Implementation option for Sensor Suite and Video Navigation for a Rendezvous with noncooperative tumbling targets

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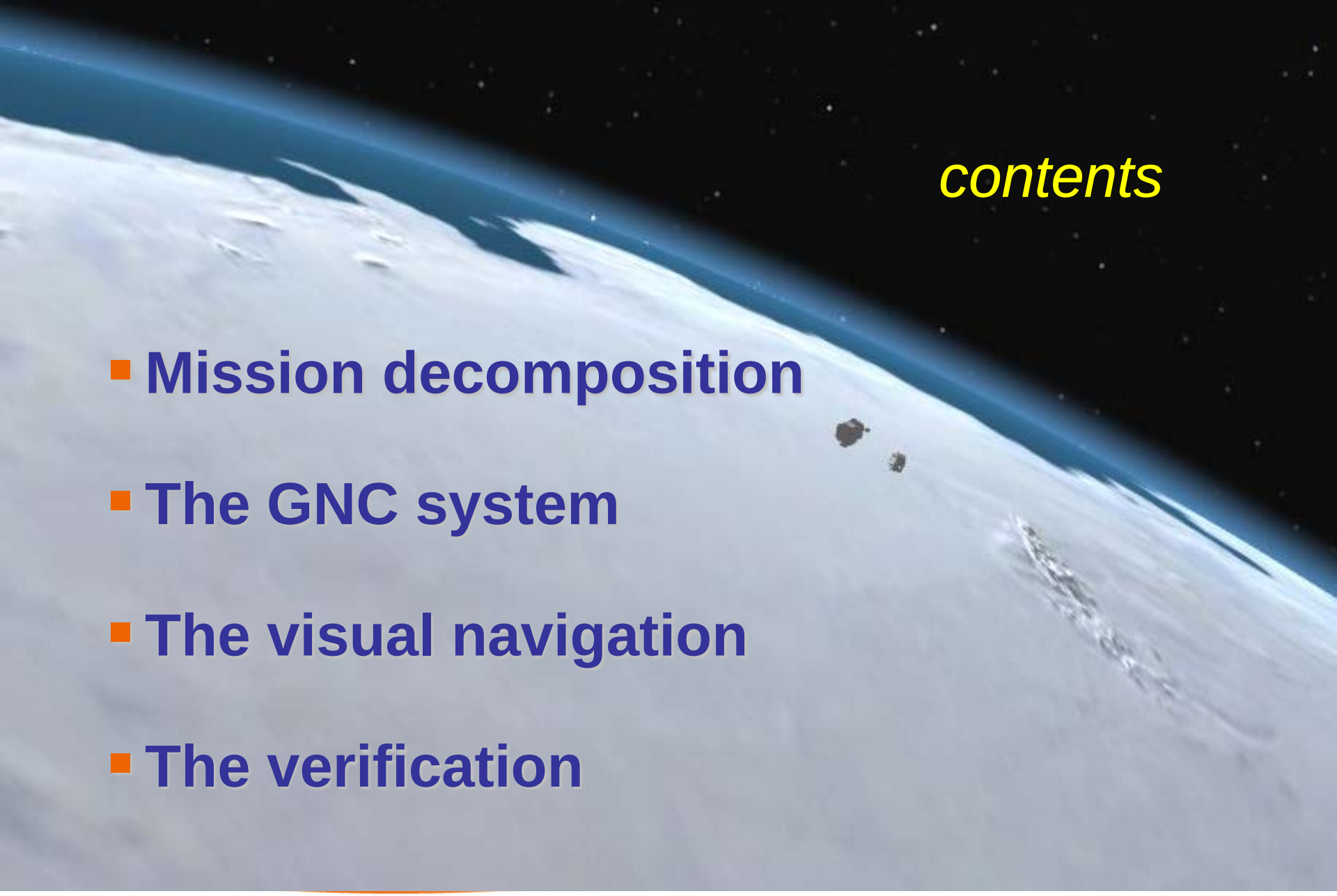

