Imaging Sensor Emulation and Dynamics Simulation for PIL/HIL
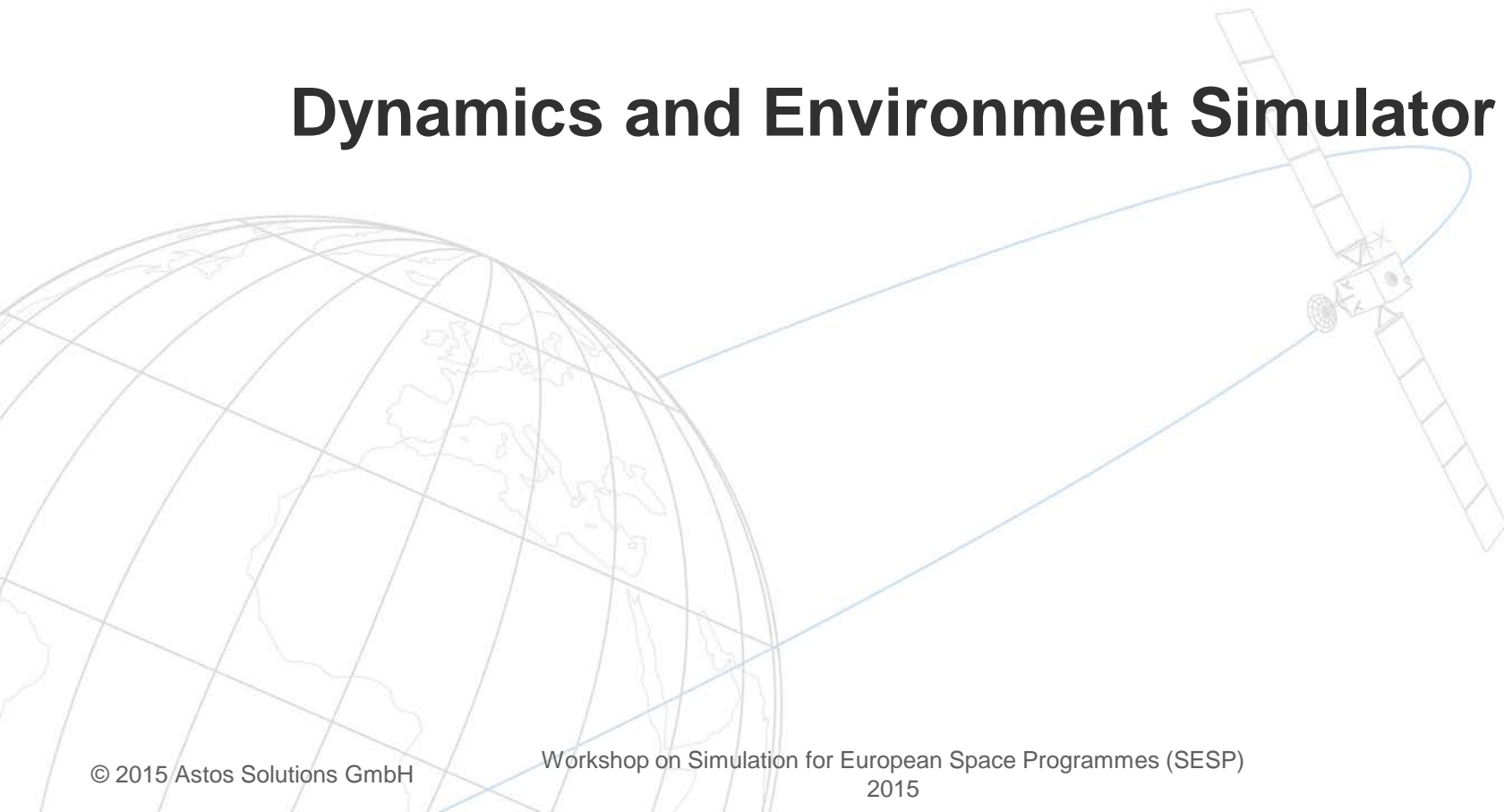
Introduction

- Latest developments in computer hardware leads to new approaches in software verification facilities

- Astos Solutions offers two simulators
  - Highly configurable dynamics and environment simulator
  - Real-time LIDAR and camera simulator

