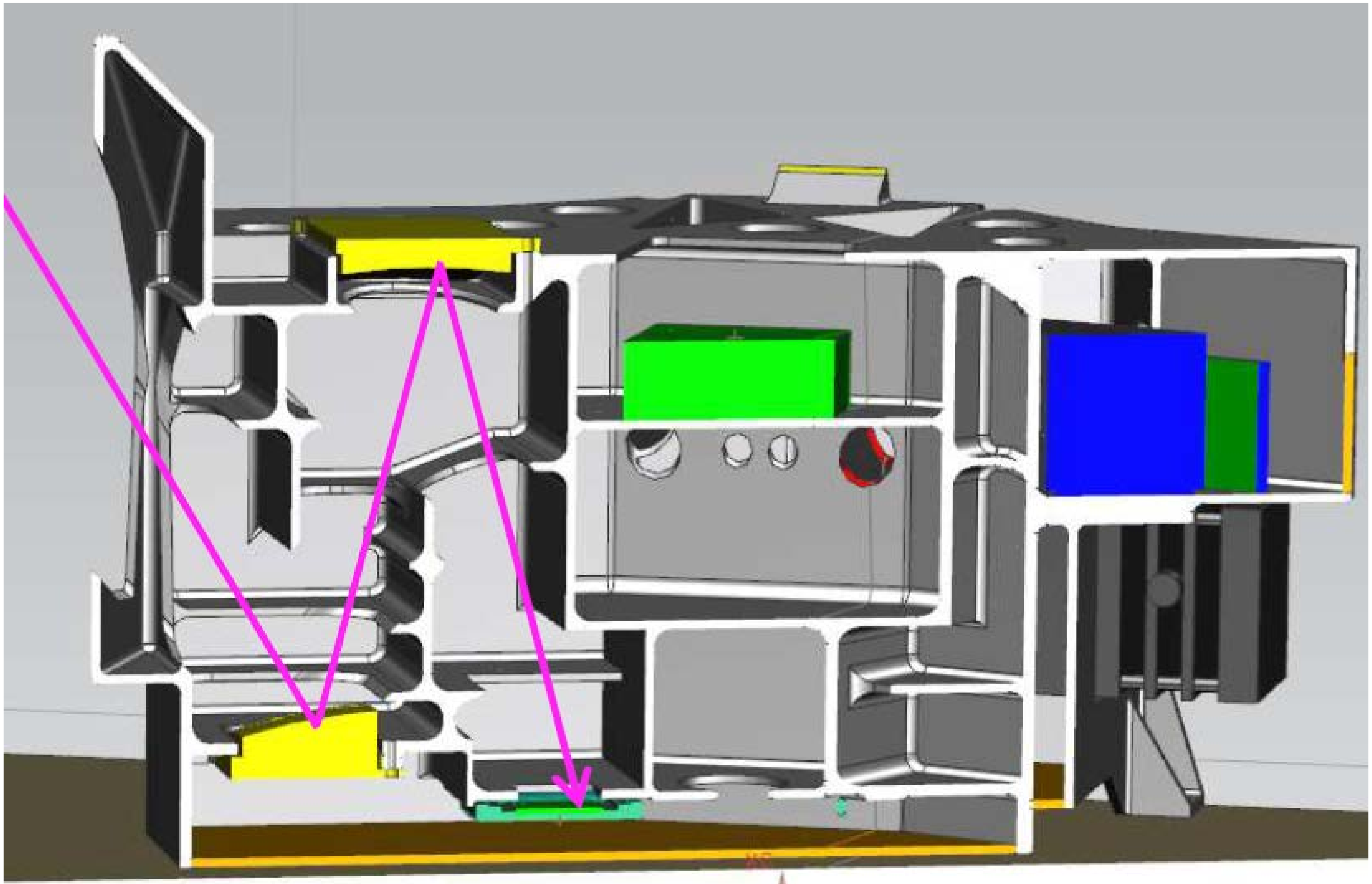
