



Development of KARI Space Debris Collision Risk Management System (KARISMA)

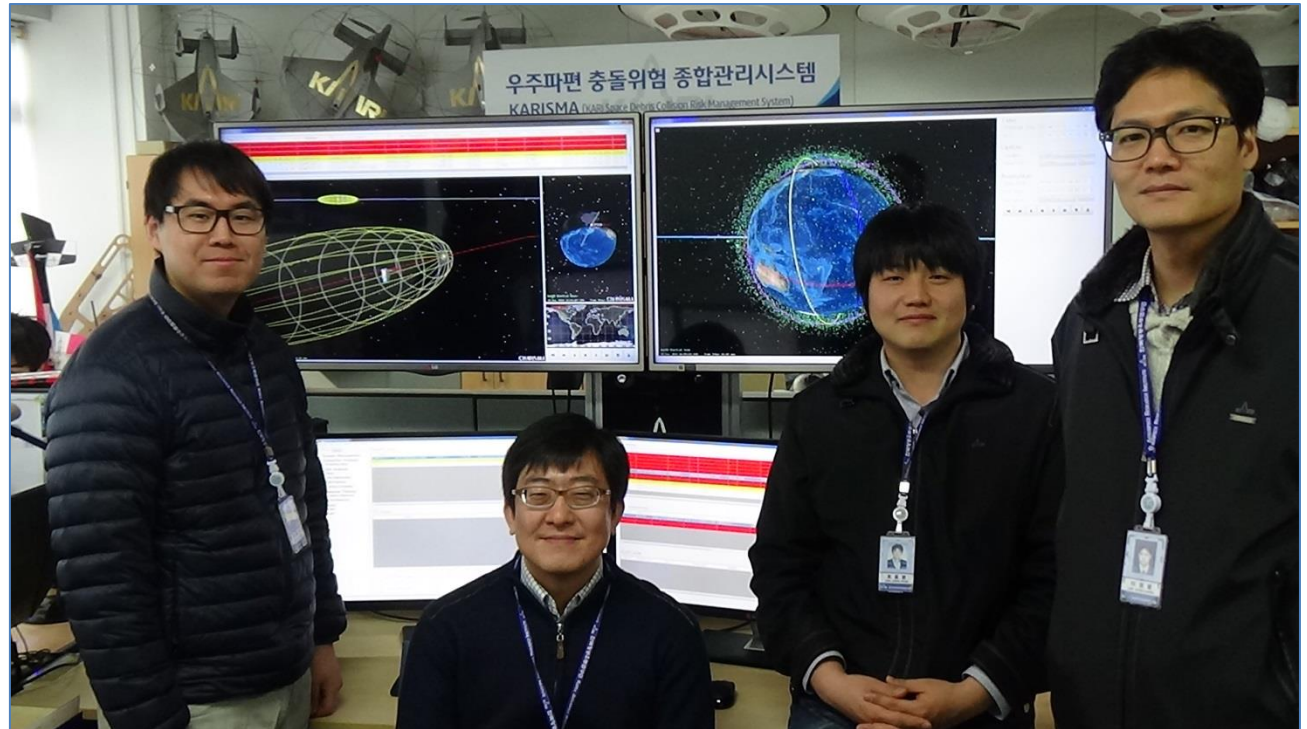
Dr. Kim, Hae-Dong

7 October 2015

AGI 1st International User Conference
Singapore

Outline

- What is the KARISMA ?
- What features are in the KARISMA ?
- Functions
- Summary



Project Members of KARISMA Development

What is the KARISMA?

- **KARISMA**
 - KARI Space debris Risk Management system
- **Developed by KARI (Korea Aerospace Research Institute)**
 - 2011.1 ~ 2013.12 (3 Years)
- **Motivation of developing the KARISMA**
 - To monitor and deal with the collision risk for KARI Constellation
- **Daily Operation at KARI Ground Station since Aug. 2014**
 - 4 LEO satellites (KOMPSAT), 1 GEO satellite (COMS)
- **Total solution tool to make a decision if a collision avoidance maneuver (COLA) is finally needed**

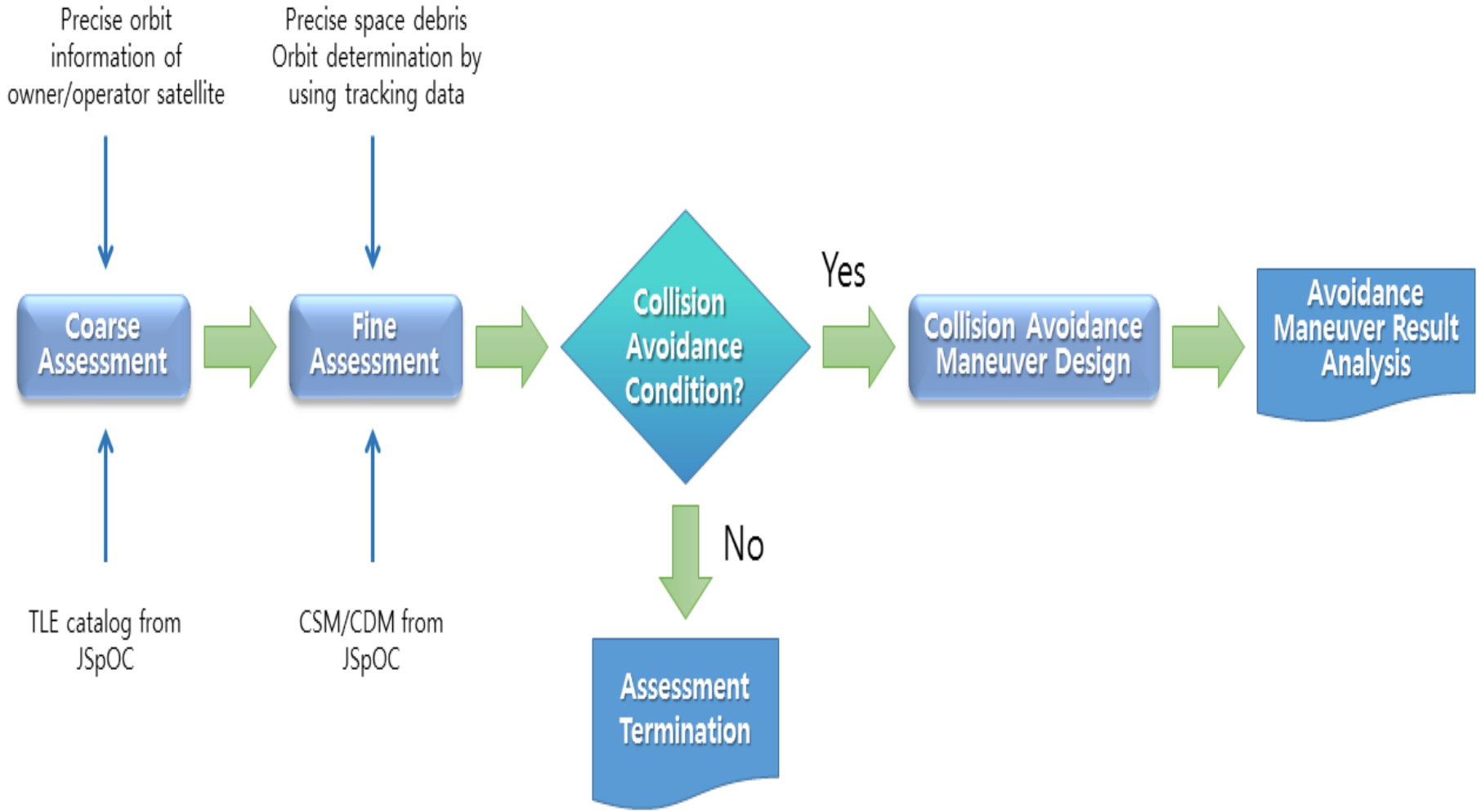
What features are in the KARISMA?

