

# SPACE TRAFFIC DATA ANALYSIS AND SYNTHESIS

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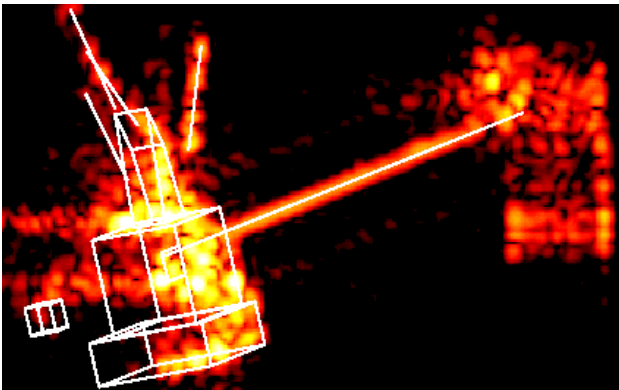
## **Overview:**

- **Introduction**
- **FGAN radar / Effelsberg radio telescope**
- **EISCAT radars**
- **ESA Space Debris Telescope**
- **Validation of the ESA MASTER model**
- **Application for Space Situational Awareness**
- **Conclusions**

- **More than 13 000 catalogued objects ( > about 10 cm)**
- **Estimated 600 000 objects larger than 1 cm**
- **For the big objects Space Traffic Management is possible:**
  - **A catalogue needs to be maintained and collision warning must be performed**
- **For the small objects statistical risk analysis is done:**
  - **Regular observations of the space environment**
  - **Building and Updating an environment model**

### **Facilities currently used by ESA:**

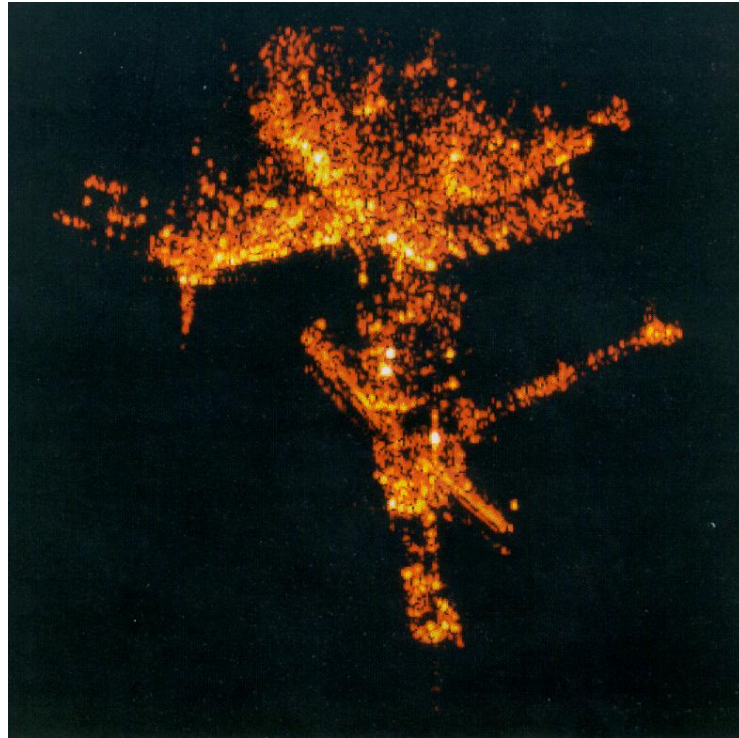
- **FGAN radar / Effelsberg radio telescope**
- **EISCAT radars**
- **1-m ESA Space Debris Telescope in Tenerife**

