Conjunction Assessment and Mitigation for GSOC Satellites

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Collision Avoidance Operation at GSOC

- Operational since 2009
  - 24/7 support by Flight Dynamics personnel
  - CDM provided by JSpOC

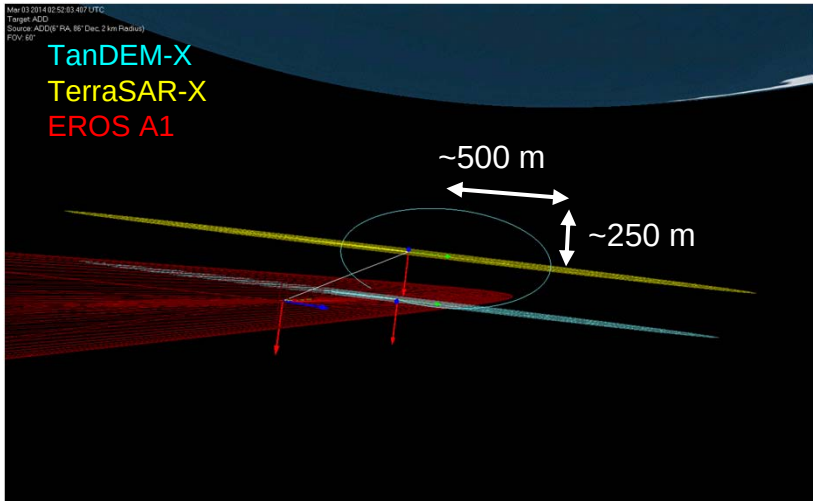
- Functionality
  - Conjunction detection
  - Conjunction risk assessment
  - Conjunction mitigation

- Supported satellites
  - 6 in LEO (400-510 km), 2 in GEO, and external satellites
  - Extended thresholds applied to TerraSAR-X / TanDEM-X (510 km)