- **Developed by mainly based on proven AGI's software**
 - STK/Engine, Astrogator, STK/PRO, STK/AdvCAT, ODTK
- **Various optimization algorithms for generating COLA planning**
 - Using MATLAB Global optimization toolbox
 - 7 different optimization algorithms including heuristics algorithm like GA, PSO, etc
- **Developed by C# language**
- **2D, 3D Display for conjunction events**
- **Using JSpOC's TLE catalog and CDM**
 - Automated process with TLE catalog and CDM
 - Trend Analysis with CDM Archive
- **Various Type of Threshold for Conjunction Events**

What features are in the KARISMA?

- **High precision OD using ODTK**
 - To process RADAR and Optical tracking data for space objects
- **User Friendly Interface**
 - Designed by satellite operations experts
- **Very Intuitive and easy operations**
 - Reflect satellite operations experience
- **Sequential processing easily**
- **Automated E-mailing service with daily analysis report**
- **Automated Text Messaging Service whenever JSpOC's CDM is arrived**
- **Fine Conjunction Assessment using JSpOC's CDM, High precision orbit from O/O or Radar/Optical POD**

Processing Flow



Functions

- **KARISMA consists of four major modules**
 - SMM : System Management Module
 - CAM : Conjunction Assessment Module
 - AMM : Avoidance Maneuver Module
 - ODM : Orbit Determination Module

SMM : System Management Module

- **System management**
- **Database management**
- **External interface & Download**
- **Support**
 - JSpOC's CDM History & Archive
 - System log
 - Global monitoring using TLE catalog
 - Reporting & E-mailing & Text message automatically

Main UI

The screenshot displays the 'Main' application window with a menu bar (Edit, File, View, Tools, Windows, Help, Member) and a toolbar. On the left is a tree view for 'System Management' with sub-items: Scheduling Setup, Satellite&Object DB, Tracking Station DB, FTP Download&Upload, Tracking Data&Request, JSpOC CDM Archive, Log History, Conjunction Analysis, Orbit Analysis, Maneuver Planing, and Output. The main area is divided into three sections: 'Current Status', 'OD Status', and 'Event Log'. A red callout box points to the 'Current Status' table with the text 'Current Status of Conjunction Risk for each satellite'.

Current Status

Satellite	ID	Object	ID	No.Event	Time To TCA	TCA	Min. Range(km)	Max. Probability	Radial(km)	In-Track(km)	C
KOMPSAT-1	26032	CZ-2C DEB	28483	1	24:48:40	2014-07-19 18:06:12	0.944	1.677E-06	-0.213	0.852	-0.8
KOMPSAT-3	38338	TZINGHUA 1	26385	9	38:23:15	2014-07-20 07:41:21	0.916	4.516E-06	0.106	0.426	0.8

OD Status

Satellite	Start Time	OD Cycle	Processing Time	Remaining Time
KOMPSAT-1	2013-04-16 18:49:22	24	2014-07-21 18:49:22	07:19:06
KOMPSAT-3	2014-01-07 01:30:00	12	2014-07-21 13:30:00	01:59:44
KOMPSAT-2	2013-04-24 14:50:40	3	2014-07-21 11:50:40	00:20:24
KOMPSAT-2	2013-04-16 17:09:30	3	2014-07-21 14:09:30	02:39:14

Event Log

Empty log area.

Satellite DB UI

Setup 3D Model for User's Satellites

Satellite DB

Norad ID: 38338 Satellite Name: KOMPSAT-3 Model: C:\W\Karisma\WImage\Wkomsat-3.mdl

Orbit Type: LEO Area: 7.7 m² Mass: 890.0 kg Fuel: 65.7 kg

Impulse: 200.5 s Radius: 5.0 m Thruster: 17.3 N Radial: 10.0 m

In-Track: 30.0 m Cross-Track: 10.0 m Ref. Lon: 293.1 deg Repeat Count: 409.0

Norad ID	Satellite Name	Orbit Type	Area(m ²)	Mass(kg)	Fuel(kg)	Impulse(s)	Radius(m)	Thruster(N)	Radial(m)	In-Track(m)	Cross-Track(m)
36744	COMS-1	GEO	7	1800	300	205	5	17.27	10	40	20
26032	KOMPSAT-1	LEO	5	765	46	205	5	17.27	10	30	10
29268	KOMPSAT-2	LEO	7.93448	744.144	46.3124	200.53	5	17.27	10	30	10
38338	KOMPSAT-3	LEO	7.688	890	65.7	200.53	5	17.27	10	30	10
39227	KOMPSAT-5	LEO	5.1	1251.5	63.4	200.53	5	17.27	10	30	10