- No special hardware required

- Low cost approach

Dynamics and Environment Simulator
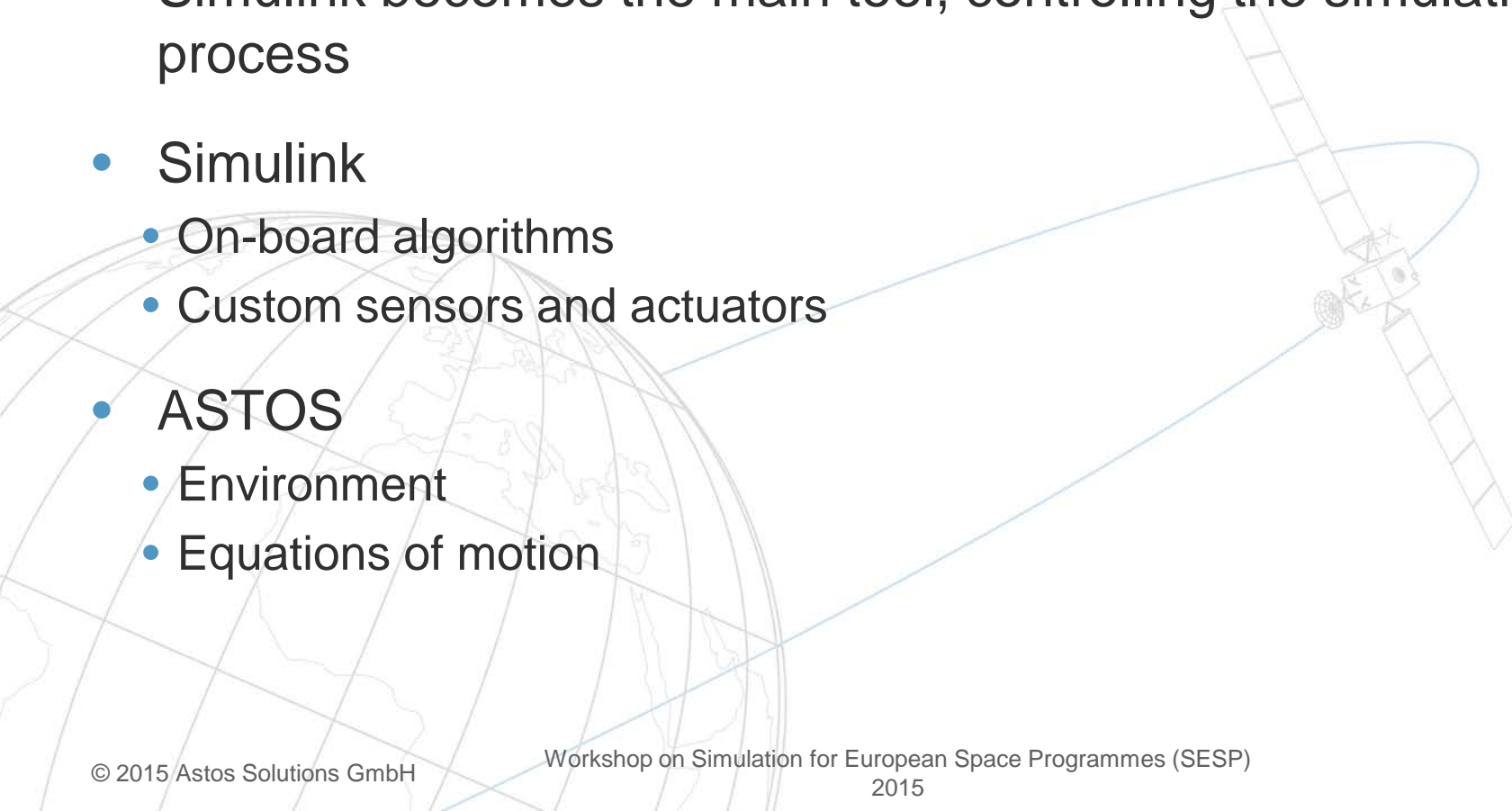
Dynamics and Environment Simulator

- The dynamics and environment simulator is based on the ASTOS software

- ASTOS was originally developed to optimize spacecraft trajectories

- During the past years, ASTOS evolved to a universal analysis tool for space missions

- ASTOS is designed as a closed self-standing tool, including a graphical user interface (GUI)

Dynamics and Environment Simulator

- The standalone version of ASTOS is designed as an open-loop simulation software