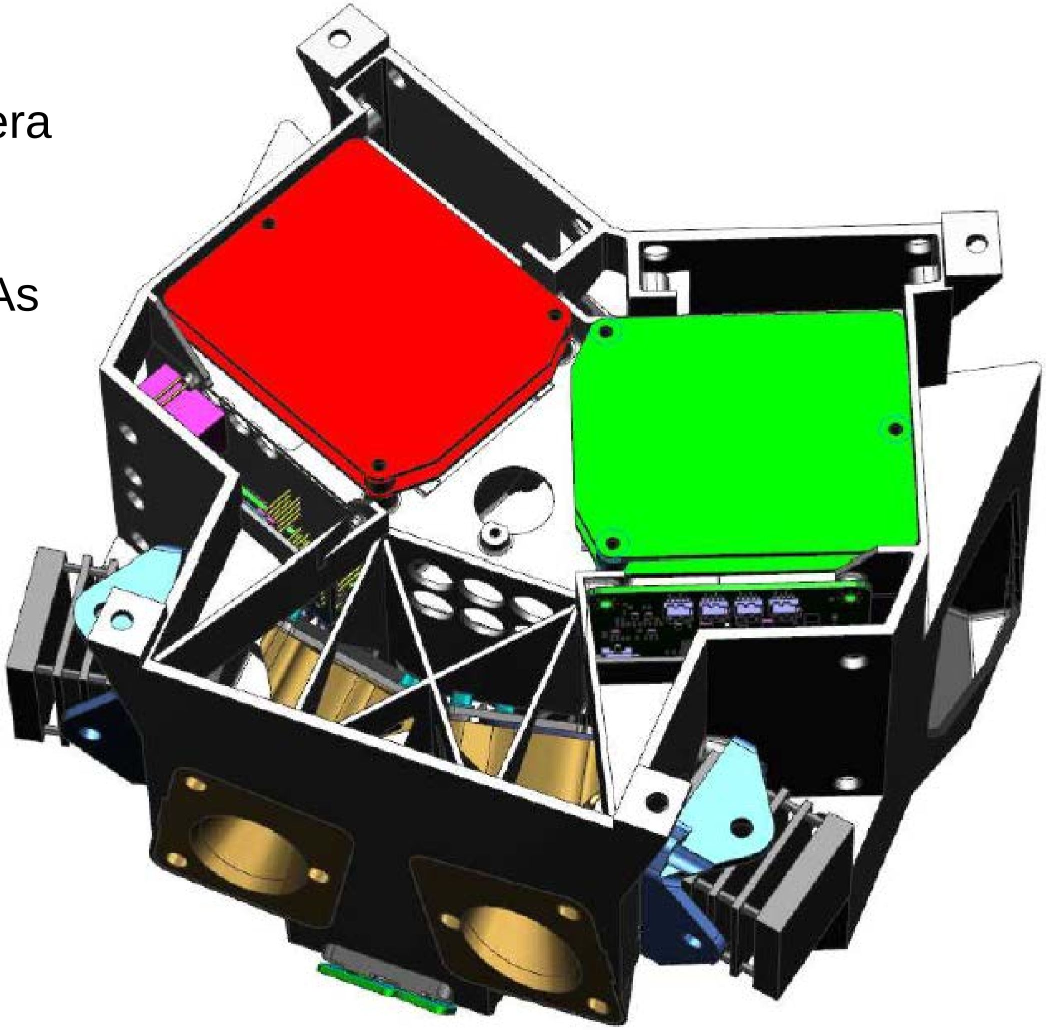


