Flight Test Results of the Micro-Tech-Sensor for Attitude and Orbit Determination

C.T.F. Kühl [1)]
M. Melf [1)]
H. Diehl [2)]
E. Gottzein [1)]

1)
Astrium GmbH
D-81663 München
Tel. +49-89-607-27284
Fax +49-89-607-28675
e-mail: christopher.kuehl@astriumspace.com

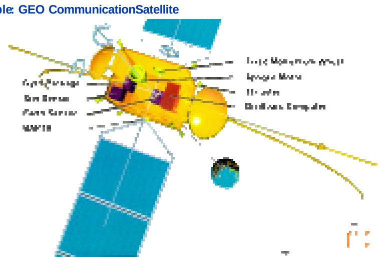
2)
EADS Deutschland GmbH

Preview

- State of the Art Sensors and Systems
- The New Sensor Principle
- Investigations
  - Analysis
  - Simulation & Experiments
- **Results taken from the MTS-AOMS Experiment on MITA**
- Performance Prediction
- Conclusions and Recommendations

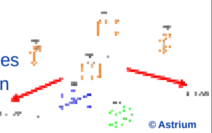
State of the Art Sensors and Systems

Example: GEO CommunicationSatellite



Attitude Determination: 3 Sensor-types

Orbit Determination : Groundstation



Proposition of a New Sensor Principle

Based on Active Pixel (APS)- and MEMS- Technology

Special Features:

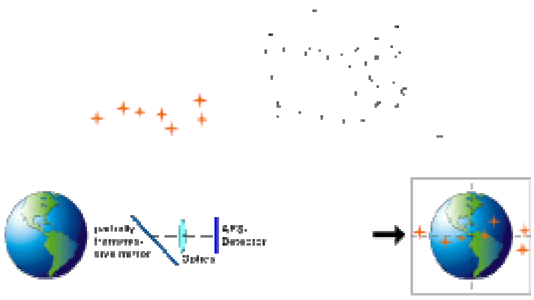
- On-Board-Autonomous Determination of
  - Attitude
  - Position
  - Rate

  Realized in a **Single** Sensor!
- Universal Application in MEO,LEO,GEO
- Reduction of
  - Mass (approx. 1,5 kg* vs. 10 kg)
  - Energy (approx. 7,5 W* vs. 15 W)
  - Complexity

MITA-Experiment

(* : Data taken from Experimental Setup)

New Sensor's Principle (Optics)



Investigations

Major emphasis in this presentation:

- Star- Centroiding accuracies and their consequences
- Algorithm- Design for Earth- Center determination in the Visual Regime
- Behavior of MicroSystemTechnology in Space

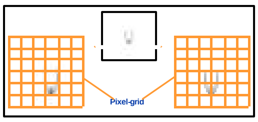
Reference Data Sets were obtained through

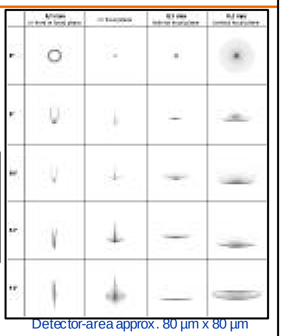
- Laboratory-experiments
- Field-experiments (Maxl-Rainer-Alm)
- Meteosat data (courtesy of Eumetsat)
- Flight-experiment (MITA)

Investigations: Centroiding

Peculiarities due to

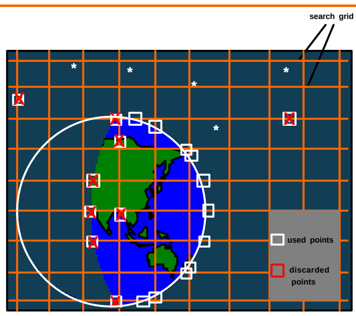
- APS- Technology exhibiting low fillfactors
- Large field-of-view





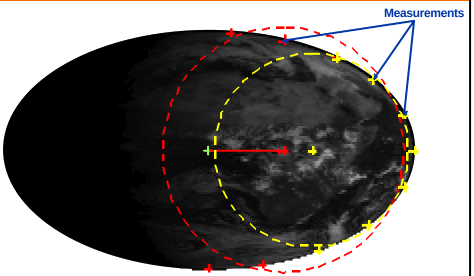
Detector-area approx. 80 µm x 80 µm

Investigations: Earth-Center (1/2)



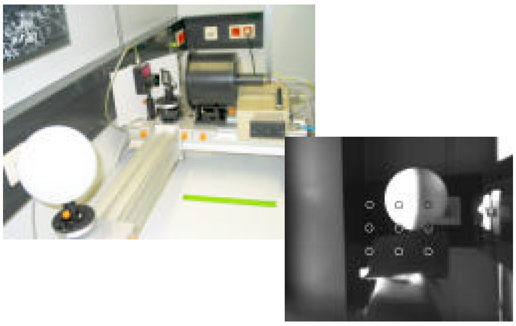
Example: GEO

Investigations: Earth-Center (2/2)