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- **The GNC system**
- **The visual navigation**
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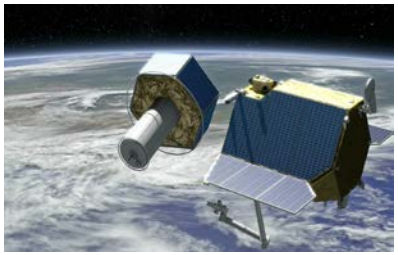
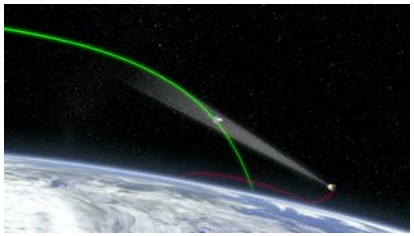
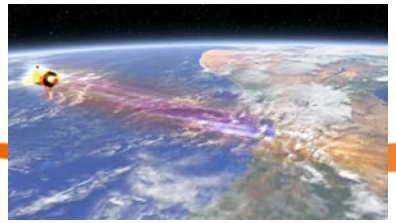
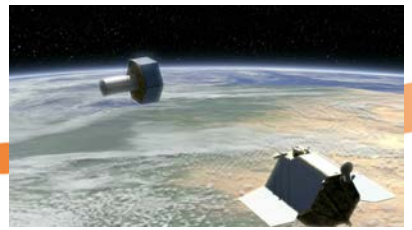
The reference mission