Camera Electronics

- Star tracker and nav. camera electronics
- Image processing w/ FPGAs
- Custom designed



On Board Computer

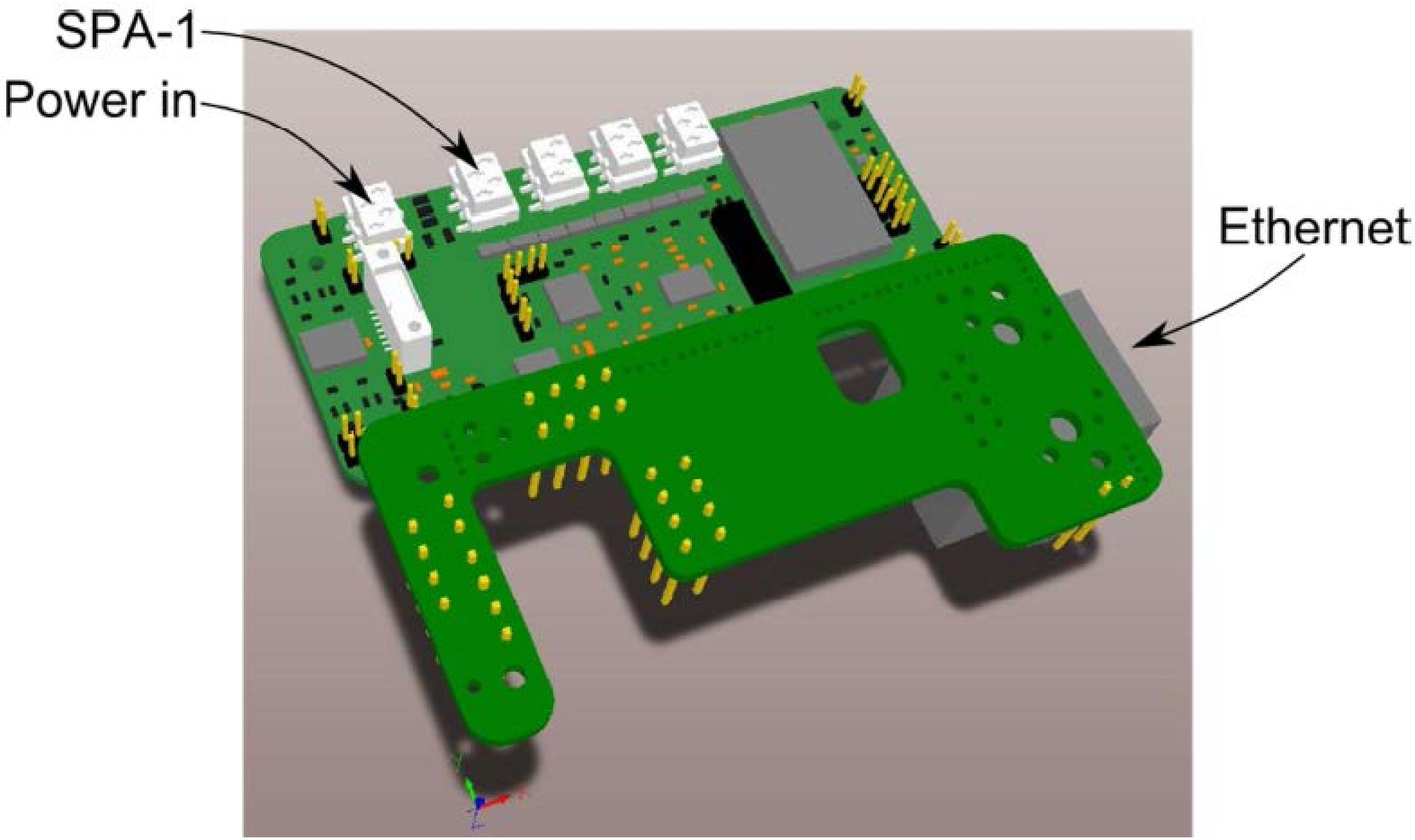
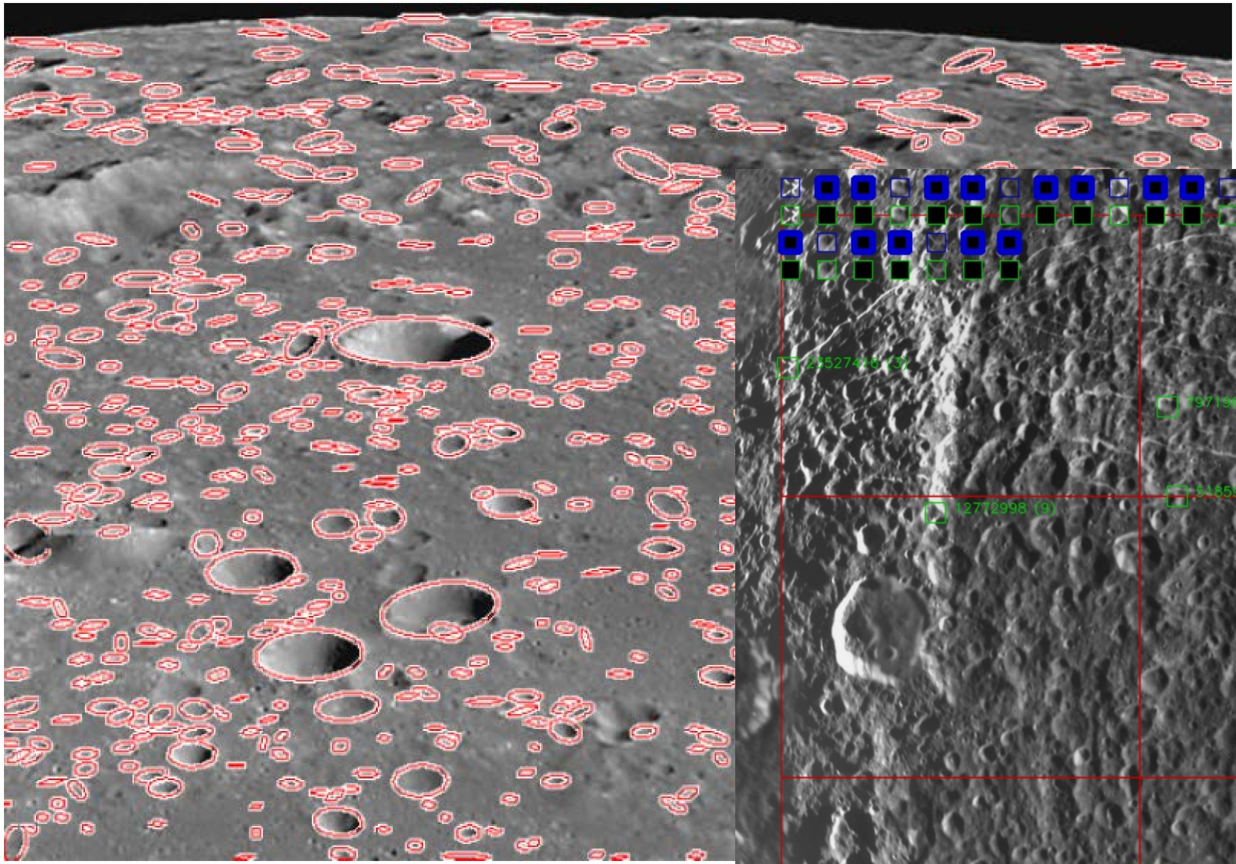
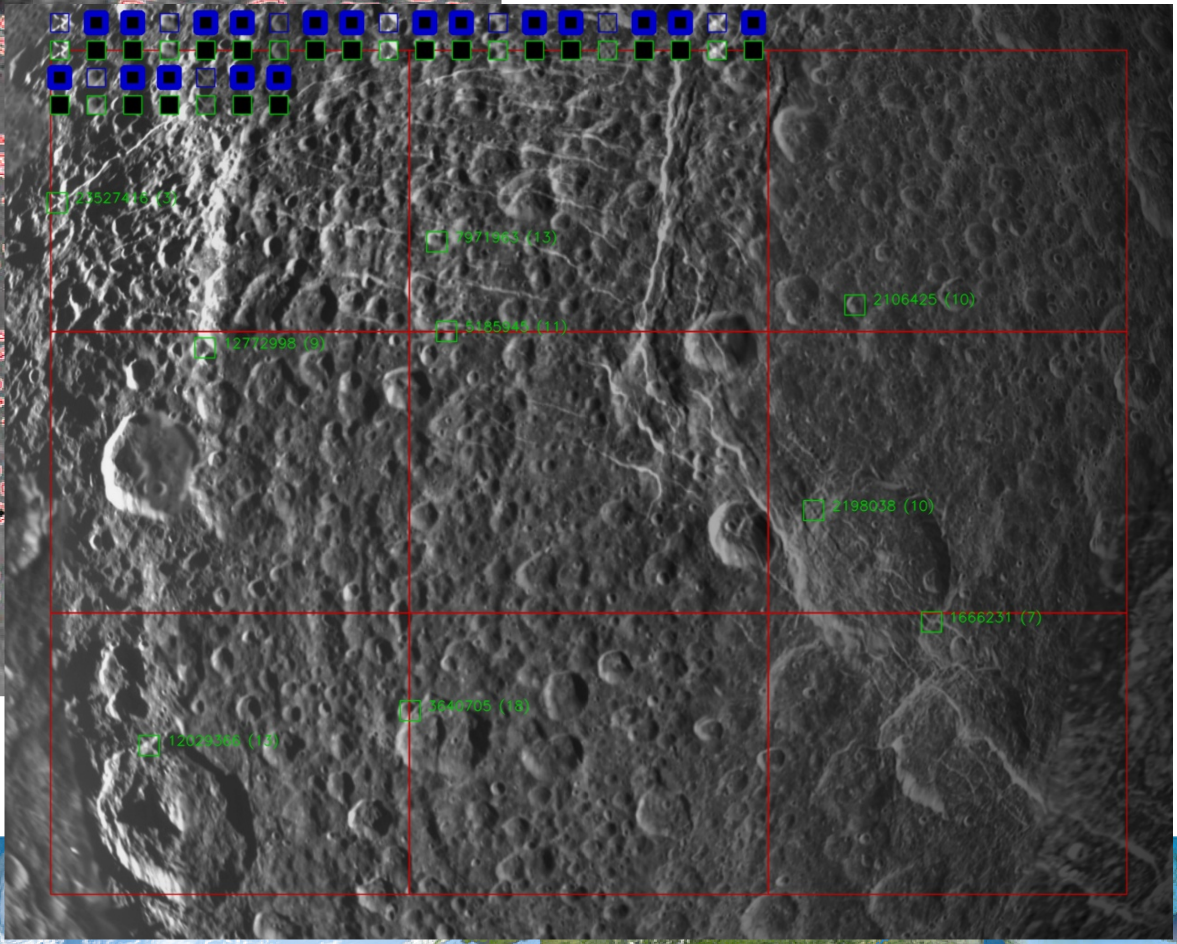