- A huge library of equipment and environment models is provided by ASTOS

- ASTOS provides simple control algorithms

- ASTOS is able to perform state integration using various integrators

- New interface in order to integrate ASTOS PIL/HIL simulations

Dynamics and Environment Simulator

- In closed loop simulations, ASTOS is linked to MATLAB/Simulink models

- Simulink becomes the main tool, controlling the simulation process

- Simulink
  - On-board algorithms
  - Custom sensors and actuators

- ASTOS
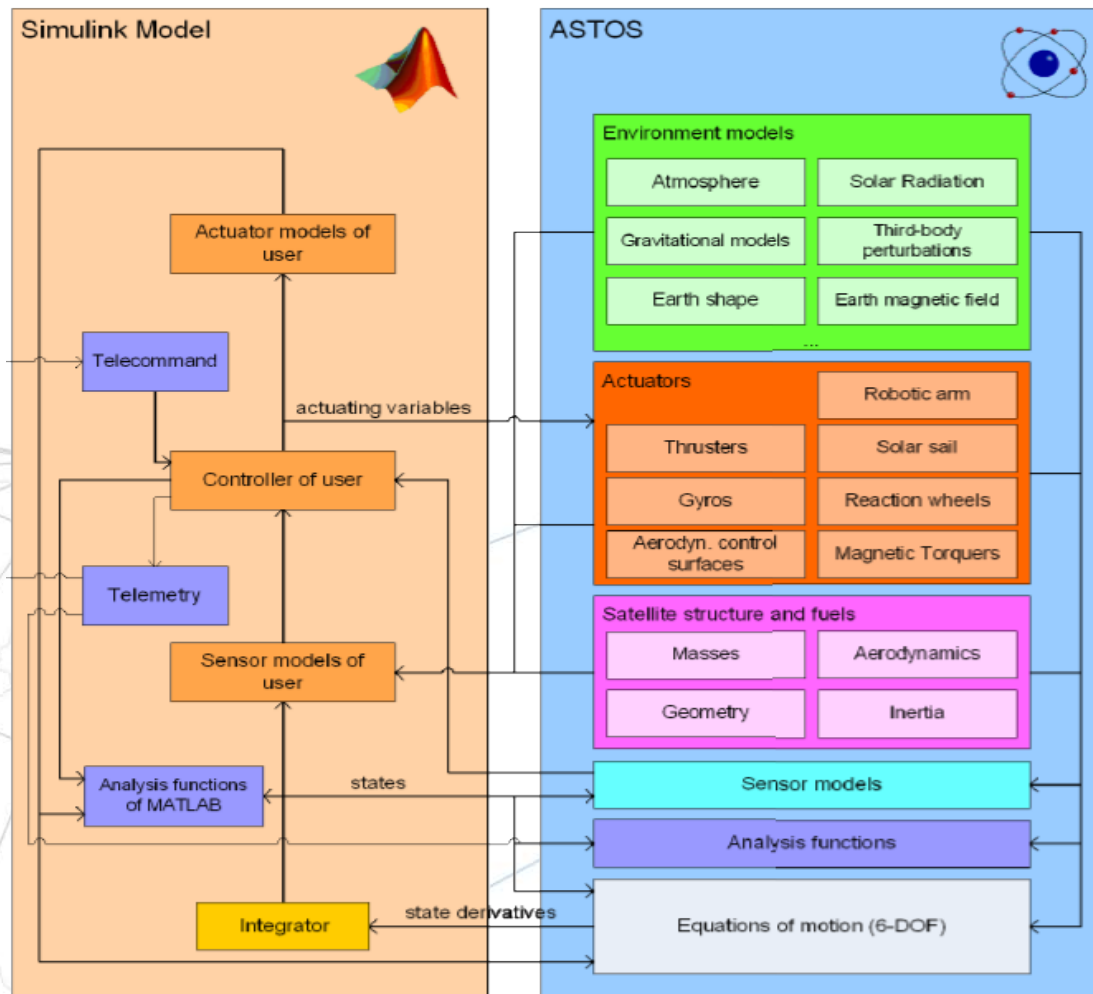 - Environment