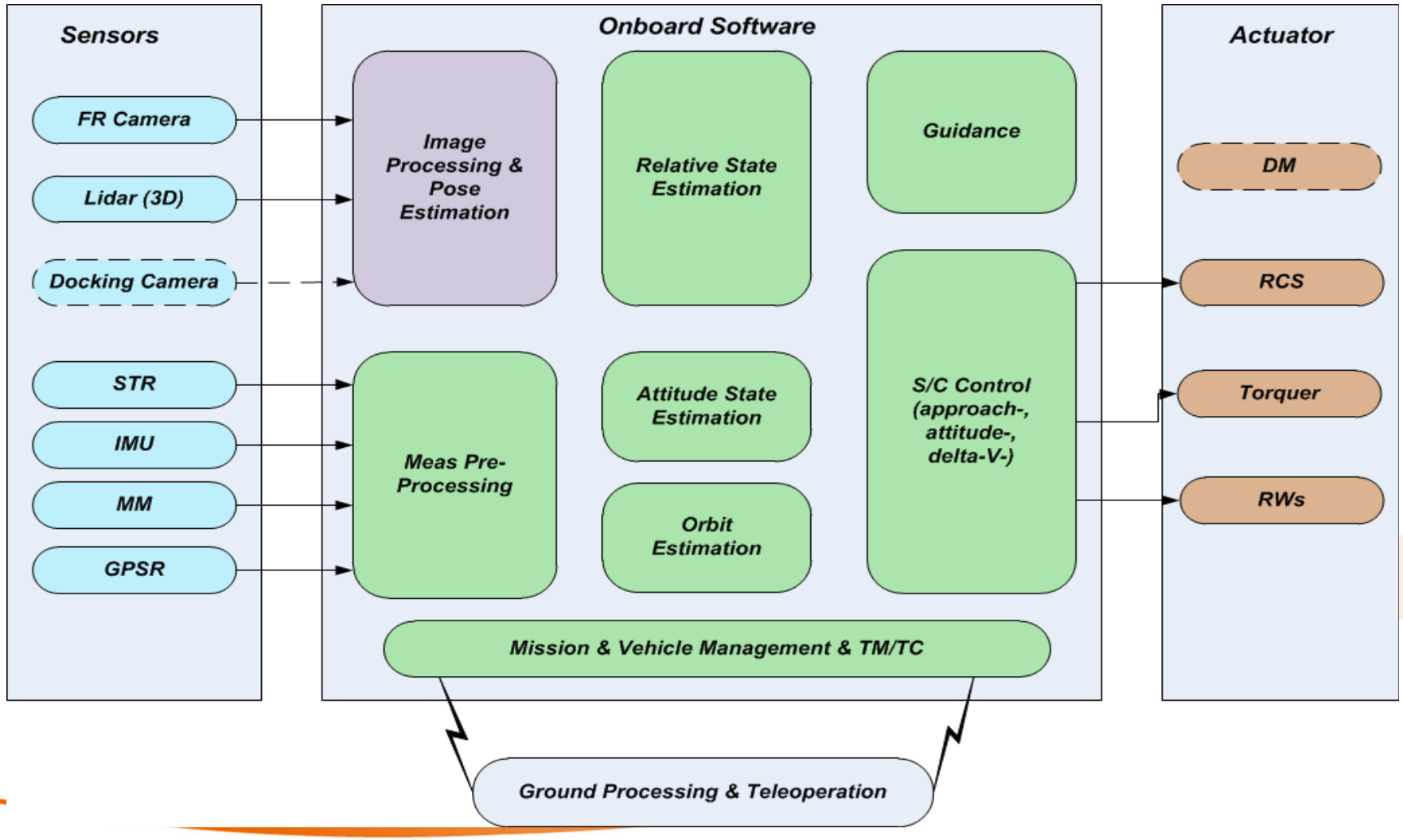






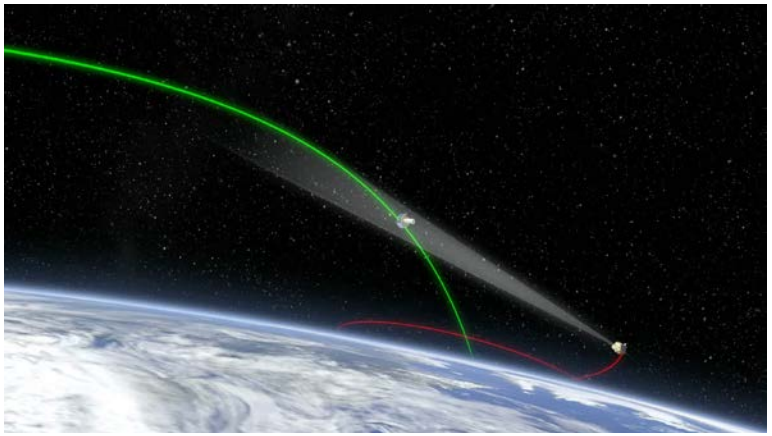


The reference system



Vision Based Navigation (VBN)

Sensor Needs



- Far-Range:
  - If autonomous rendezvous is envisaged, relative measurement shall become available at distances > 10km

→ this allows an approach w.o. dedicated target tracking campaign from ground, applying NORAD TLE

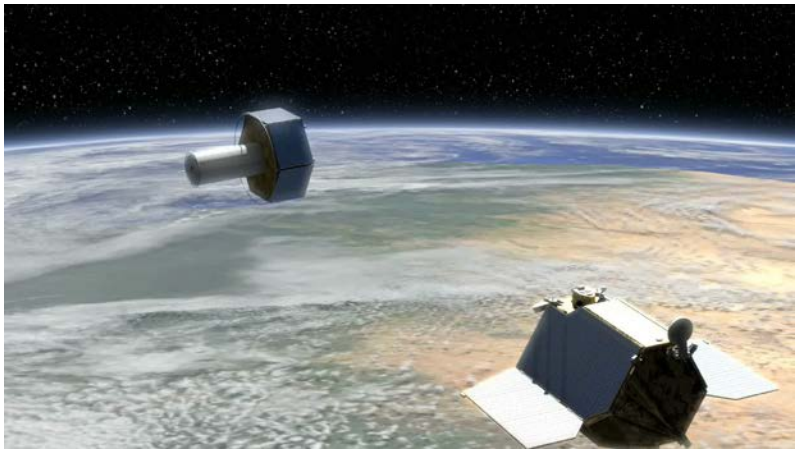
  - Due to low maneuver activity measurement gaps are acceptable (propagation mode)

- Mid-Range:

  Continuous position measurements (at least range and LoS) should be available for relative state (position and velocity) estimation

VBN – Sensor Needs

- Close-Range:
  - In close range the target geometry and the target motion has significant impact on measurements



➔ for the determination of the relative state vector the ***target geometry and the target attitude*** needs to be known
➔ full 6D-pose-estimation and tumbling motion estimation
➔ 3D measurement information is needed
➔ a large FoV is needed
➔ complex onboard processing of 3D information in real time

VBN – Diff. Technologies for Diff. Ranges

- Far-Range:
  - Long Range Radar Systems are not yet available and would have high power and mass demands
  - Stereo camera needs large baseline and strong alignment requirements
  - Range measurement is not mandatory for state estimation

