ESA Off World Living Project: Navigation and Communication System Design

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Over twenty years experience in:

• Flight Dynamics
• Orbit modelling
• Orbit prediction and determination
• Sensor modelling
• Planetary reference frame definition and modelling
• Extensive flight and mission heritage
• Definition of national and international standards
Designing a navigation system for manned and robotic missions to Mars
European Space Agency project

• Why build a navigation system?
• Design the space segment (spacecraft instruments, orbit configuration)
• Design the surface-based system components
• Simulate and test system performance at three landing sites
Space segment design

Satellite ground track

5° mask angle zone

Beacon location

Inclined orbit

Polar orbit

Equatorial orbit

Equatorial orbit

Sinus Meridiani

Eos Chasma

Holden Crater
Truth models

Mission Scenarios

Terrain models

Intervisibility

Kalman Filters

State vectors

Observable formation

Sensor models

Clocks and oscillators
Ranging (UWB, WiMax)
Accelerometers
Gyros
Odometers

‘True’ biases
‘Estimated’ biases

‘True’ PVT errors

Accuracy

Integrity

Uncertainty estimates

Continuity

Availability

PVT estimates

PVT Uncertainty estimates

Mission Scenarios

- Spacecraft
- Astronauts
- Surface vehicles
- Robotic probes

Trajectories

- Position (t)
- Velocity (t)
- Acceleration (t)
- Jerk (t)

Truth models

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- ‘Estimated’ biases

‘True’ PVT errors

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PVT Uncertainty estimates

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Continuity

Availability

Mission Scenarios

Navigation and positioning simulator design
Holden Crater Mission Traverses

- Pressurised rover vehicles with two astronauts
- All missions are ‘over the horizon’
- Each traverse may take several days
Ranging coverage signal degradation

Scenario 1
One 25W transmitter at base

Scenario 2
Two 25W transmitters at base
Two 10W transmitters en route

Scenario 3
Two 25W transmitters at base
Ten 10W transmitters en route
Example of results and visualisation

Sample simulation results: four beacons, one way ranging, clock resets on orbiter pass
Conclusions

- Experienced group at UCL
- System design for planetary navigation
- Space segment
- Surface assets
- Practical experience in real world missions
- Greatly looking forward to working with you all