  - Equations of motion

Dynamics and Environment Simulator

- The simulator comes with a MATLAB toolbox comprising standard models for sensors and actuators

- The toolbox contains control algorithm blocks, e.g. spin control

- Several utility blocks are available
  - Coordinate transformations
  - Interface blocks for a telecommand/telemetry console
  - Simulation console used for simulating system errors

- All analysis and plotting functions of the ASTOS standalone version can still be accessed
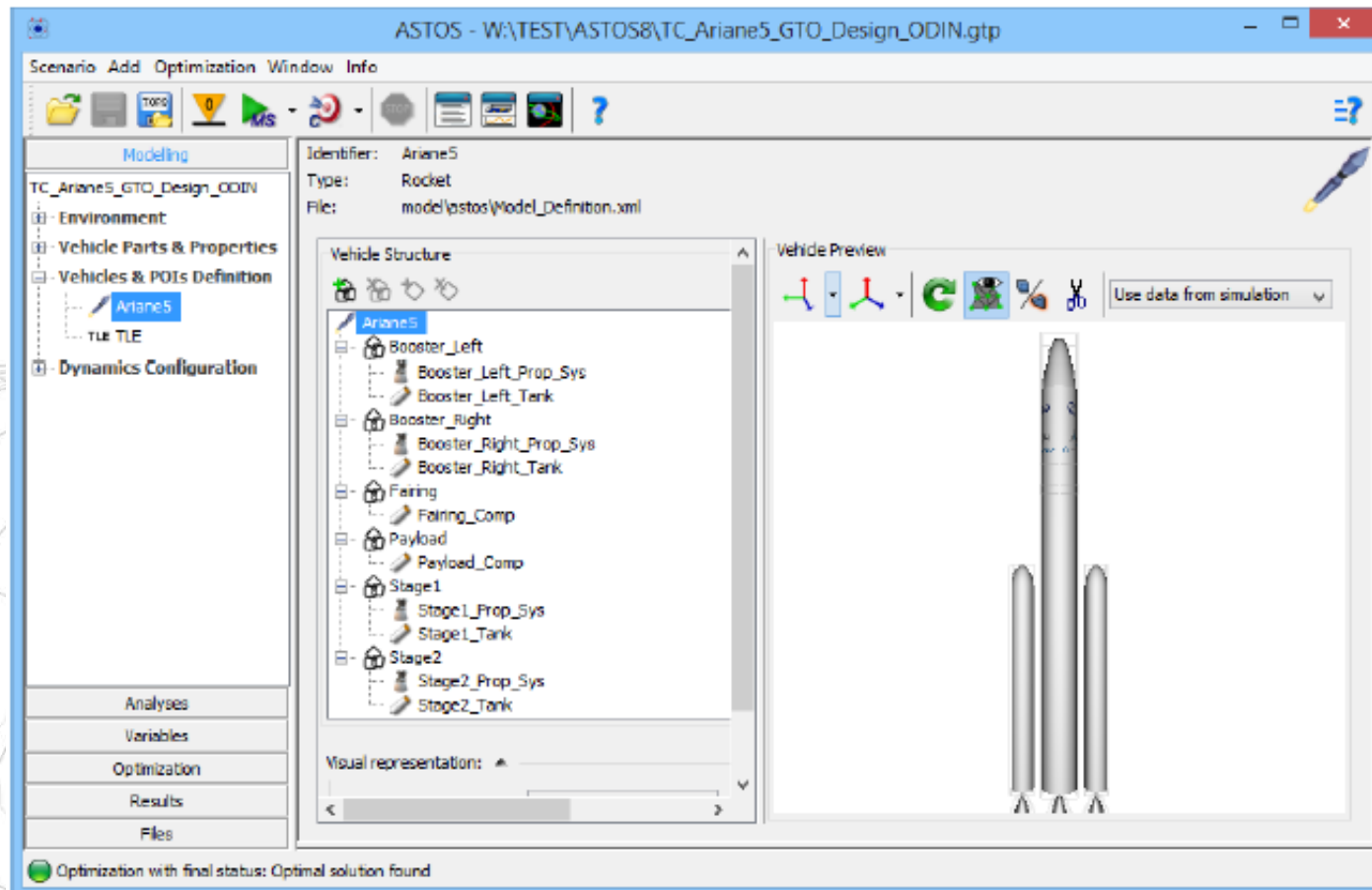
Dynamics and Environment Simulator