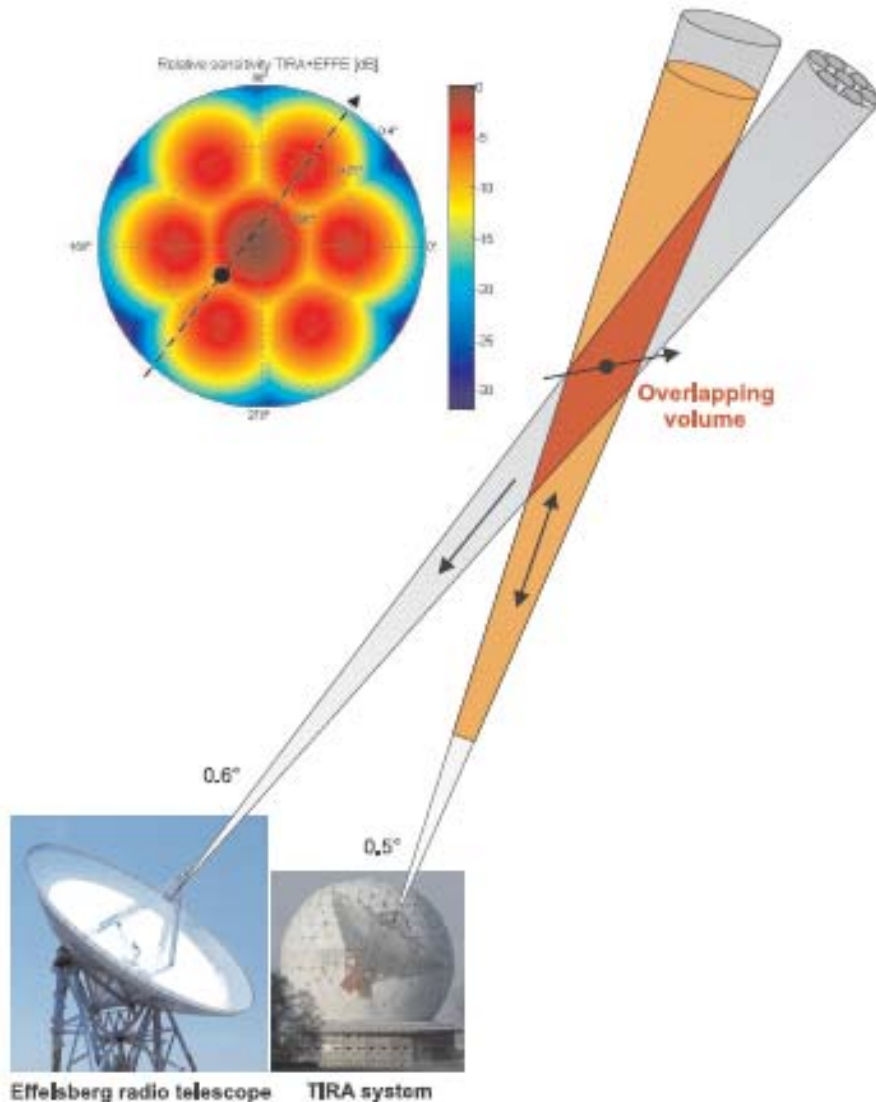


## **FGAN/TIRA radar (Wachtberg/Germany):**

- operated by FGAN (Research Establishment for Applied Science)
- antenna: 34 m parabolic reflector in a 49 m radome
- tracking radar: L-band (1.333 GHz), 1 MW peak power,  $0.45^\circ$  3 dB beamwidth, 1 ms pulse length, 30 Hz pulse repetition,  $\sim 2$  cm objects at 1,000 km
- imaging radar: Ku-band (16.7 GHz), 13 kW peak power,  $0.031^\circ$  3dB beamwidth, 256s pulse length, 55 Hz pulse repetition,  $\sim 15$  cm range resolution
- Space Debris Applications: tracking support: risk object re-entries (Skylab, Salyut-7, Mir); conjunction event verification
- imaging support: S/C emergencies (e.g. Adeos); verification of S/C integrity (e.g. Salyut-7, Mir)