Database for User's Satellites

New Modify Delete

Event Log

FTP Download UI

The screenshot displays the 'Main' window of the KARISMA KSFDS application. On the left is a tree view under 'System Management' with 'FTP Download&Upload' selected. The main area contains four download configuration panels: 'TLE Download', 'CDM Download', 'IGS Download', and 'Ground Station Data'. Each panel includes fields for 'User', 'Password', 'Download Time', and 'Every' intervals, along with 'Download Now' and 'Next Download' status indicators. The 'Ground Station Data' panel has additional checkboxes for 'OD Stack File', 'OD Ephemeris File', 'Prediction File', and 'Tracking Data'. A callout box labeled 'IGS DATA Download' points to the 'IGS Download' panel. Another callout labeled 'NORAD TLE Download' points to the 'TLE Download' panel. A third callout labeled 'JSpOC CDM Download' points to the 'CDM Download' panel. A fourth callout labeled 'Information of Ground Station' points to the 'Ground Station Data' panel. At the bottom, there is an 'Event Log' section.

Global Monitoring UI

Option for View-point

The screenshot displays the 'Constellation' software interface. The main window shows a 3D Earth model with several satellite orbits overlaid in different colors (yellow, blue, red, purple). The Earth is surrounded by a field of green dots representing other satellites. The control panel on the right includes the following sections:

- Time:** Universal Time (2014/07/21 02:32:08) and KST (2014/07/21 11:32:08).
- Option:** Satellite (COMS-1) and View From (Satellite) with an Apply button.
- Animation:** Start Time (2014/07/21 11:31:31), End Time (2014/07/21 11:31:31), and Play Mode (Real Time) with an Apply button.
- Animation Buttons:** A set of standard media control buttons including Play, Stop, Previous, Next, and Home.

At the bottom left, the text reads: 'Earth Inertial Axes', '21 Jul 2014 00:11:28.000', and 'Time Step: 3.00 sec'. At the bottom right, the text reads: 'KARISMA'.

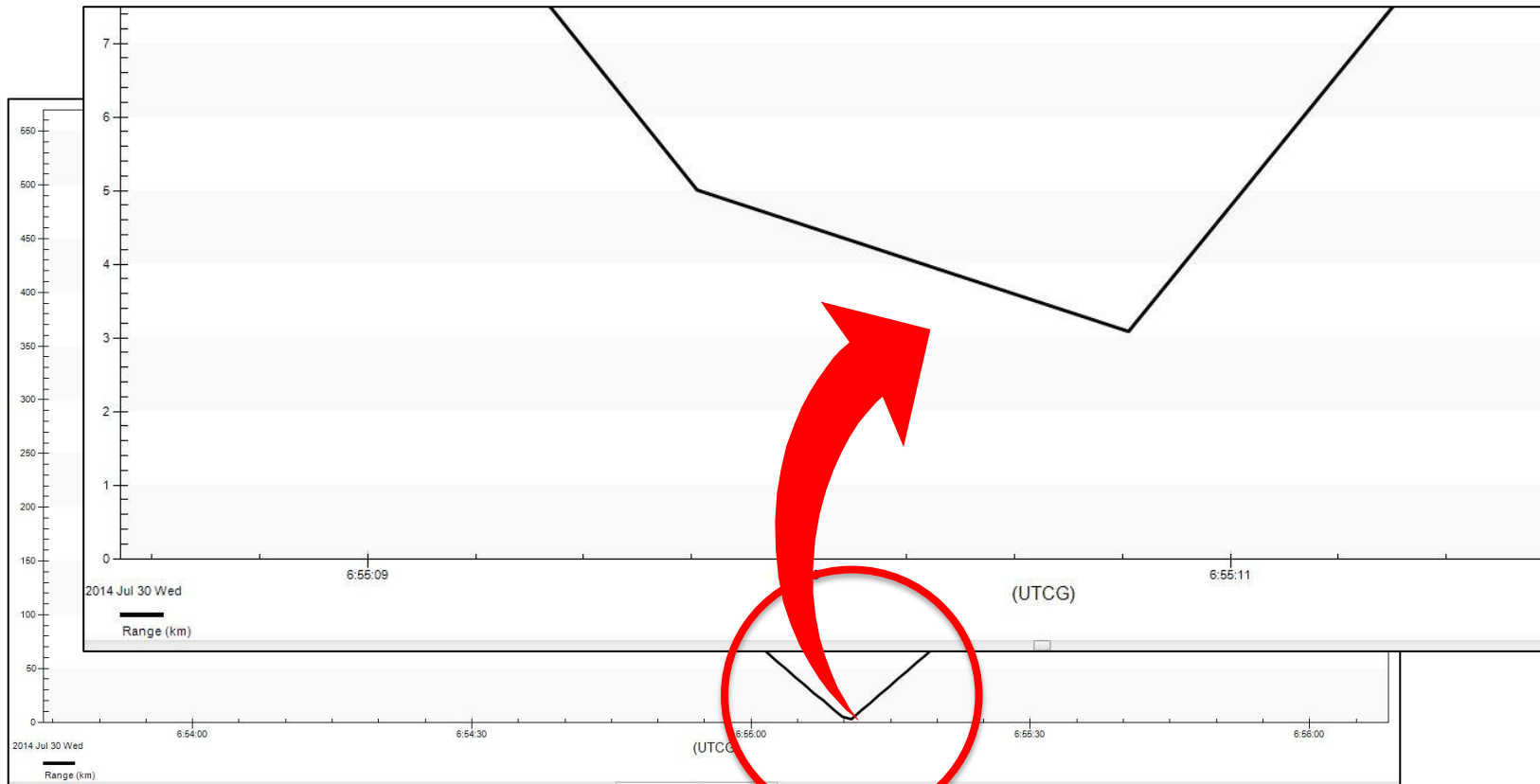
Animation Button

CAM : Conjunction Analysis Module

- **Screening (Coarse Assessment)**
 - using TLE catalog
 - Automatic processing by scheduling
- **Fine Assessment**
 - using various orbit source including CDM, precise orbit by o/o, POD by radar & optical measurement
 - Send conjunction events to AMM for COLA planning
- **JSpOC's CDM assessment**
 - Using JSpOC's CDM
 - Automatic process when CDM arrives
- **Support**
 - Trend analysis
 - Conjunction Geometry analysis using VDF