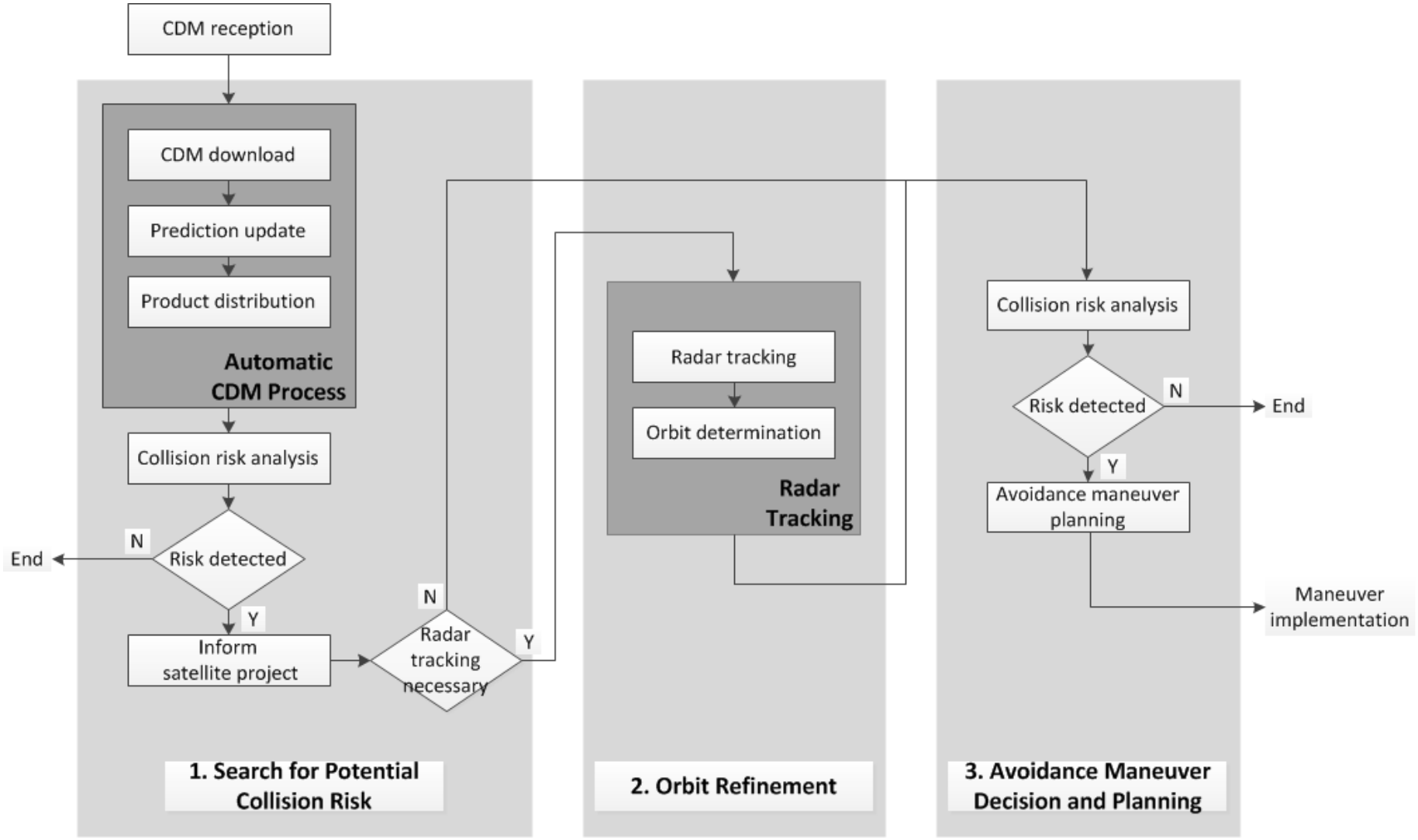
Operational Satellite

- TerraSAR-X (2007-) / TanDEM-X (2010-)
  - Controlled against a reference orbit inside a tube of 250 m radius
  - Flying in a close formation with the relative distance < 500 m
  - 510 km altitude