MIR re-entry  
FGAN image of MIR





## Effelsberg 100 m radio telescope:

- operated by Max-Planck-Institute for Radio Astronomy
- located near Bonn (Germany), 21 km South-West of FGAN
- 7-horn L-band multi-feed
- chosen overlap volume is 600 – 1400 km altitude
- detection of 1 cm objects

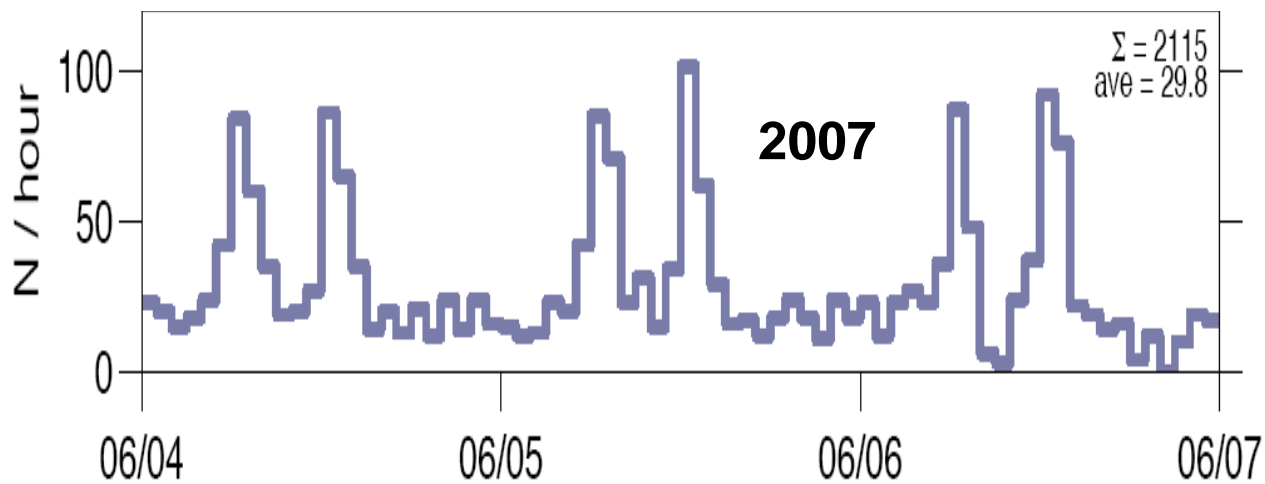
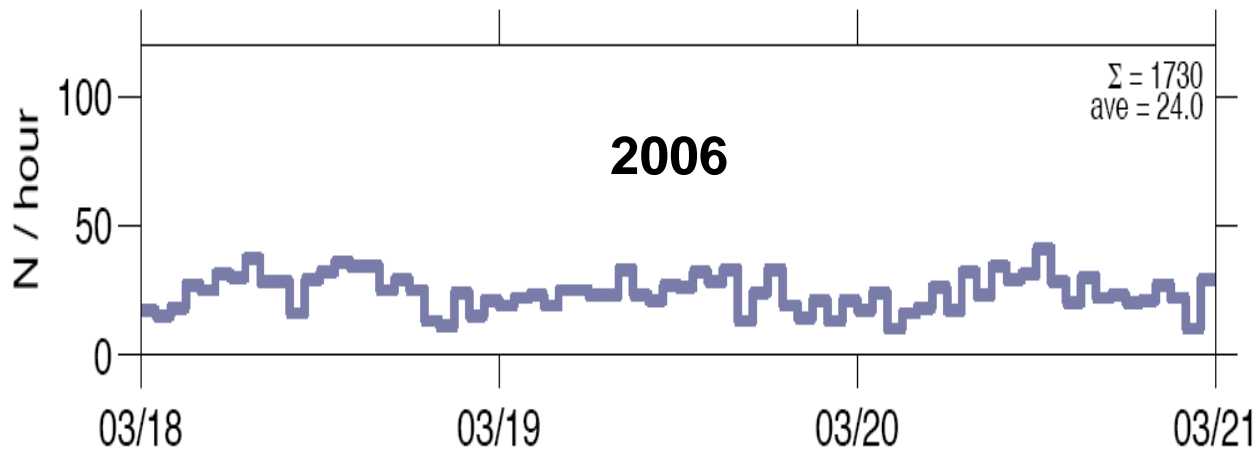
<b>Year</b>	<b>Catalogue Objects</b>	<b>Uncorrelated Objects</b>	<b>Total</b>
<b>1996</b>	85 (69)	232 (245)	317 (314)
<b>1999-1</b>	69	309	378
<b>1999-2</b>	83	269	352
<b>2000</b>	94	377	471
<b>2001</b>	114	416	530
<b>2002</b>	116	426	542
<b>2003</b>	108	431	539
<b>2004-1</b>	118	464	582
<b>2004-2</b>	107	422	529
<b>2005</b>	129	404	533
<b>2006</b>	126 (88)	390 (336)	516 (424)
<b>2007</b>	102	483	585
<b>2008</b>	To be performed on: 18 -19 November 2008		
<b>Average</b>	<b>114</b>	<b>416</b>	<b>530</b>