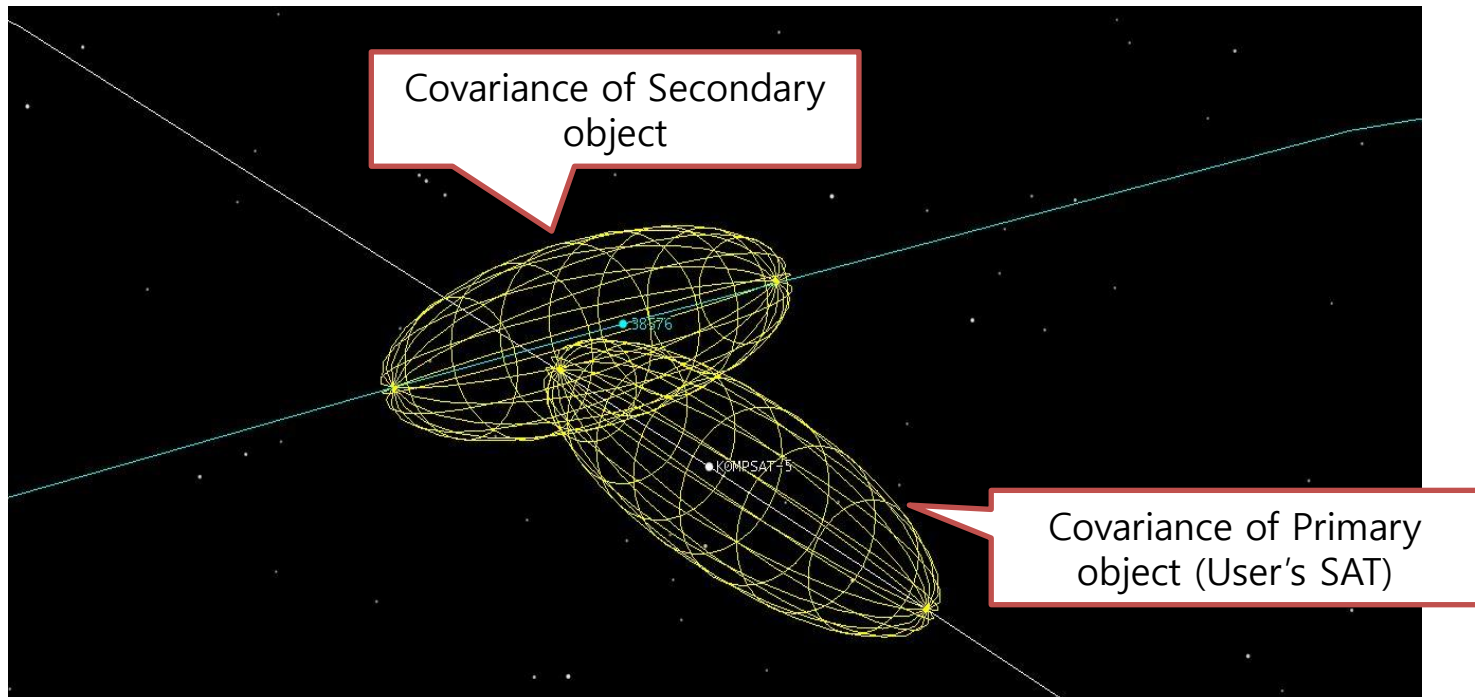
Trend Analysis of Conjunction

- Events update time vs. Miss Distance at TCA
- Events update time vs. Collision Probability at TCA



3D Conjunction Analysis

- Covariance Ellipsoid
- RIC Distance
- Conjunction Geometry
- Animation



Screening Setup UI

The screenshot shows the Karisma Screening Setup interface. On the left is a navigation tree with 'Screening Setup' selected. The main area is divided into 'Primary' and 'Secondary' sections. The 'Primary' section has a 'Satellite' dropdown set to 'KOMPSAT-2' and an 'Orbit Source' dropdown set to 'Ground Station Data'. Below these are input fields for 'Radial' (5.0 m), 'In-Track' (20.0 m), and 'Cross-Track' (10.0 m). The 'Secondary' section has an 'Orbit Source' dropdown set to 'NORAD TLE Catalog' and similar input fields for 'Radial' (5.0 m), 'In-Track' (20.0 m), and 'Cross-Track' (10.0 m). A table below lists satellite data with columns for ID, Name, Orbit Type, Source, and various distance metrics. A callout box points to the 'Covariance File' checkbox and the 'Radial' input field in the Primary section, with the text 'Covariance Value (or using Covariance File)'. Another callout box points to the 'Orbit Source' dropdown in the Primary section with the text 'Orbit source for User's Satellites'. A third callout box points to the 'Orbit Source' dropdown in the Secondary section with the text 'Orbit source for Space Objects'. At the bottom, there is an 'Event Log' showing system messages.

Orbit source for User's Satellites

Orbit source for Space Objects

Covariance Value (or using Covariance File)

Satellite ID	Satellite	Orbit Type	Orbit Source	Radial(m)	In-Track(m)	Cross-Track(m)	Covariance File Path
36744	COMS-1	GEO	NORAD TLE Catalog	5	20	10	-
26032	KOMPSAT-1	LEO	NORAD TLE Catalog	100	100	100	-
29268	KOMPSAT-2	LEO	Ground Station Data	5	20	10	-
38338	KOMPSAT-3	LEO	NORAD TLE Catalog	5	20	10	-
39227	KOMPSAT-5	LEO	NORAD TLE Catalog	20	20	10	-

Event Log

```
(2014-07-21 14:18:22)S - VO * Overlay Add "C:\Karisma\WImage\Wlogo.png" XOrigin Right YOrigin Bottom Transparent On WindowID All
(2014-07-21 14:18:21)S - VO * Overlay Modify "AGL_Logo_small.ppm" Show off WindowID All
(2014-07-21 14:16:08)S - ACAT */AdvCAT/TrendAnalysisRun_AdvCAT Compute ShowProgress On
(2014-07-21 14:16:08)S - ACAT */AdvCAT/TrendAnalysisRun_AdvCAT Secondary Add "12987.sa" 20000 20000 20000
(2014-07-21 14:16:08)S - ACAT */AdvCAT/TrendAnalysisRun_AdvCAT Primary Add "KOMPSAT-5.sa" 20000 20000 20000
(2014-07-21 14:16:08)S - ACAT */AdvCAT/TrendAnalysisRun_AdvCAT PntToPnt On
```