Conjunction on 2014/03/03

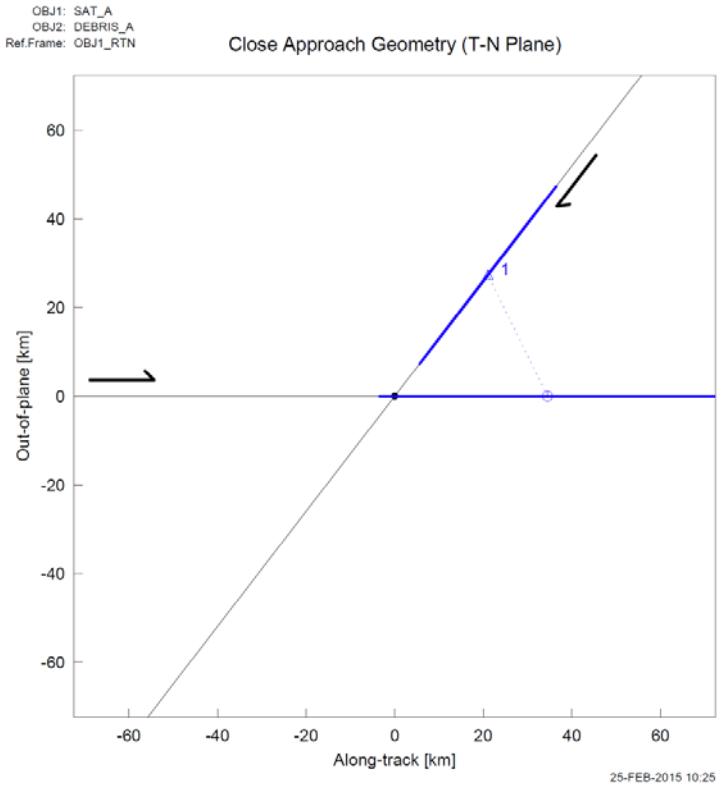


Process Overview

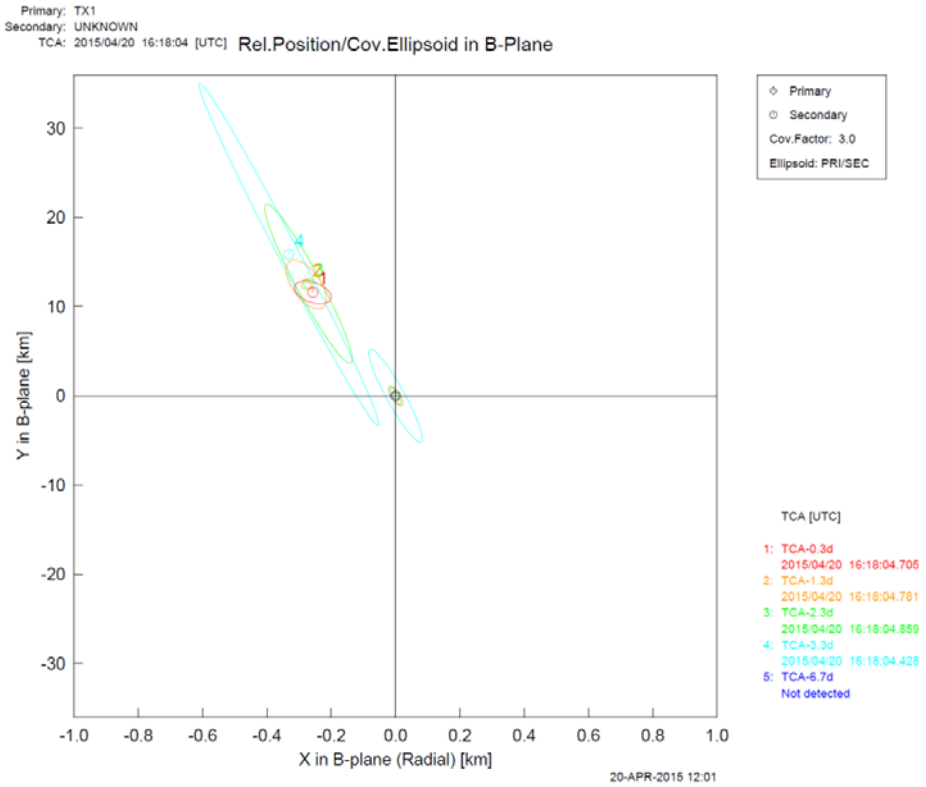


Collision Risk Assessment