Circle fit in half ellipse ⇒ Deviation of the center approx. ± 3°

Laboratory-Experiment: Setup



Field-Experiment: Setup

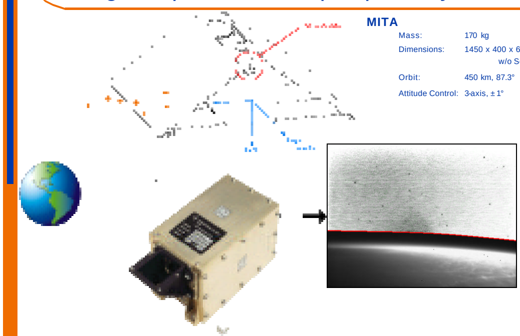
Opdix APS Camera with Data Acquisition

Miesbacher Fleckvieh

Flight-Experiment: Setup, Optical System

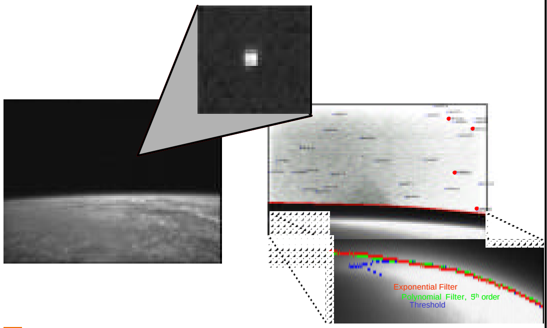
MITA

Mass:	170 kg
Dimensions:	1450 x 400 x 620 mm w/o Solar Array
Orbit:	450 km, 87.3°
Attitude Control:	3-axis, ± 1°

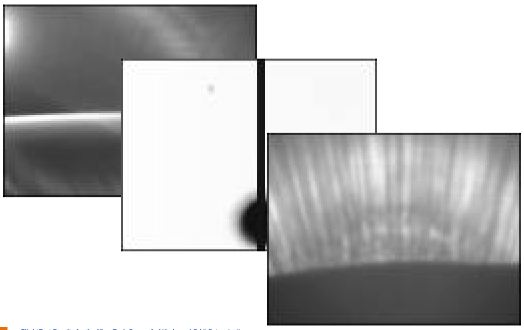


Flight-Experiment Results, Optical System

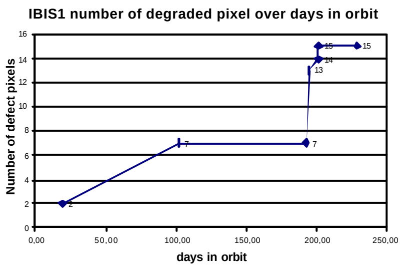
Flight-Experiment Results, Optical System



Flight-Experiment Results, Optical System



Flight-Experiment Results, Optical System

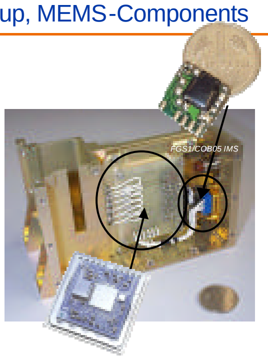


Flight Experiment: Setup, MEMS-Components

Redundancy by introduction of

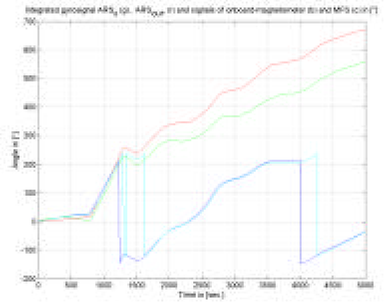
Magnetometers (e.g. FHG)
- Increased Robustness and Accuracy of Attitude (EMF-Model)– and Position (Filtering)

Rate-sensors (e.g. Bosch)
- Increased Robustness and Accuracy of Rate-Signal



Bosch DRS MM-1.0

Flight-Experiment: Results, MEMS- Components



Performance Prediction

Errors Geometrically Additive in First Order Approximation

– Attitude Accuracies
- Earth-Center — approx. 360´´, 1ó (goal: 3ó)
- Single Star-Centroiding — approx. 10´´, 1ó (goal: 3ó) (calibrated system)
- Inertial attitude — approx. 5.3´´ (25´´), 1ó (goal: 3ó) (5 observed stars)

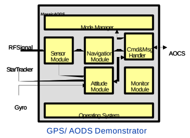
– Orbital Radius and 3D-Position Accuracy:
- GEO, GTO, LEO(SSO) — approx. 5 km , 1ó (goal: 3ó) (after 2-3 orbits)

(➔ Limitation of Accuracy Primarily due to Determination-Inaccuracies of Earth-Center)

Attitude & Orbit Accuracies Sufficient for Most Missions!

Conclusion

- Functionality of the proposed Sensor was successfully demonstrated
- Attitude & Orbit Accuracies meet requirements for a wide range of satellite missions
- Sensor applicable for orbits around other planets by software-adaptation
- Algorithms can be adapted for use in the GPS/ AODS Demonstrator (ESTEC Contract No. 16634/02/NL/US)



GPS/ AODS Demonstrator

Recommendations and Future Work

- Procedures for on-board autonomous calibration and use of available *a priori* information for further improvement of the system's accuracy and reliability
- Use of up-to-date APS-technology (if possible space-qualified)
- Enhancement of functionality and reliability using filters and shutters based on LC/ TNC technology
- Development of experimental Flight-Model
- In-Orbit Flight Experiment and performance assessment