Monitoring UI

Screening using TLE catalog

The screenshot displays the Monitoring UI interface, which is divided into several sections:

- Screening Table:** A table with columns: Time To TCA, TCA, Satellite, ID, Object, ID, Min. Range(km), Max. Probability, Radial(km), In-Track(km), Cross-Track(km), Start Time, and Stop Time. It lists various satellite conjunctions, such as METEOR 2-5 DEB and COSMOS 1328.
- Modify threshold & Refreshing:** A callout box pointing to the 'Modify' and 'Refresh' buttons in the control bar below the screening table.
- Trend Analysis of Conjunction:** A callout box pointing to the 'Trend Analysis' button in the control bar.
- Fine Assessment Table:** A table with columns: To COLA, Time To TCA, TCA, Issue Time, Satellite, ID, Orbit Source, Object, ID, Orbit Source, Measurement Type, and CDM Date. It provides detailed data for specific conjunctions.
- Fine Assessment using precise orbit:** A callout box pointing to the 'Delete' button in the control bar below the fine assessment table.
- CDM Data Display:** A table with columns: To FA, Time To TCA, TCA, Issue Time, Satellite, ID, Frame, Object, ID, Frame, CDM Date, and Min. Range. It is currently empty.

Conjunction Analysis

Scheduling

Satellite: Orbit Type:

Time: Fixed Check Periodic Check

Time: Hour

Alarm

CA Warning:

FA Warning:

Orbit Type:

Prediction duration: Duration Day

Satellite	Check Time	Time	Periodic	Unit	CA	Unit	FA	Unit	Duration	Unit
COMS-1	Fixed	01:55:00	-	-	5	Min. Range(Km)	3	Min. Range(Km)	3	Day
KOMPSAT-1	Fixed	17:17:15	-	-	3	Min. Range(Km)	1	Min. Range(Km)	3	Day
KOMPSAT-2	Fixed	01:52:50	-	-	3	Min. Range(km)	1	Min. Range(km)	3	Day
KOMPSAT-3	Fixed	17:42:00	-	-	3	Min. Range(Km)	1	Min. Range(Km)	3	Day
KOMPSAT-5	Fixed	15:31:00	-	-	3	Min. Range(Km)	1	Min. Range(Km)	3	Day

SMM Scheduling UI

Compute

Monitoring

Screening

Time To TCA	TCA	Satellite	ID	Object	ID	Min. Range(km)	Max. Probability	Radial(km)	In-Track(km)	Cross-Track(km)	Start Time
09:45:36	2014-07-29 02:42:45.117	KOMPSAT-2	29268	EBERS-1 DEB	32711	2.152	0.07E-07	1.534	0.221	1.493	2014-07-29 02:42:44.973
17:37:31	2014-07-29 10:34:39.820	KOMPSAT-2	29268	FENGYUN-1C DEB	31722	2.29	1.00E-06	1.534	0.221	1.493	2014-07-29 10:34:39.293
30:05:15	2014-07-29 23:02:24.277	KOMPSAT-1	26032	DELTA-1 DEB	19105	0.858	1.00E-06	0.798	-0.052	0.311	2014-07-29 23:02:24.055
37:58:01	2014-07-30 06:55:10.400	KOMPSAT-5	39227	BREEZE-M DEB	38776	1.501	1.00E-06	1.449	0.32	-0.225	2014-07-30 06:55:10.053

LEO 3.000000 GEO 10.000000

Fine Assessment

Satellite	ID	Orbit Source	Object	ID	Orbit Source	Measurement Type	CSM Status	CSM Date	Min. Range (km)	Analytic Prob
KOMPSAT-1	26032	TLE Catalog	DELTA-1 DEB	19105	NORAD TLE Catalog	-	Waiting	-	0.858	0.00E+00

LEO 1 GEO 3

JSpOC CDM

To FA	Time To TCA	TCA	Issue Time	Satellite	ID	Frame	Object	ID	Frame	CDM Date	Min. Rang
-------	-------------	-----	------------	-----------	----	-------	--------	----	-------	----------	-----------

Min. Range(km)
2.152
2.29
0.858
1.501

Min. Range (km)
0.858

Fine Assessment (Manual)