## **European Incoherent Scatter Radars (EISCAT):**

- EISCAT Antennas: Tromsø (N), Kiruna (S), and Sodankylä (Fin), Longyearbyen (N)
- Tromsø radar: 32 m antenna, UHF-band (929 MHz), 7 MHz bandwidth, 2 MW peak power
- In 2005: 700 hours of measurement, recording about 8000 debris events
- From 11 March 2007 to 11 February 2008 4600 hours of space debris observations, yielding about 182 000 analysed beam passage events





**EISCAT Svalbard Radar hourly space debris detection rates**



## **The ESA Space Debris Telescope (Tenerife/Spain):**

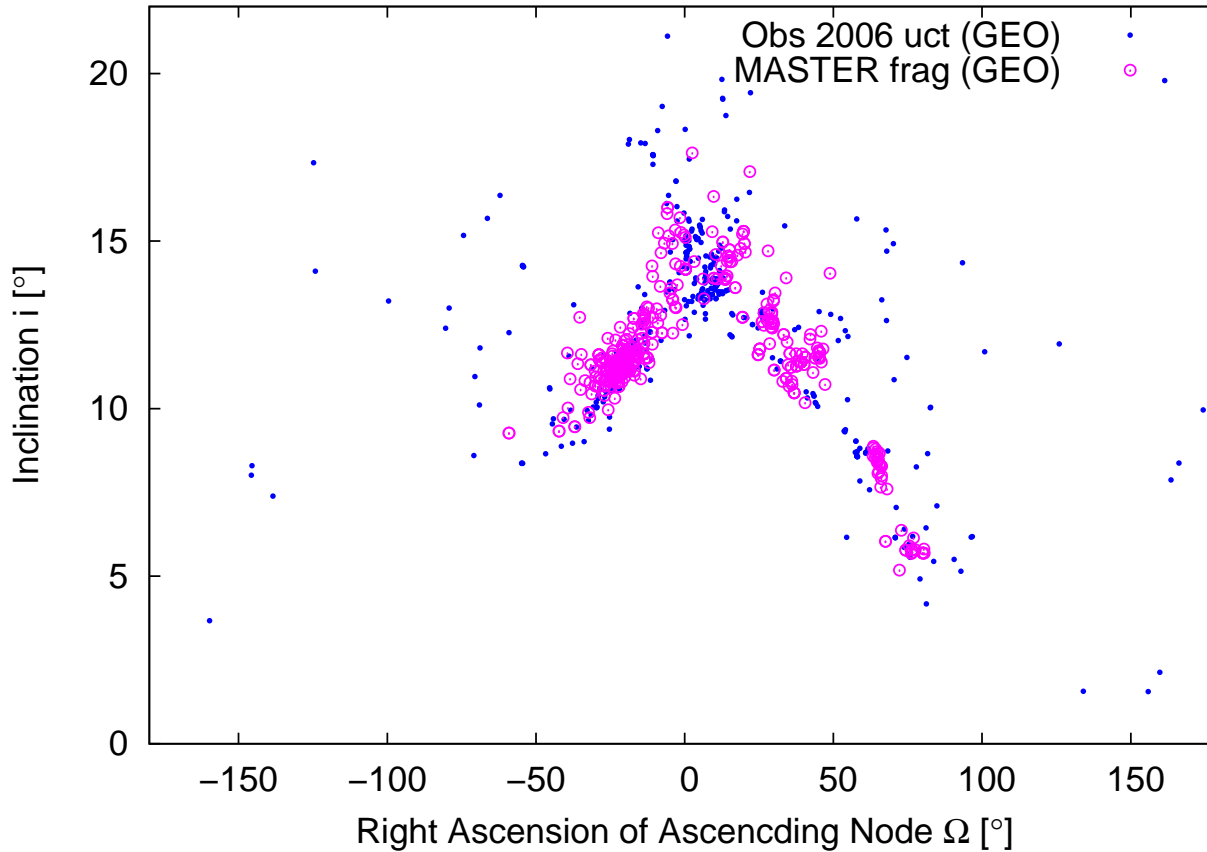
- optics: 1 m aperture,  $0.7^\circ$  field-of-view, Ritchey-Chrétien & Coudé foci
- CCD: 4096 x 4096 pixels; S/N threshold  $\sim 5.0$ ,  $\sim 2$  sec integration time,  $\sim 19$  sec read-out time
- detection threshold: 19 - 21 mag (  $\sim 15$  cm GEO objects of albedo 0.1)
- $120^\circ$  of GEO visible
- 120 nights/year