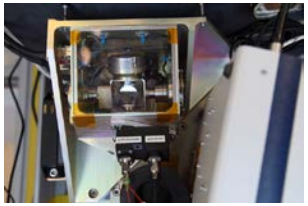
  ➔ Infrared sensor are of low resolution

  ➔ monocular monochromatic camera as LOS-only sensor

- Mid Range
  - camera (mono or stereo): Lightwight, but needs external illumination (large gaps in case of sun illumination or high power with artifical illumination).
  - Lidar is the preferred solution(scanning with variable FoV)

VBN – Diff. Technologies for Diff. Ranges

- Close-Range:
  - 3D information can be retrieved from stereo cameras, Lidar or imaging radar. The latter is very demanding in power and mass.

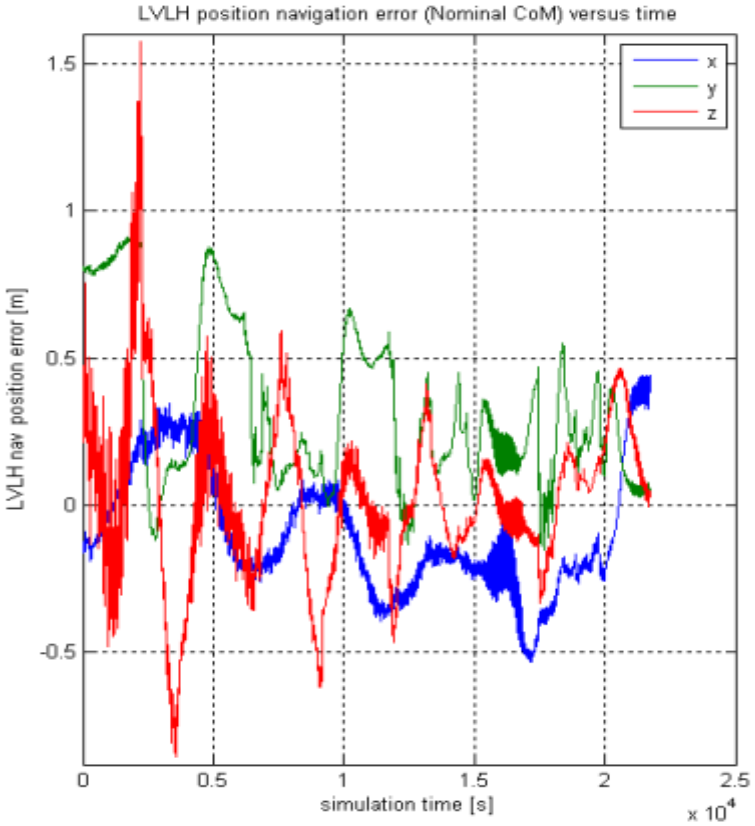


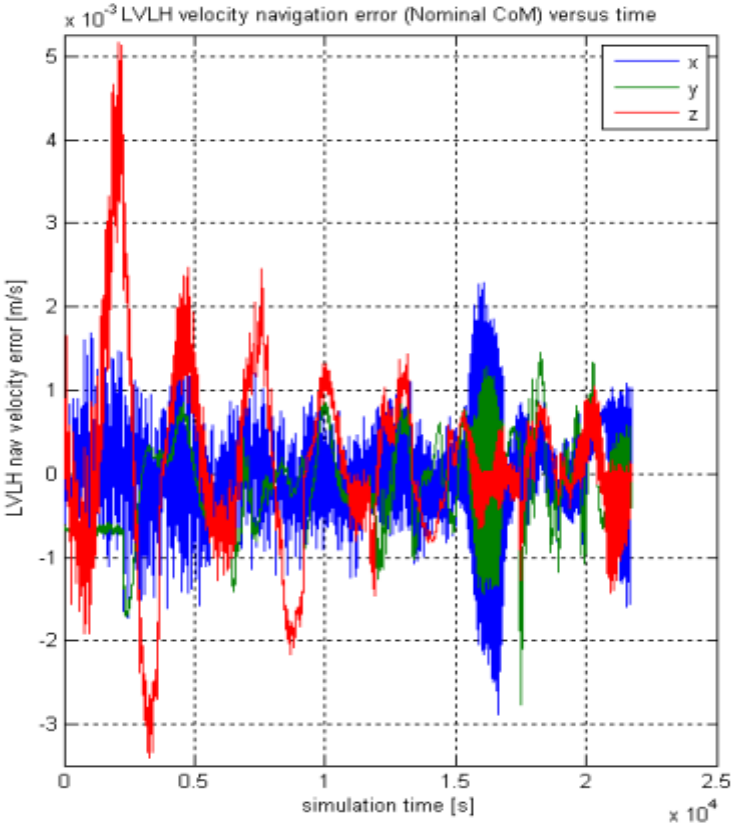
  - stereo camera are light and artificial illumination can be performed with reasonable power demand in close range. Very interesting are PMD cameras in this context.