Conjunction geometry plot

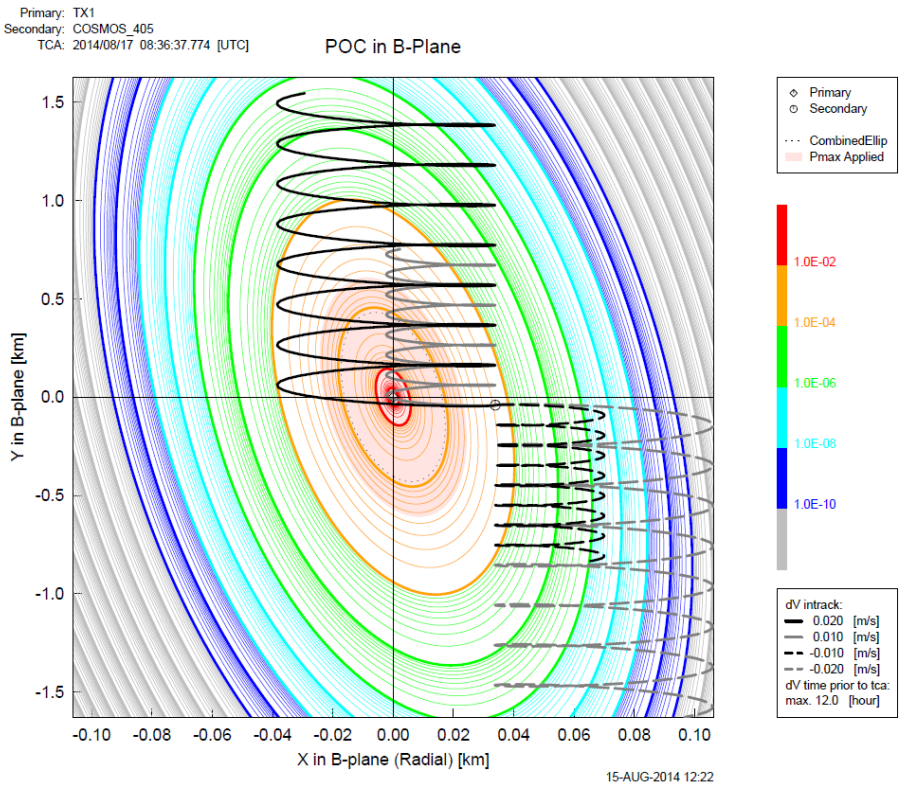


Prediction history plot

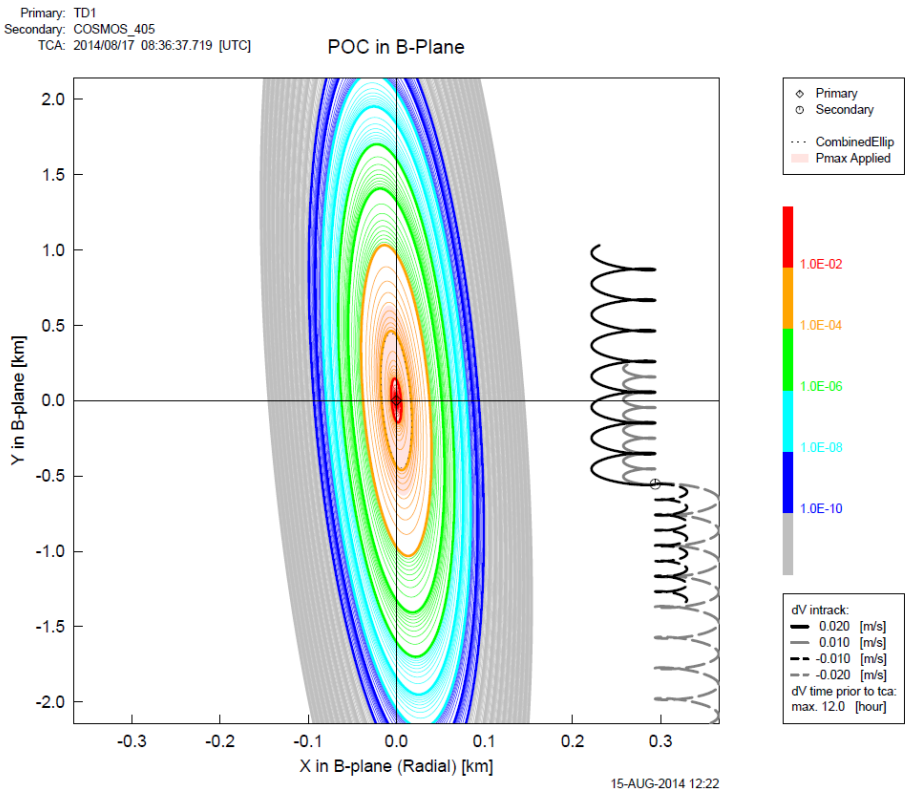


Maneuver Planning (1/2)