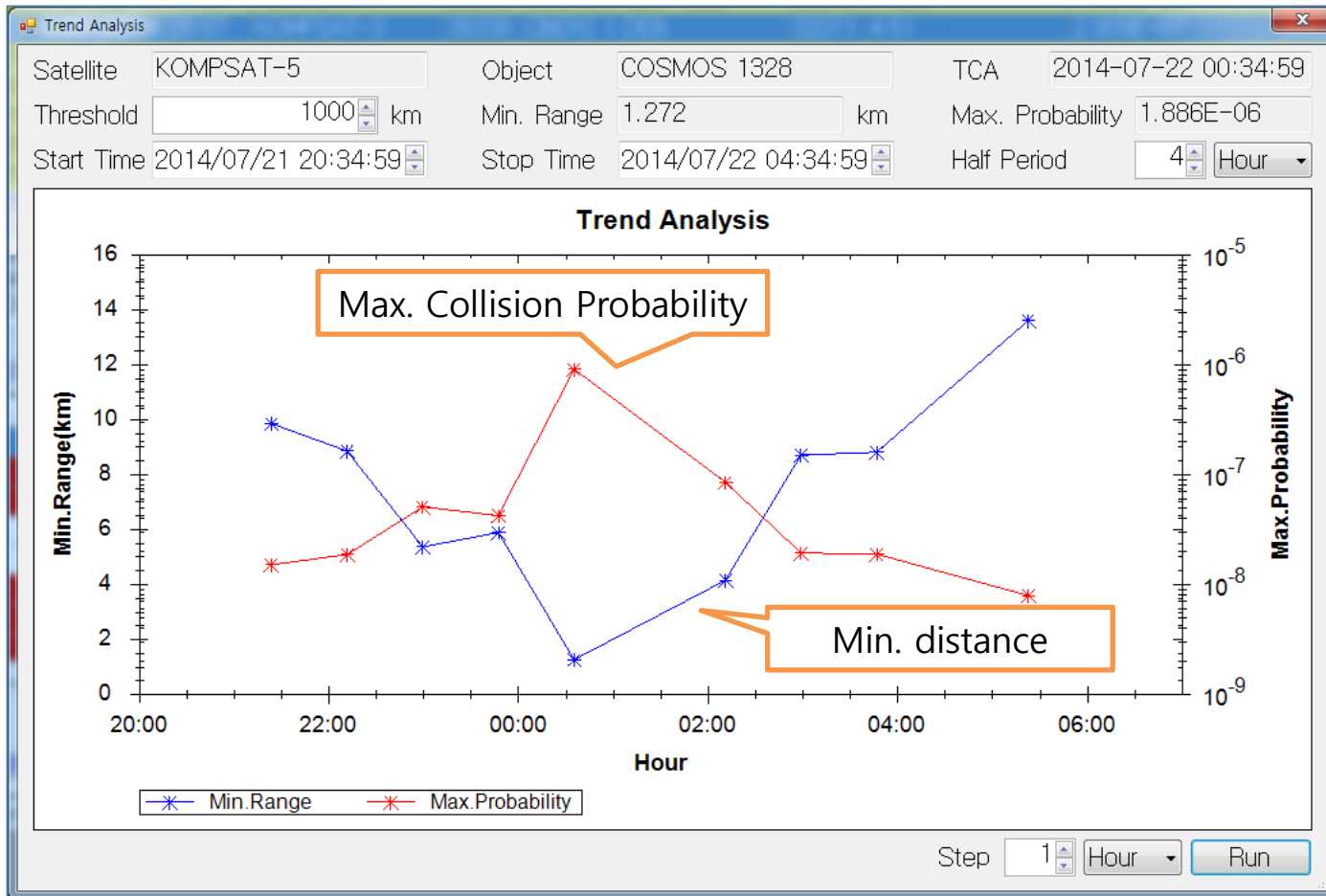
- Manual Analysis using provided orbit source by user
- Input : orbit source, covariance (File)