  - due to the large FoV (40deg) the scanning lidar is also applicable for close range distances

VBN – mid range

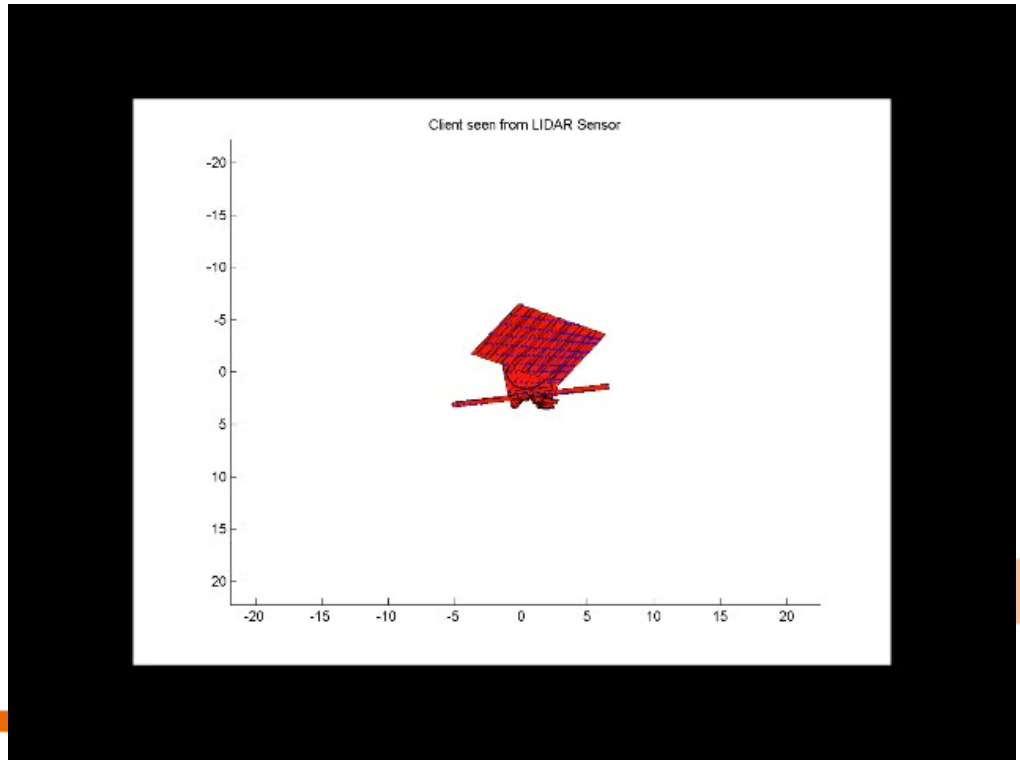
- Lidar range and LOS measurements





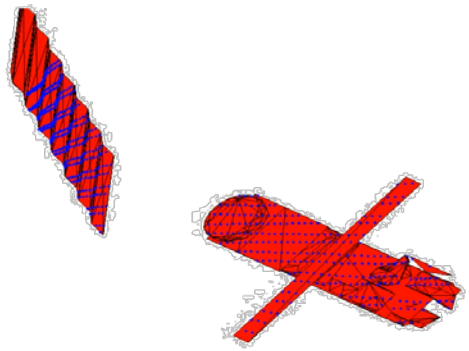
VBN – close range navigation

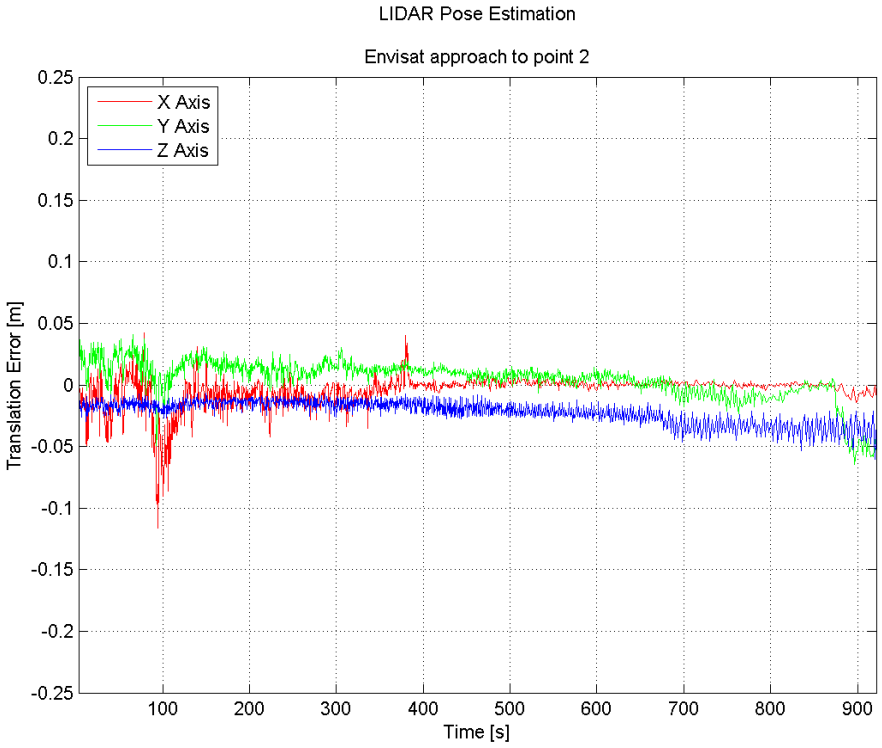