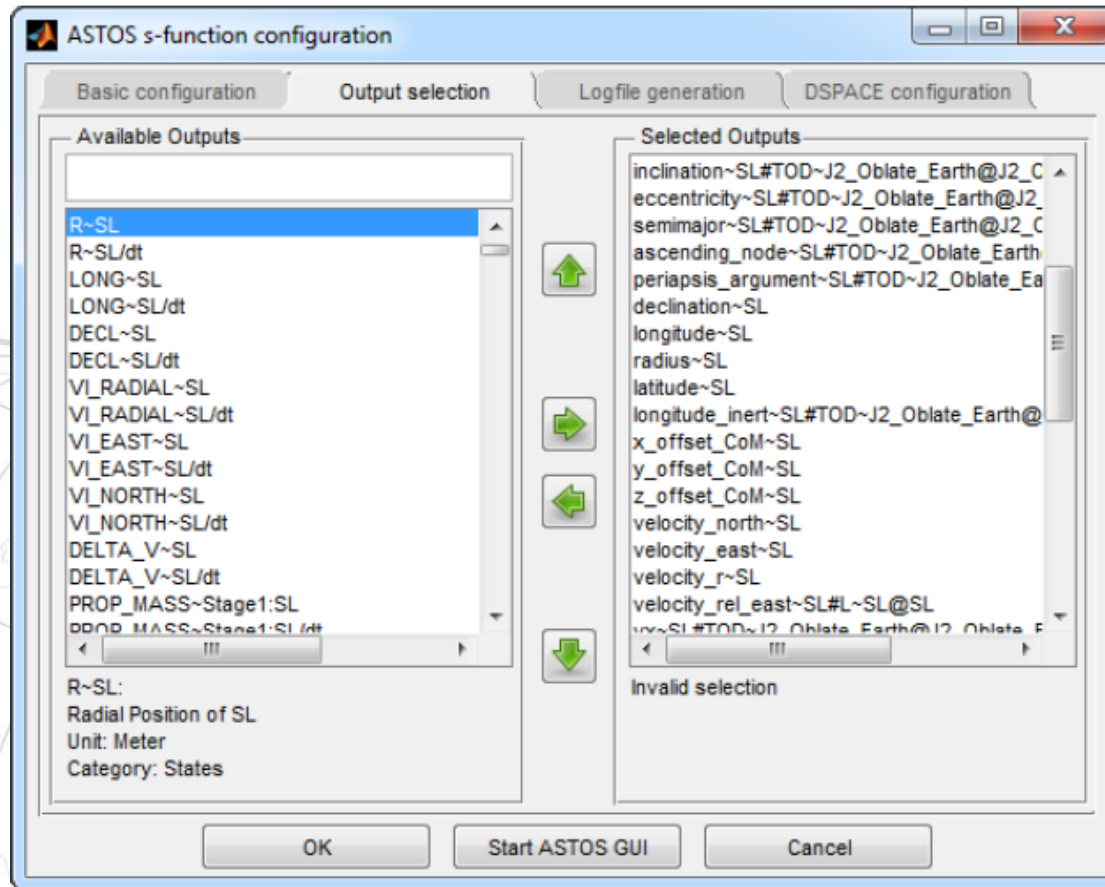- Architecture of coupled GNC analysis

Dynamics and Environment Simulator

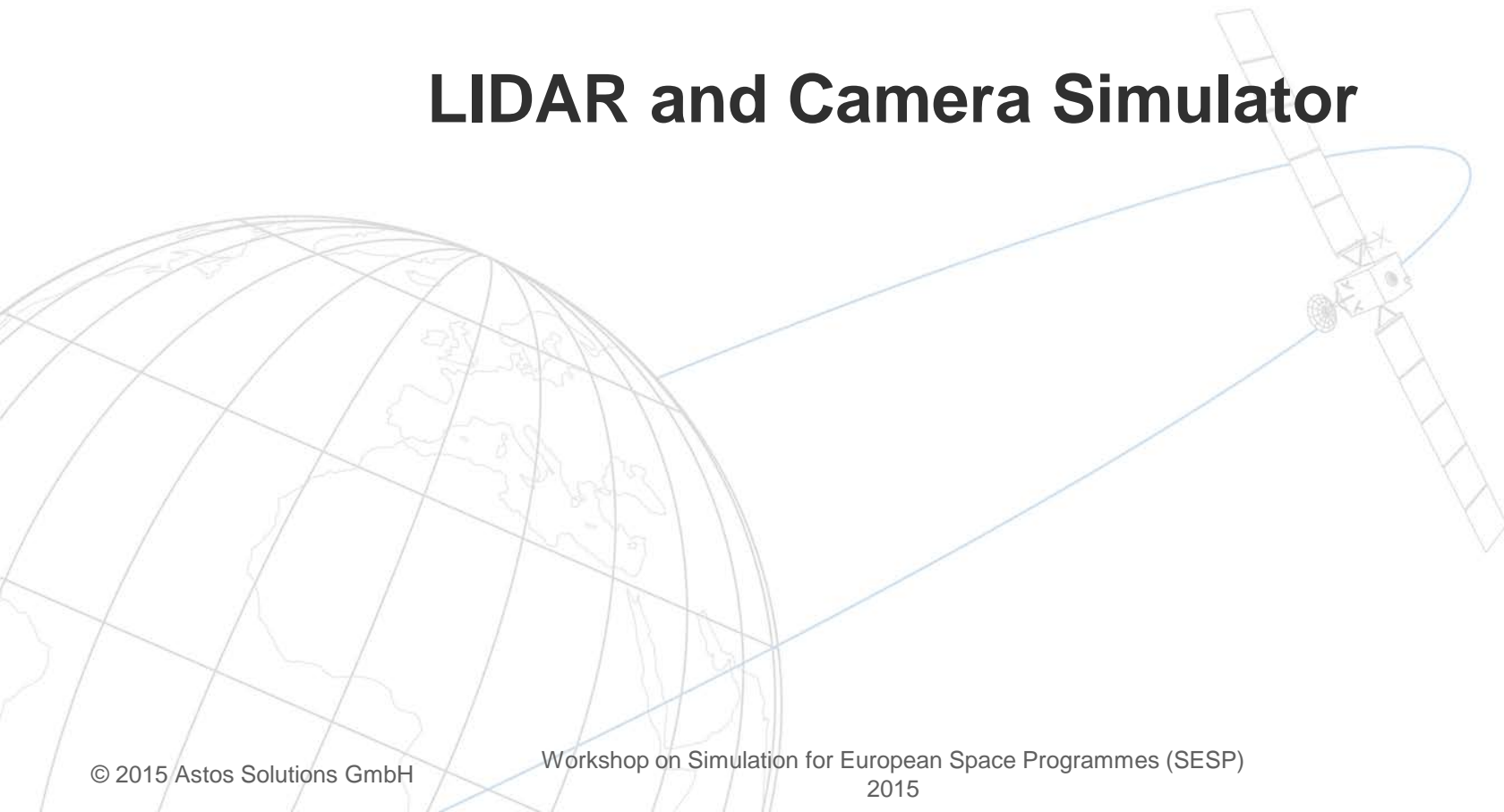- Scenario configuration is done through the ASTOS GUI

Dynamics and Environment Simulator

- Output functions are selected from the ASTOS Simulink block

LIDAR and Camera Simulator

Workshop on Simulation for European Space Programmes (SESP) 2015

LIDAR and Camera Simulator

- Based on VESTA, a 3D graphics engine developed by Astos Solutions GmbH

- VESTA is able to produce photo-realistic images in real-time

- Supported features
  - Shadows, including eclipse shadows
  - Reflections
  - A realistic atmosphere model based on physical properties, e.g. Rayleigh scattering
  - Hierarchical tile-based texture maps for planet surfaces