Orbit source directory

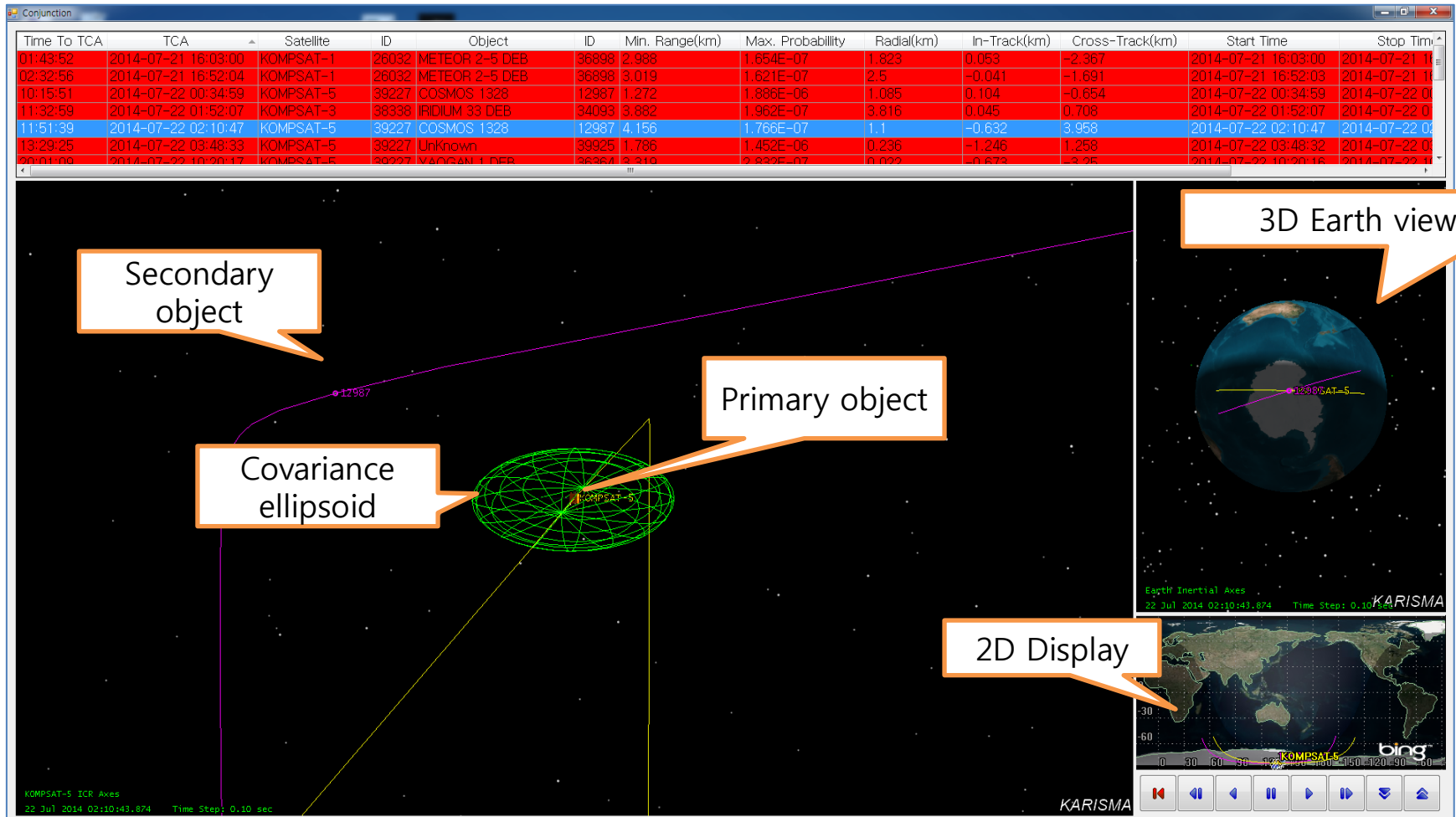
Covariance input

ID	Orbit Source	Object	ID	Orbit Source	Measurement Type			
39227	POD Ephemeris	COSMOS_1328	12987	POD Ephemeris	Radar	4.156	1.836E-008	1.836E-008
39227	POD Ephemeris	COSMOS_1328	12987	POD Ephemeris	Radar	5.766	1.435E-008	1.435E-008
39227	POD Ephemeris	COSMOS_1328	12987	POD Ephemeris	Radar	8.712	1.301E-008	1.301E-008
39227	POD Ephemeris	COSMOS_1328	12987	POD Ephemeris	Radar	8.817	1.594E-008	1.594E-008
39227	POD Ephemeris	COSMOS_1328	12987	POD Ephemeris	Radar	12.829	1.059E-008	1.059E-008
39227	POD Ephemeris	COSMOS_1328	12987	POD Ephemeris	Radar	13.599	1.242E-008	1.242E-008
39227	POD Ephemeris	COSMOS_1328	12987	POD Ephemeris	Radar	17.357	7.722E-009	7.722E-009
39227	POD Ephemeris	COSMOS_1328	12987	POD Ephemeris	Radar	18.46	8.652E-009	8.652E-009
39227	POD Ephemeris	COSMOS_1328	12987	POD Ephemeris	Radar	22.088	5.017E-009	5.017E-009
39227	POD Ephemeris	COSMOS_1328	12987	POD Ephemeris	Radar	23.394	5.362E-009	5.362E-009
39227	POD Ephemeris	COSMOS_1328	12987	POD Ephemeris	Radar	26.953	2.892E-009	2.892E-009
39227	POD Ephemeris	COSMOS_1328	12987	POD Ephemeris	Radar	28.397	2.945E-009	2.945E-009
39227	POD Ephemeris	COSMOS_1328	12987	POD Ephemeris	Radar	31.921	1.173E-009	1.173E-009

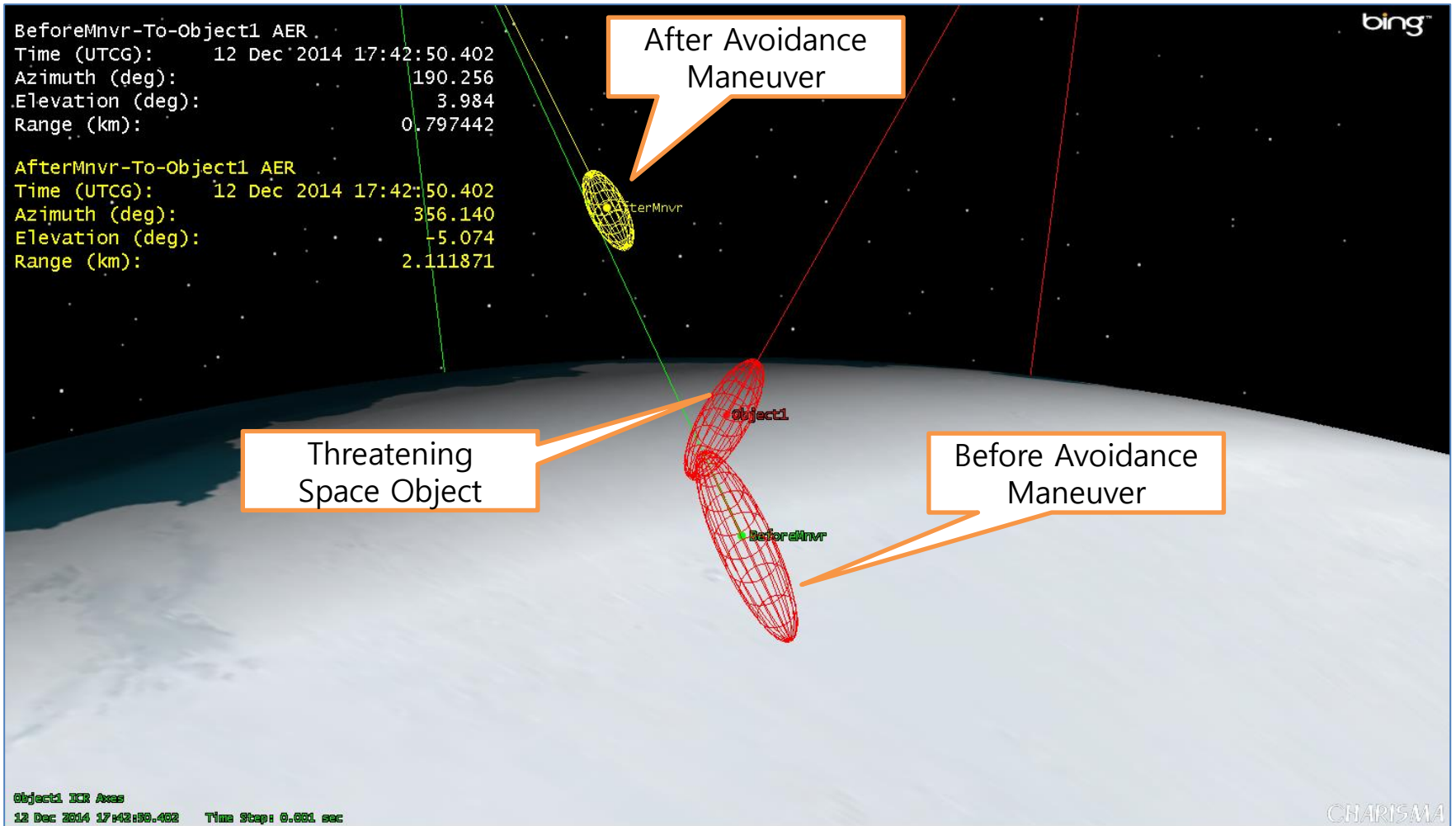
Trend Analysis



Conjunction Geometry (VDF)

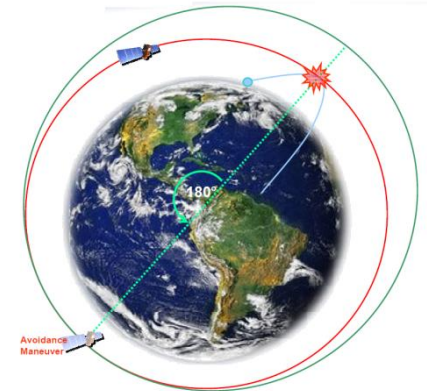


Conjunction Geometry (VDF)