- Based on raw measurements from a 3D-LIDAR
  - LIDAR provides dense 3D point cloud
  - Model-knowledge of target object used for initial coarse pose-estimation followed by pose-refinement and tracking

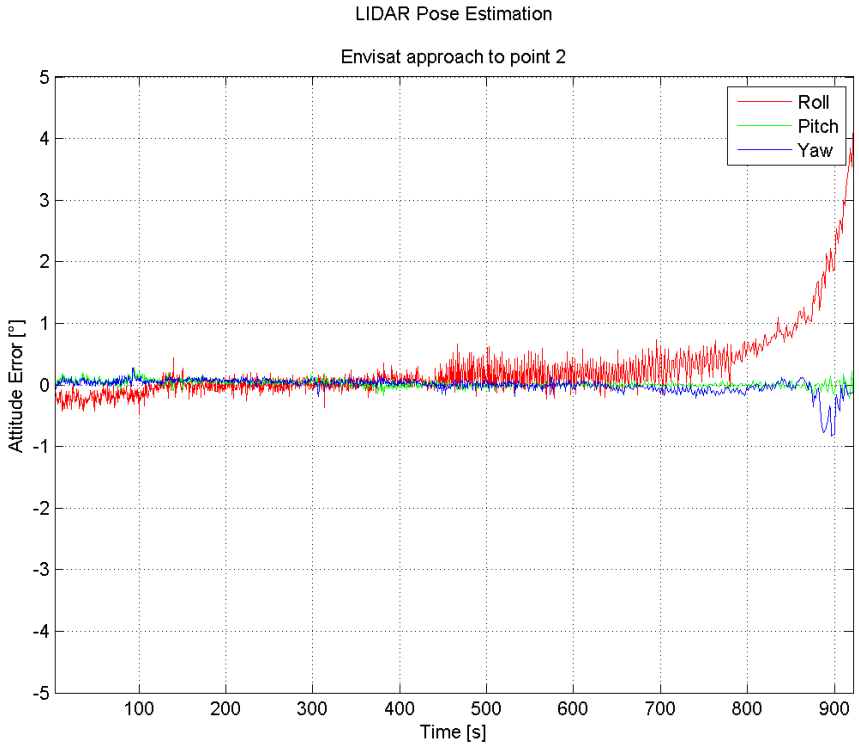


VBN – close range navigation

Simulation results of an application to ENVISAT approach trajectory.