COSMOS 405 encounter to TerraSAR-X

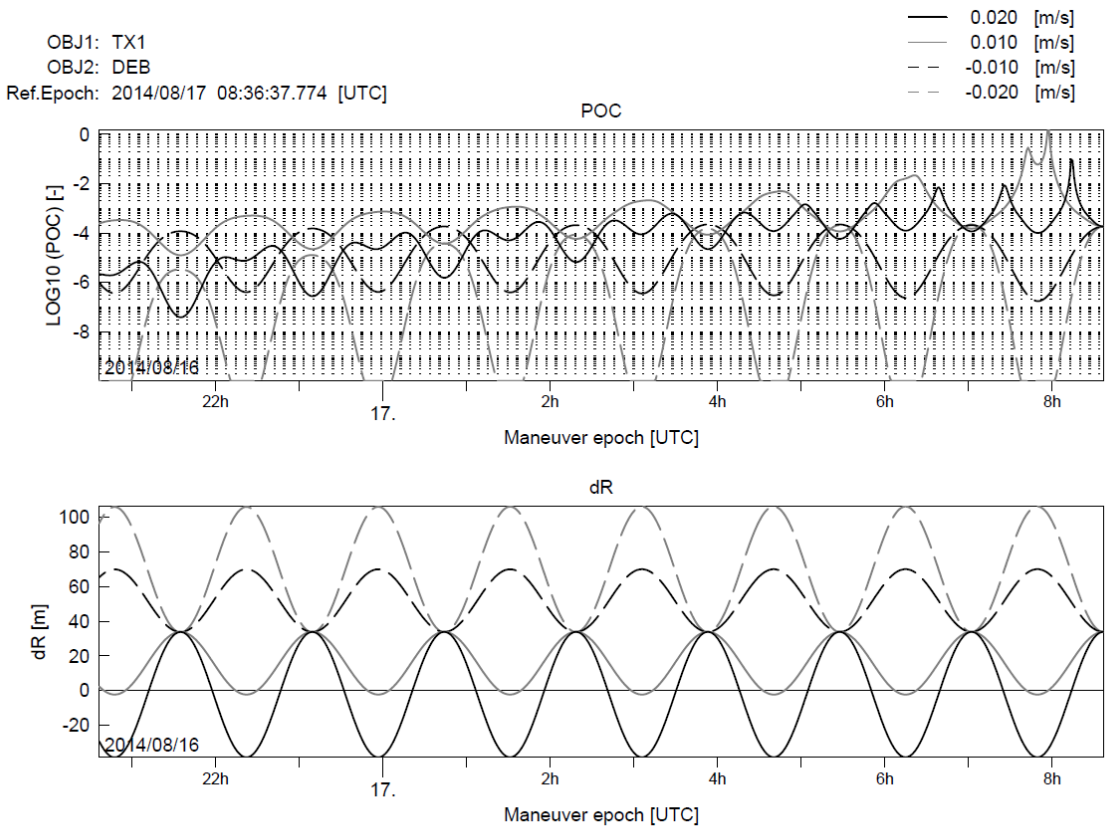


COSMOS 405 encounter to TanDEM-X



Maneuver Planning (2/2)

- Maneuver effect w.r.t. maneuver epoch
  - Probability
  - Miss distance
  - RTN components
  - TCA



Processed Conjunctions

		2012		2013		2014	
Satellite	Altitude	CSM	CAM	CSM	CAM	CSM/CDM	CAM
TSX/TDX (excl.tdtx)	510	16	2	2222 (1560)	0	7366 (4237)	4
GRACE-1	460 (-400)	1	0	0	0	0	0
GRACE-2	460 (-400)	1	0	2	0	0	0
BIRD	510 (-480)	8	0	0	0	10	0
TET	500 (-460)	3	0	1	0	0	0
SBW-1 (excl.ctrl)	GEO	35 (6)	1	19 (6)	0	110 (8)	0
SBW-2 (excl.ctrl)	GEO	59 (0)	0	135 (2)	0	224 (6)	0

- CSM generation thresholds for TSX/TDX were enlarged in 2013 Aug.
- Message format was changed to CDM in 2014 May.