- Major advantage is the low cost approach to verify vision-based navigation concepts
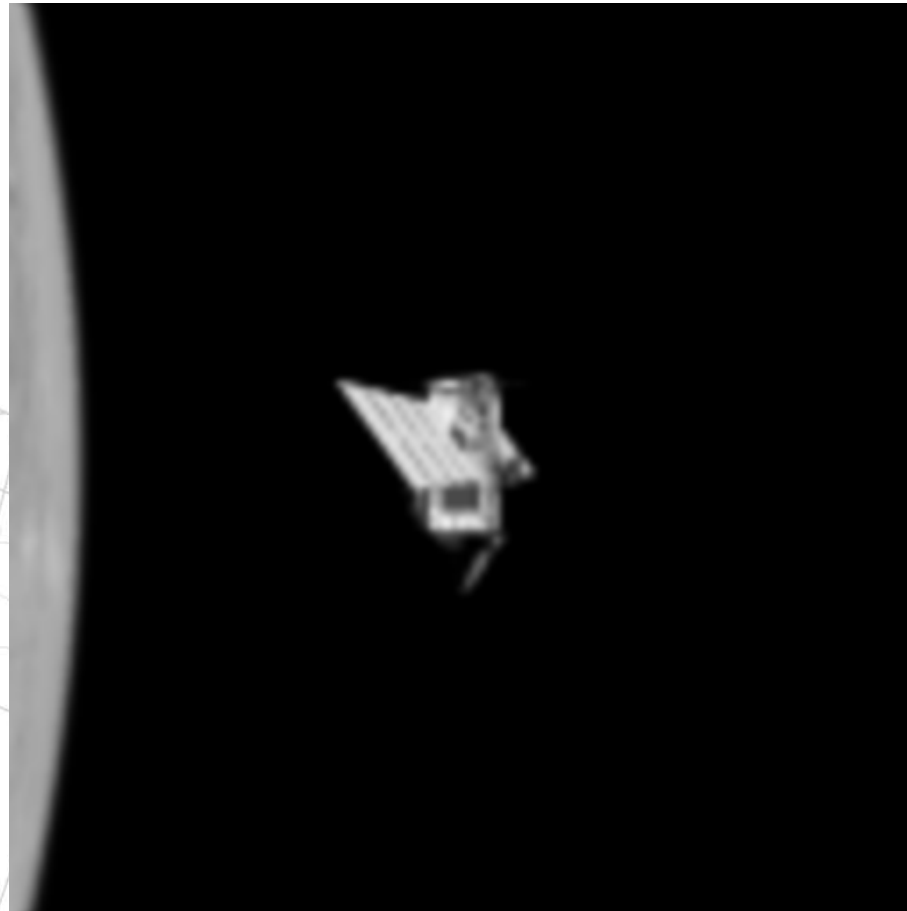
LIDAR and Camera Simulator

- The simulator extends VESTA by several sensor models

- Two camera models are available
  - Simple camera model acting like a pinhole camera
  - Physical camera model based on focal length, aperture etc.

- Currently, one scanning LIDAR model is available
  - Sinusoidal wave for the horizontal axis
 - Triangle function for the vertical axis
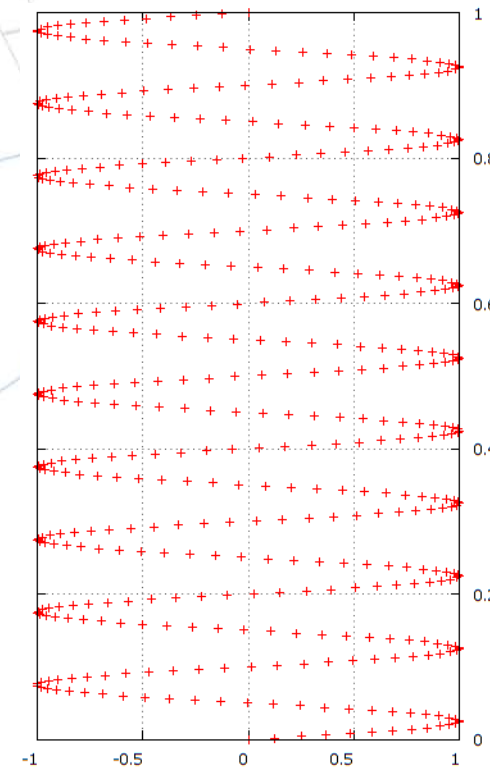
LIDAR and Camera Simulator

- Physical camera model provides depth of field simulation

LIDAR and Camera Simulator

- Input to the simulator
  - XML configuration file containing scene and sensor definition
  - 3D models provided as Wavefront OBJ or Max 3DS files
  - Object positions and attitudes (as quaternions)
  - Control commands to change sensor parameters during simulation