<b>Survey Scenario</b>	<b>Uncorrelated Detections</b>	<b>Correlated Detections</b>	<b>Correlated Objects</b>	<b>Total Detections</b>	<b>Observation Hours</b>	<b>Scanned Area [deg<sup>2</sup>]</b>
<b>GEO</b>	<b>461</b>	<b>476</b>	<b>187</b>	<b>937</b>	<b>130.4</b>	<b>2685.1</b>
<b>GTO</b>	<b>579</b>	<b>332</b>	<b>229</b>	<b>911</b>	<b>233.7</b>	<b>4871.6</b>
<b>Combined</b>	<b>1040</b>	<b>808</b>	<b>320</b>	<b>1848</b>	<b>364.1</b>	<b>7556.7</b>

2006 ESA GEO and GTO surveys

## Available observation data to validate the MASTER model

<b>Instrument</b>	<b>Location</b>	<b>Approx. Lower Threshold</b>
<b>ESA Space Debris Telescope</b>	<b>Tenerife, Spain</b>	<b>15 cm in GEO</b>
<b>Tracking and Imaging Radar</b>	<b>Wachtberg, Germany</b>	<b>2 cm at 1000 km</b>
<b>Goldstone Radar</b>	<b>California, USA</b>	<b>2 mm at 1000 km</b>
<b>Haystack Radar</b>	<b>Massachusetts, USA</b>	<b>4 mm at 1000 km</b>
<b>Liquid Mirror Telescope</b>	<b>New Mexico, USA</b>	<b>1 cm (NaK), 3 cm (other) at 1000 km</b>