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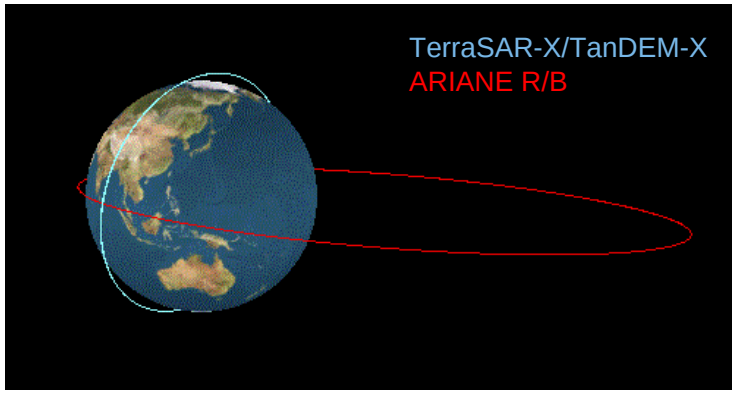
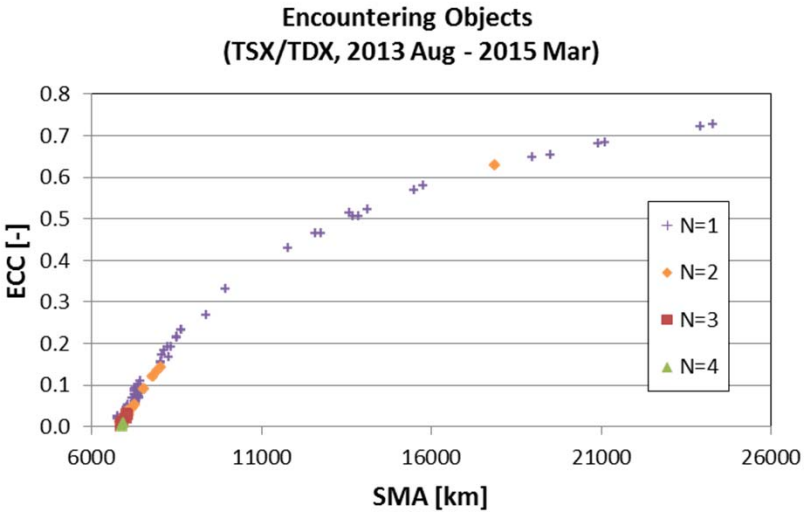
LEO Conjunction (1/2)

- Objects with high eccentricity (e.g. R/B)
  - Large object size
  - Large orbit uncertainty (~500 m in radial 1σ)



- Multiple encounters of an object
  - Objects with similar SMA and smaller orbital plane angle
  - Critical event could change due to along-track errors
  - Higher possibility of recurrence