- Output of the simulator
  - Generated images (coloured or monochrome)
  - Set of LIDAR sample points, containing information about surfaces hit by the LIDAR ray
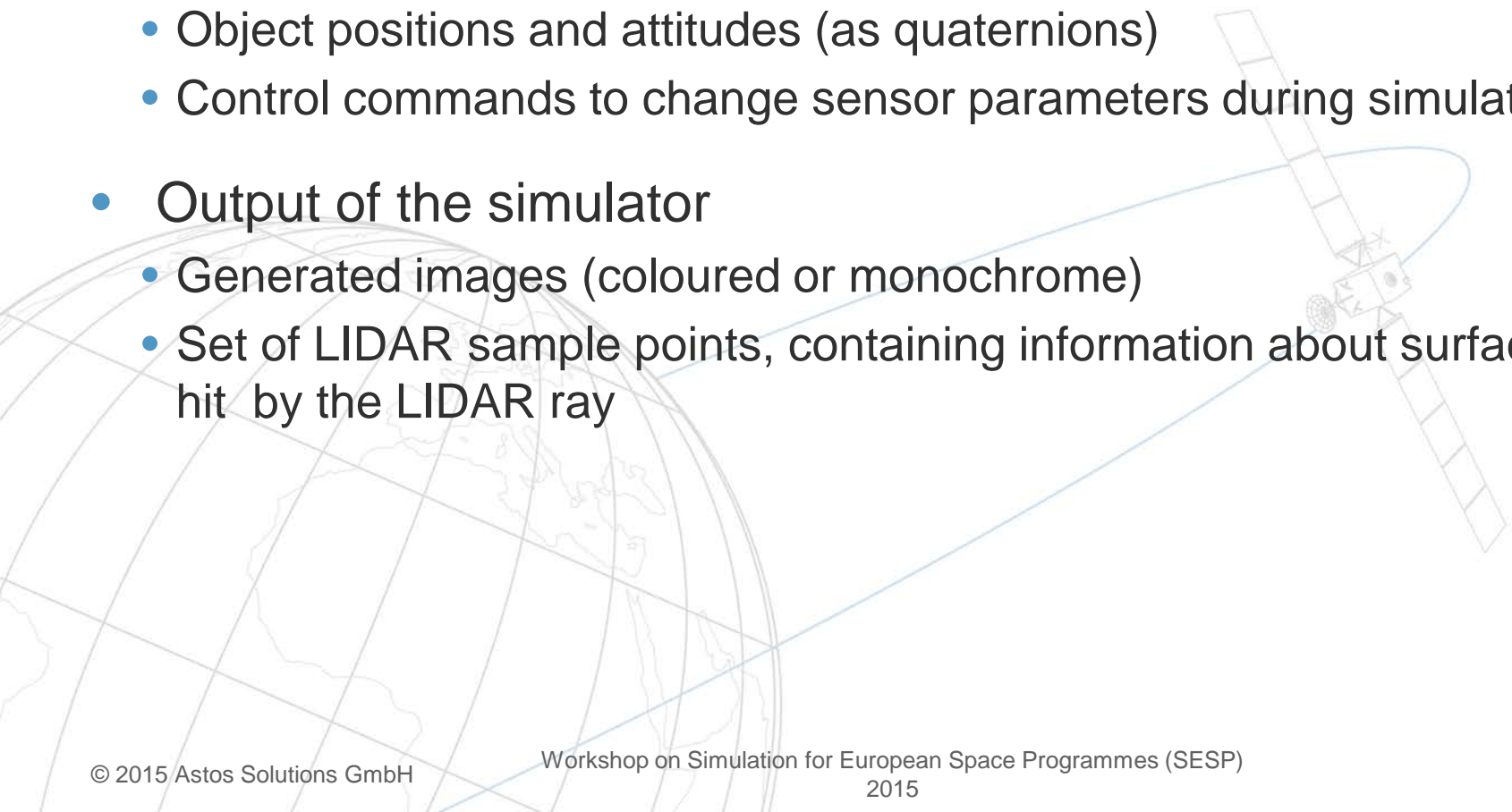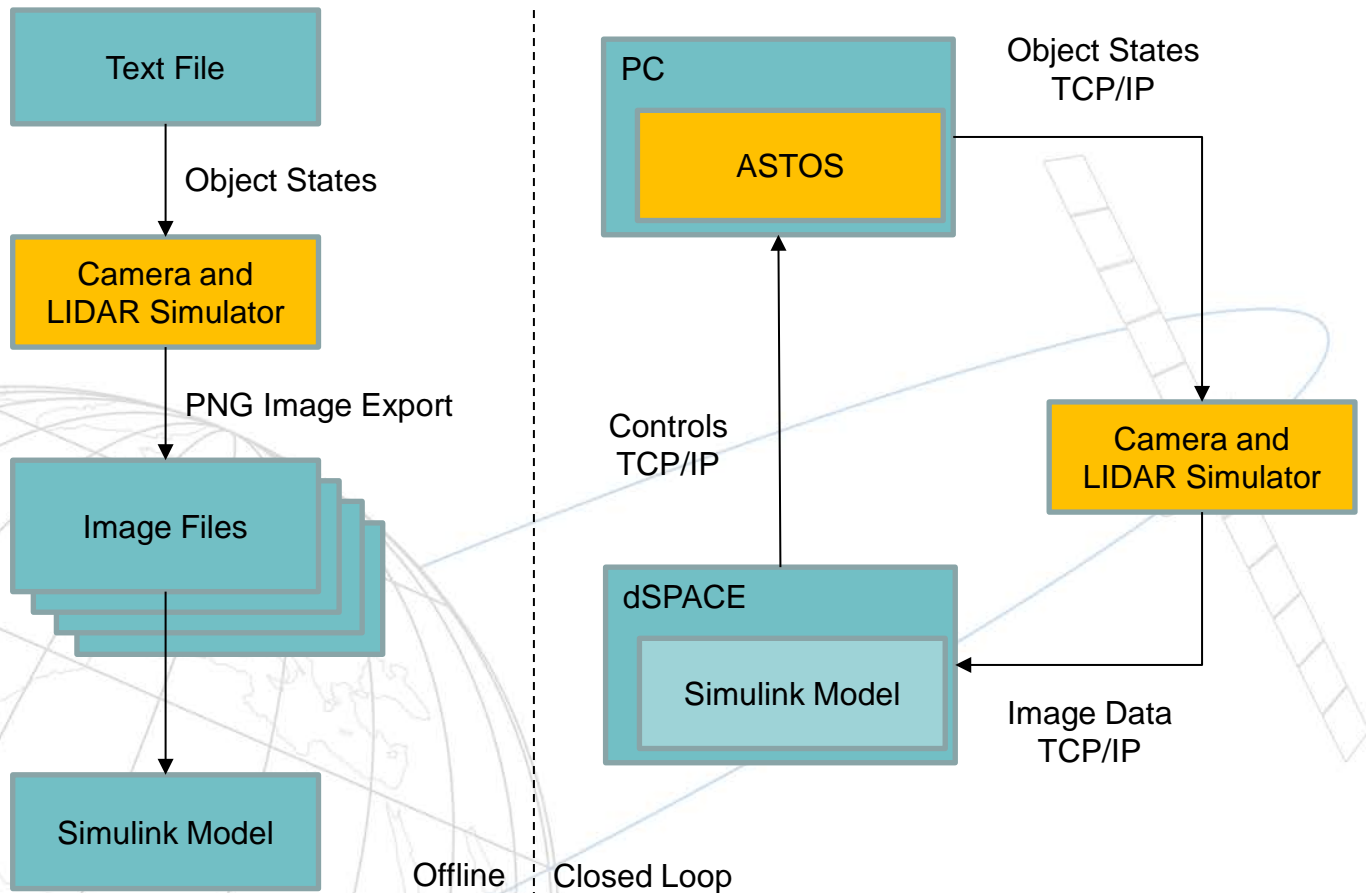
LIDAR and Camera Simulator