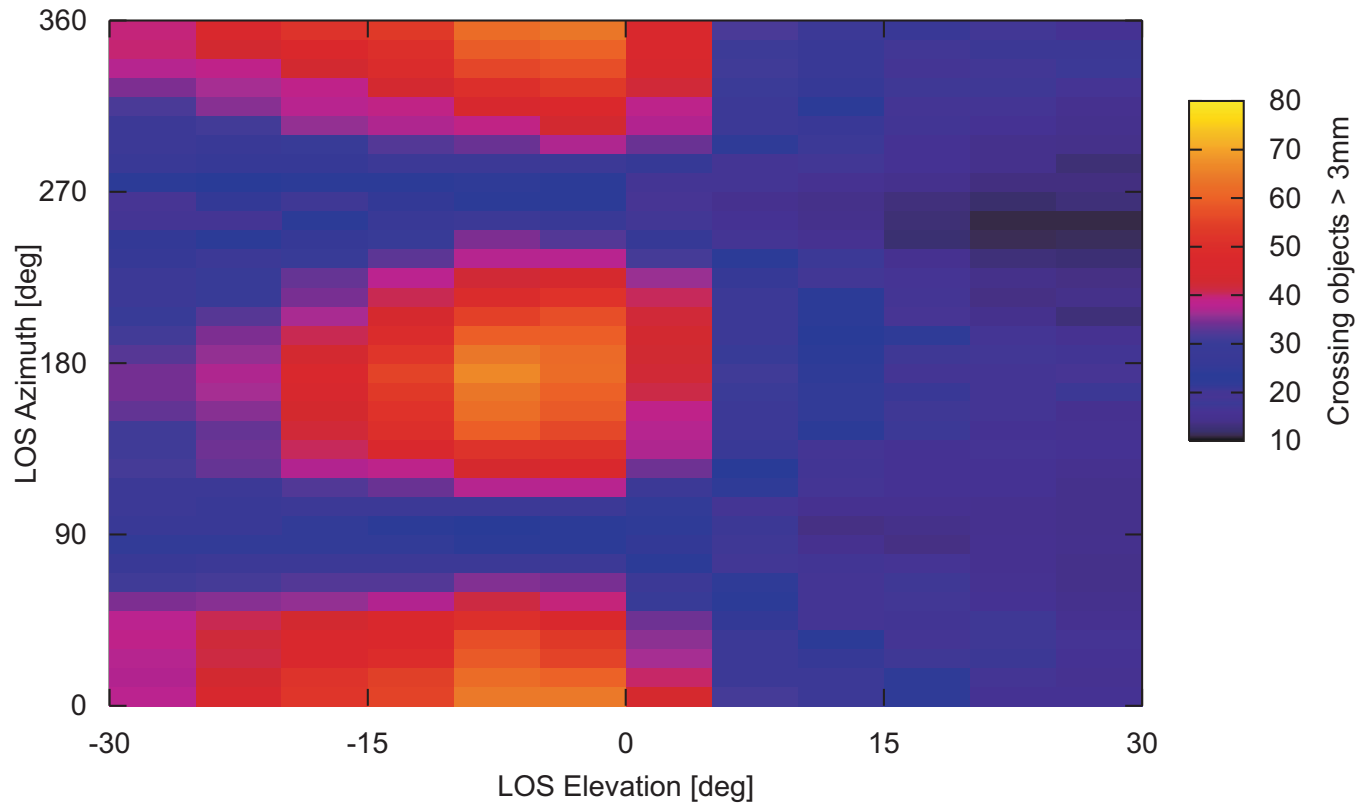


***Inclination versus right ascension of ascending node for the MASTER-2005 fragment detection events and the uncorrelated detections ('uct') of the 2006 observations***

## **Applications for Space Situational Awareness: A Space-Based Telescope**

- **Studied by AIUB/NLR/ASRO in 2003/2005**
- **10-30 cm telescope in LEO or GEO**
- **Design, architecture, operations, performance and cost analysis**
- **Especially in GEO a useful complementary data source for a space surveillance system**

GEO, 2005-12-21 00:00+24h



**Number of objects larger than 3 mm crossing the 6-deg field-of-view of a telescope in GEO in 24 h.**

## **Conclusions**

- **Powerful radars and telescopes exist in Europe**
- **As of today only statistical analysis or local catalogues**
- **Required for a Space Traffic Management:**
  - **Continuous availability of sensors**
  - **Data Processing Centre**
- **Political will (and money) for a STM system needs to be built**
- **ESA Ministerial Council in Nov 2008 a decisive milestone**