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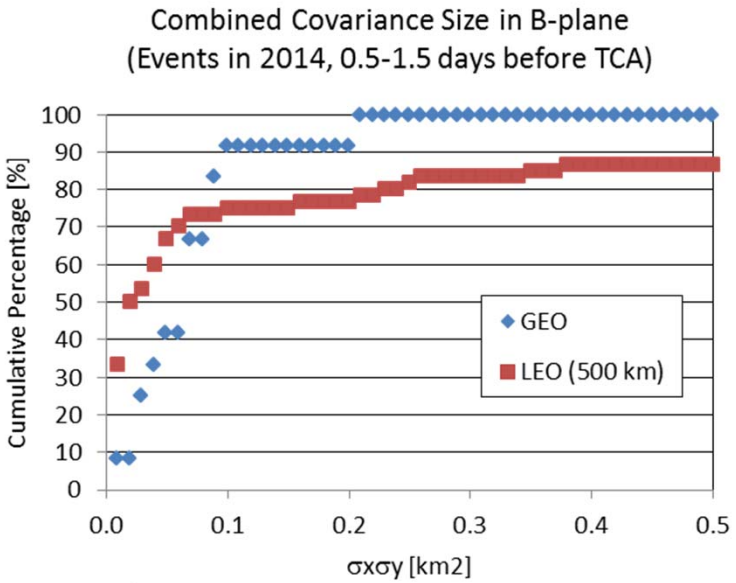
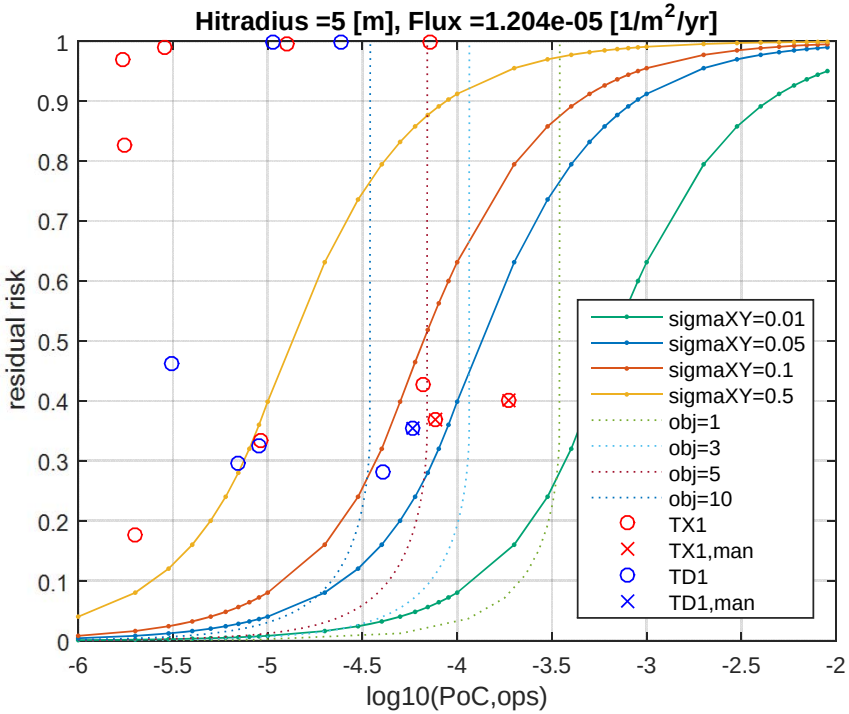
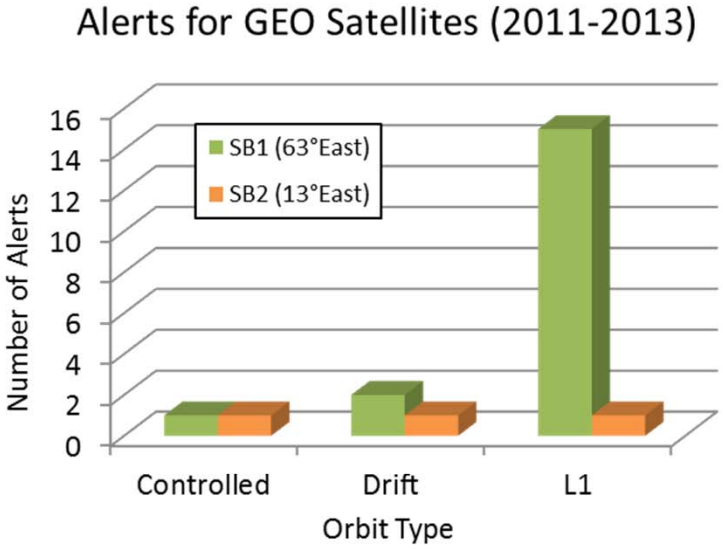
LEO Conjunction (2/2)

- The residual risk for critical conjunctions is still high to perform effective avoidance maneuver
- Larger orbit uncertainities are expected at lower altitude