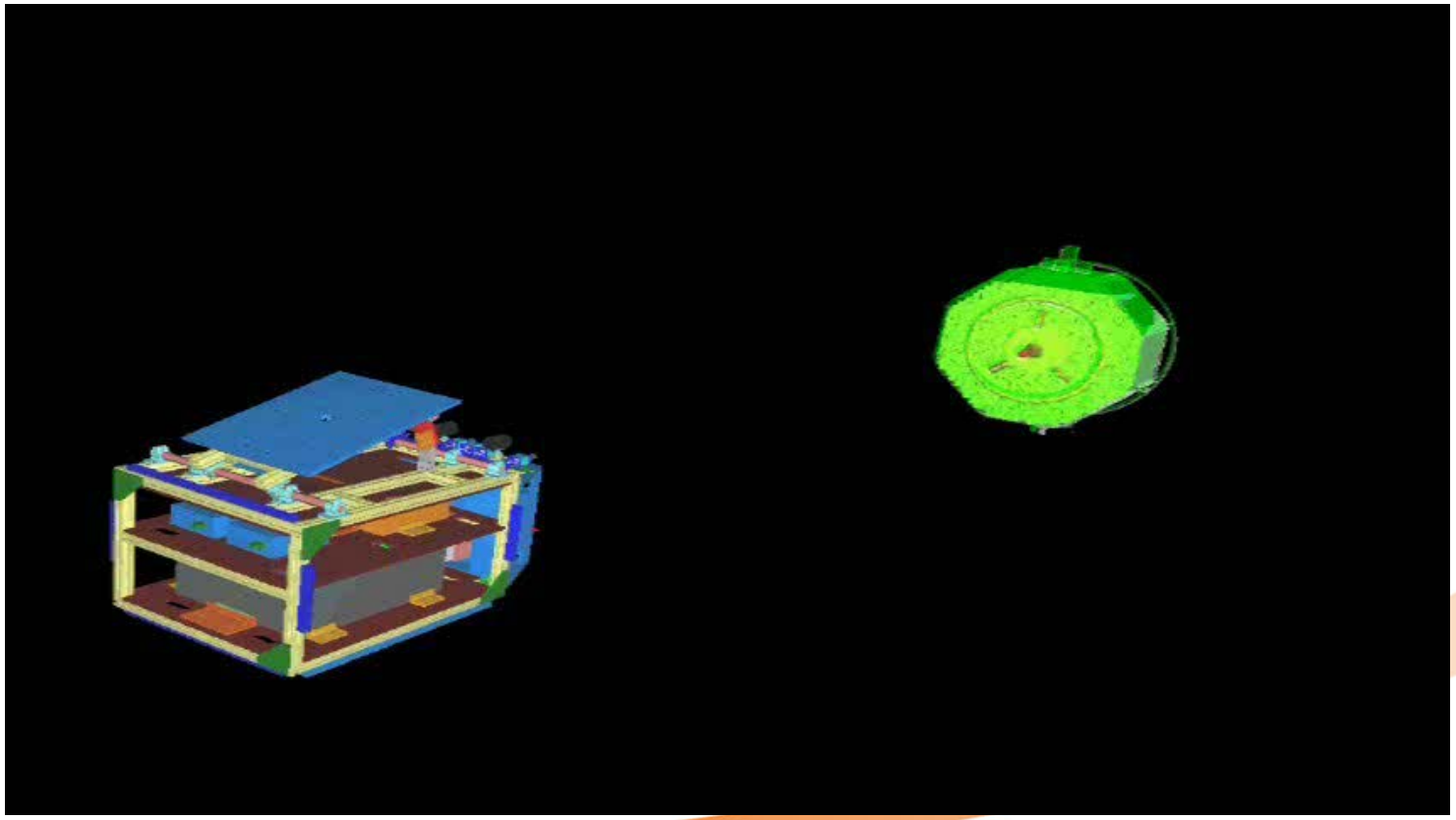






VBN – verification

Sensors and image processing have been tested in simulation …



VBN – verification

… and in real lab environments.