Space-based Sensor Suite for Space Situational Awareness and Space Domain Awareness applications

Authors and Affiliation:

Dr. Thorben Haarlammert (thorben.haarlammert@jena-optronik.de, +49 3641 200-284)

Thomas Hennig, Dr. Simon Chelkowski, Andreas Hornig and Florent Bouillon
Jena-Optronik GmbH, Otto-Eppenstein-Str.3, 07745 Jena, Germany

Introduction

The importance and relevance of space for civil and military purposes has increased significantly in recent years. On the one hand, the number of spacecraft in Earth orbit has increased sharply which has an impact on the safe operation of these vehicles. On the other hand, many nations view space as an active military terrain that will play an increasingly important role in future conflicts. For this reason, the demand for and predictive space situational awareness (SSA) data for space domain awareness (SDA) activities has increased significantly.

Securing a spacecraft that is orbiting earth is performed best, when its direct vicinity is continuously monitored by different optical sensors that are combined in a SSA sensor suite.

Jena-Optronik GmbH (JOP) has a strong heritage in the development of opto-electronic sensors for numerous space-based applications. JOP is market leader in providing optical cameras in form of star sensors. Furthermore, with our Rendezvous- and Docking Sensors (RVS) portfolio we are the worldwide leading company in the area of rendezvous- and docking operations in space.

In conclusion, JOP has the best pre-requisites to develop an optical SSA sensor suite, which combines space-proven components in a flexible manner to obtain one data set that covers the satellite surrounding volume and identifies incoming threats.

see separate handout "Terminology: SST, SSA and SDA"
for the definitions and explanation of these terms

SSA Sensor Suite

The purpose of a SSA / SDA application focused sensor suite is to detect, track and identify incoming threats in the direct vicinity / surrounding volume of a satellite / spacecraft.

Many essential components of such a sensor suite already exist in Jena-Optronik's portfolio and further ones are currently being developed.

Sensors for such a suite are:
- Cameras with different field of views To detect illuminated objects
- Laser threat detection To detect incoming laser radiation
- IR Camera To detect unilluminated objects
- LIDAR/Laser range finder To actively detecting & tracking of objects
- Central Processing Unit Fusion of sensor data and control
- Gimbal mount For cameras with identification purposes

Find out more

Essential Components of a SSA Sensor Suite and latest product development

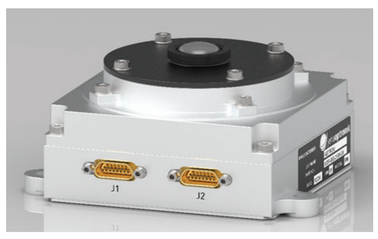
Visible cameras

- All of JOP's current visible camera products are based on the FaintStar2 detector
- Main functionality is defined in software
- Flexible building blocks enable different applications
  - generic hardware + application driven software = desired functionality

IR Camera

ASTROtir – a compact thermal infrared camera for space applications.

Jena-Optronik is developing a long wave thermal infrared camera for space application. The camera combines compactness and image correction capabilities with long lifetimes in geostationary and lower orbits.



Features:
- Exchangeable optics to adapt the field of view to customer needs
- Utilizing a state-of-the-art micro-bolometer
- Electrical circuitry following a New Space approach, allowing a small and light-weight but also high reliable IR camera
- Regulated power & SpaceWire Interface
- Optional internal shutter for sun protection, correction & calibration
- FPGA-based camera controller with non-uniformity correction, bad pixel maps
- Optional further image processing capabilities implementable

Laser Threat detection

JOP has developed autonomous laser threat detection sensor ASTROlas.

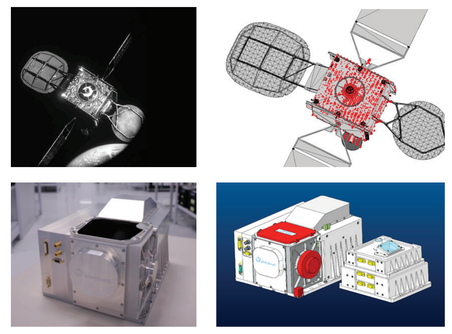
Laser radiation for either tracking or blinding of a satellite or spacecraft is a high risk for sensitive optical instruments. As an answer to such threats, Jena-Optronik developed the autonomous sensor ASTROlas, which allows satellite-based laser threat detection, identification and tracking.

Highlights - ASTROlas features and design parameters:
- Radiation-hard as well as compact and robust mechanical design
- Single FPGA for data processing
- Wide field lenses (>100° FoV) optimized for laser detection
- Four spectral channels in the range of 0.4...1.7µm:
  - Dedicated lens for laser spot Imaging
  - Bandwidth and center wavelength of each channel is adaptable
- Laser pulse detection capability, differentiation between pulsed and constant laser beams
- Laser power density determination (radiometry)
- Overlay of 2D-image and detected laser beam

LiDAR Sensors

With our RVS© portfolio we are the worldwide leading company in the area of rendezvous- and docking operations in space. Since 2010, the RVS – and later on the RVS 3000 as well – became a standard sensor for autonomous approaches of unmanned space transporters e.g. with the International Space Station ISS.

Currently we are working on using our established technology for SSA / SDA purposes. A range extension to at least 25km or even more than 100km is currently been evaluated. Such a LiDAR system will be a great extension of the SSA sensor suite as it can actively scan the spacecraft's surrounding volume for incoming threats. Moreover, an approaching object can be scanned in detailed and while approaching its distance can be tracked with high precision.



ASTROhead camera image of Intelsat 901 in orbit
taken during MEV mission
RVS 3000-3D - scan & pose of Intelsat 901 in orbit

RVS 3000-3D
CAD size comparison between RVS3000-3D and µRVS

µRVS - The next generation LiDAR: small, light and eye safe

Within the frame of a DLR project we are - together with several partners - developing new LiDAR technologies, with the goal of a miniaturized space-qualified LiDAR sensor. Due to the selected key components, the new LiDAR will be significantly lighter, smaller and will have a reduced power consumption. µRVS will be qualified in the upcoming years.

Conclusion

Jena-Optronik GmbH has a wide variety of sensors that are capable of being used in a SSA / SDA sensor suite right now. Such a sensor suite is able to detect, track and ideally identify incoming threats to any spacecraft that is equipped with it.

The sensor suite can be configured to work autonomously and independently of the primary mission of the host spacecraft. Data processing from the different sensors is done autonomously. In case of a detection, the suite will provide key information to the spacecraft, track the threat and enabling the spacecraft operator to decide on how to react on basis of factual data.

This capability will be key in the future operation of spacecrafts where the number of civil and military actors in the space domain increases.

Jena-Optronik GmbH is ready to support you in securing your valuable space assets.