Image Processing

- Star tracker
- Crater navigation
- Feature tracking
- Container finding (2 methods)





Navigation Algorithms

- Sensor data fused on board in real-time.
    - Compensates for loss of sensor performance due to miniaturization

- Navigation software distributed over several subsystems:
    - IMU : accel. & gyro compensation, high-rate integration
    - Camera electronics : image processing
    - OBC : pos, vel, attitude integration, Kalman filter

- Navigation method depends on scenario phase:
    - Inertial
    - Terrain relative
    - Container relative

Comparison to Modular COTS System

State-of-the-art	Mass (g)
1x NPAL camera	1450
1x LN-200S IMU	800
1x NEAR laser ranger	3000
1x Automous Star Tracker A-STR	3000
1x OBC695	1500
Total	9750

SINPLEX (preliminary)	Mass (g)
Housing + optics	1500
2x IMUs	150
2x Laser transmitter + receiver	1800
4x Camera electronics	500
2x OBC	150
2x PDCU	100
Total	4200

Benefits/Drawbacks of Integration

- Main technology development is integration of components

- Pros/Cons are the same as the integrated vs modular debate

- Benefits of integrated system:
    - Small, low mass, low power
    - Tuned to specific types of missions

- Drawbacks:
    - Hard to make changes
    - Less flexible
    - Higher development costs

- However, interplanetary S/C are already one-of-a-kind integrated systems. SINPLEX fits into this methodology.

SINPLEX Roadmap

- Just had CDR for breadboard system
- System components to be fabricated by March 2013
- Integrated & calibrated breadboard system ready by June 2013
- Hardware-in-the-loop testing, system performance verification until end of 2013
- Bring breadboard system to TRL 4
- Plan to develop the technology further via another EC project