- Wide range of interfaces available
  - TCP/IP
    - State input
    - Command input
    - Result output for images and LIDAR data
  - Camera Link®
    - Image output (not available for LIDAR data)
  - Text files
    - State input
  - PNG image export of generated camera images
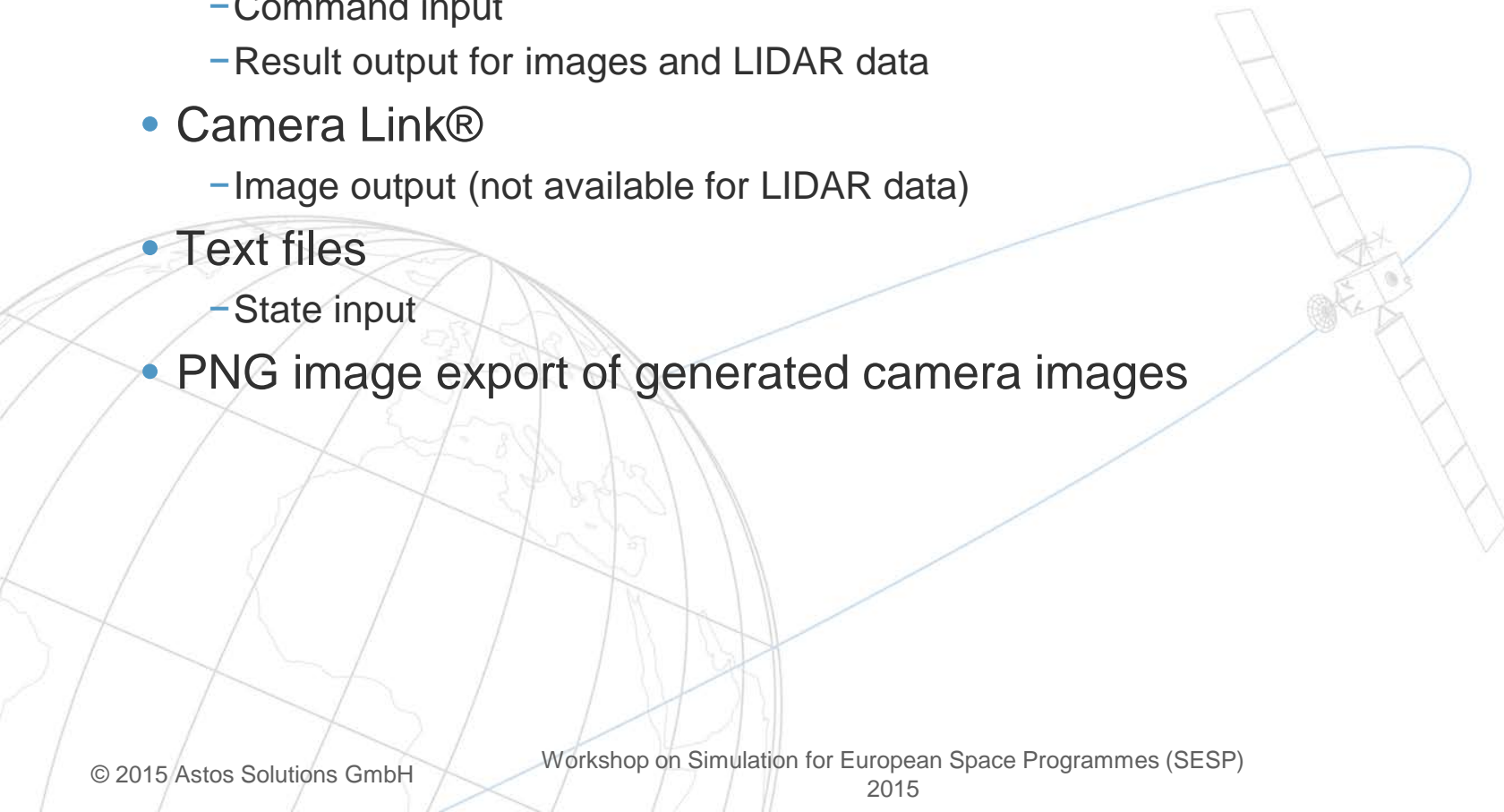
LIDAR and Camera Simulator

- Open and closed loop use cases are possible

Leadership requires solutions

Thank you!