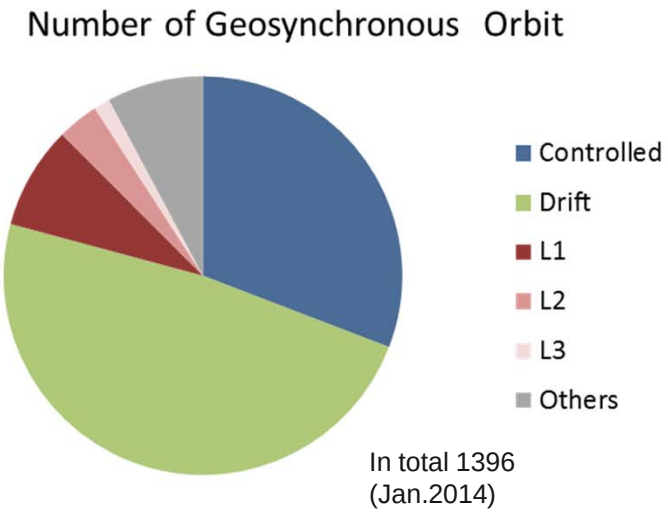




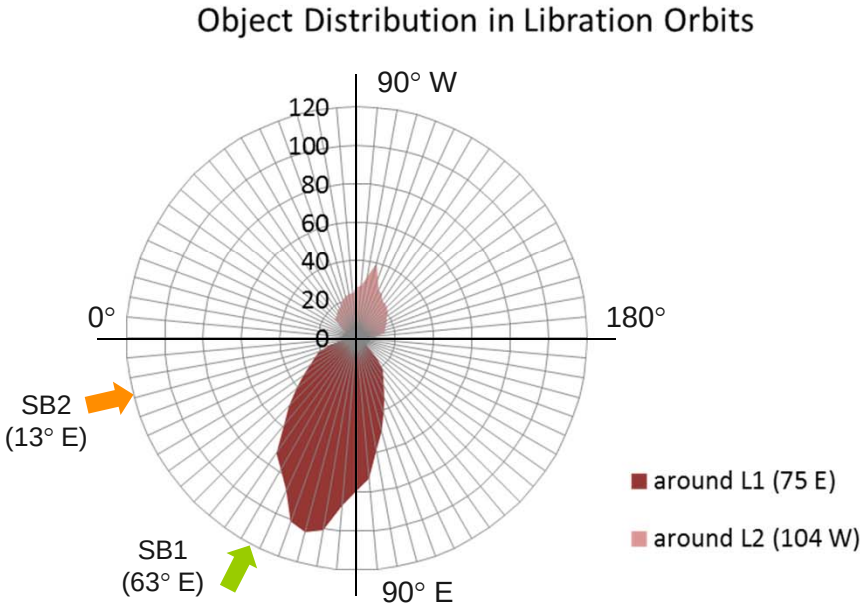
GEO Conjunction



- Total / radial dist. < 50.0 km
- Satellites in neighboring boxes not counted



In total 1396
(Jan.2014)



BACARDI:
Backbone Catalogue of Relational Debris Information

- Objective
  - Databank with preferably high completeness and high accuracy
  - Primary source: sensor data and operator data
  - Secondary source: externally generated ephemerides
- Science and Research
  - Databank generated from sensor network (tracking radar, surveillance radar, telescopes, laser tracking)
  - Fast compulation: orbit determination, propagation, object identification and detection of maneuvers and fragmentations
  - Basic algorithms implemented
- Mission Support
  - Orbit information, collision prediction, re-entry prediction

Collision Avoidance Operation using BACARDI

- Collision avoidance system integration with BACARDI
  - CDM process
  - Tracking radar (TIRA system, FHR) data process for conjunction assessment
  - First catalog from SMARTnet telescope available for conjunction screening end of 2015

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Summary

Collision avoidance operation at GSOC

- Operational satellites in LEO (400-510 km) and GEO since 2009
- Collision avoidance of the satellites in close formation performed successfully
- The process and products for risk assessment and maneuver planning presented
- Interface with BACARDI planned

Feedback and lessons

- Results of processed CDMs and avoided conjunctions presented
- Orbit accuracy for high-eccentric orbit shall be improved
- Multiple encounters of an object shall be intensively observed
- The residual risk for critical conjunctions is still high for most orbit uncertainties
- GEO conjunction results in relation to orbit type and population presented