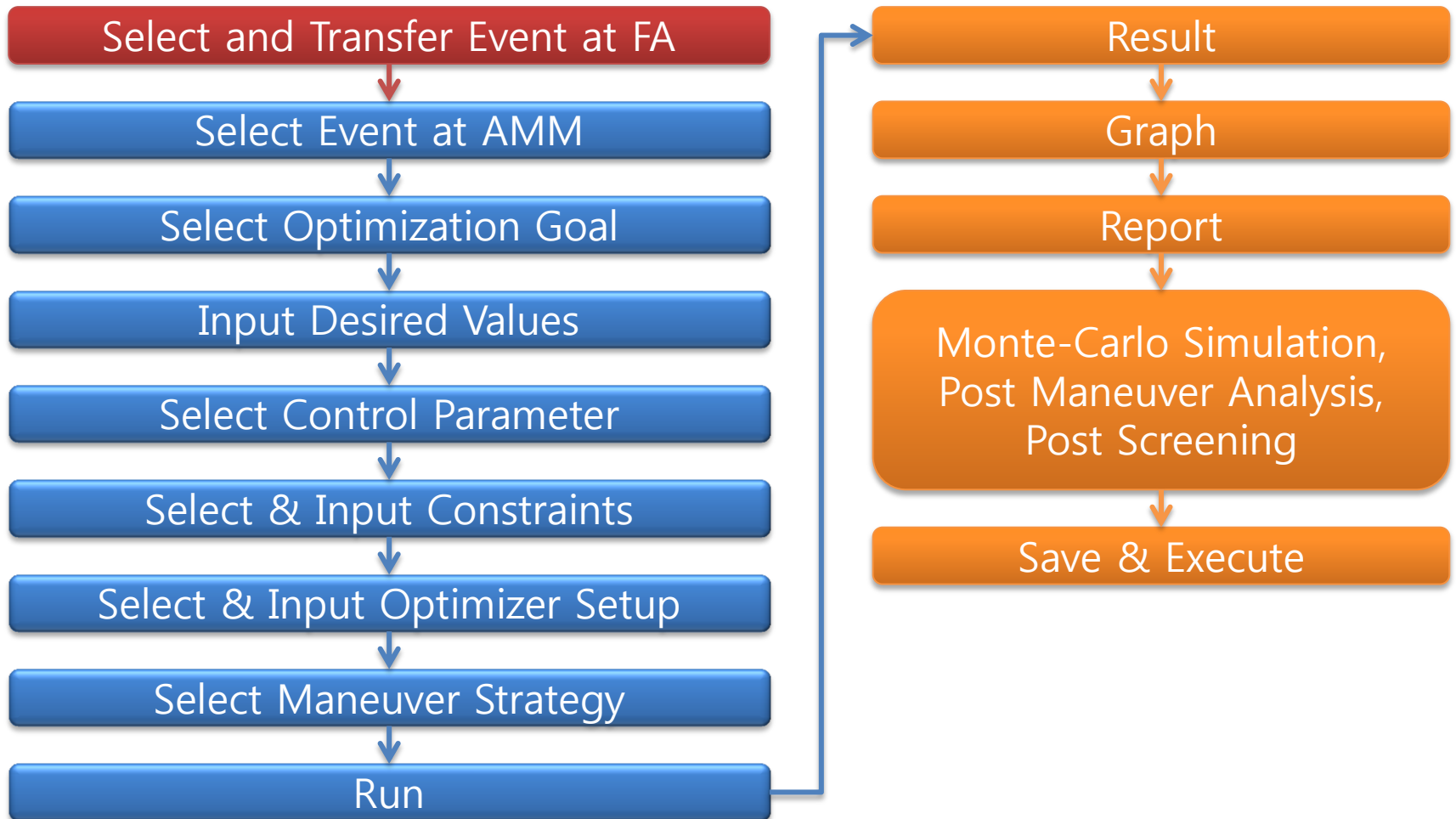


AMM : Avoidance Maneuver Module

- **Generate Collision Avoidance (COLA) Maneuver Plan**
 - Transferred from Event list of CAM Fine Assessment
- **Optimization COLA**
 - 7 Optimization algorithms including heuristic algorithms like GA, PSO
- **Multiple, Complex Targeting**
 - Against for Multi-threatening objects
 - Considering various operations conditions
 - Ground-track maintenance, station-keeping
- **Support**
 - Monte-Carlo simulation
 - Post COLA burn analysis
 - Re-assessment after COLA



Flow-chart of COLA planning



COLA – LEO CASE

The screenshot shows the KARISMA software interface with the following components:

- System Management:** A tree view on the left containing: Scheduling Setup, Satellite&Object DB, Tracking Station DB, FTP Download&Upload, Tracking Data&Request, JSpOC CDM Archive, Log History.
- Conjunction Analysis:** Screening Setup.
- Orbit Analysis:** Maneuver Planning.
- Output:** A section for mission results.
- Maneuver List:** A table with columns: Plan, Send, Selection, Creation Time, Issue Time. A callout box labeled "Event for COLA" points to a row with Selection checked.
- Analysis Time:** Start Time: 2014/07/30 00:00:00 UTC, Stop Time: 2014/07/31 00:00:00 UTC. A "Normal Simulation" button is present.
- Targeting:** A panel with radio buttons for LEO (selected) and GEO. A callout box labeled "Targeting for COLA" points to this section.
- Monte Carlo Simulation:** Option: Position Error, Thruster Error. Sigma: 1σ, Solution Number: 1. A callout box labeled "Monte Carlo simulation" points to this section.
- Event Log:** A log at the bottom showing system events and simulation steps.

The zoomed-in screenshots show the following Targeting configuration options:

- Targeting 1:** Orbit Type: LEO (selected), GEO.
- Targeting 2:** Orbit Type: Single (selected), Multi.
- Targeting 3:** Optimization Goal: Minimize Delta V (checked). Preference: Increasing Altitude (selected), No Preference, Decreasing Altitude.
- Targeting 4:** Optimization Goal: Min. Distance (2 km), Radial Distance, Numeric Probability, Max. Probability, Analytic Probability.
- Targeting 5:** Velocity: Vi (checked), Vr, Vc. Maneuver Time prior to TCA: Fixed (selected), TCA From: -3 Hr, Stop Time: 2014/07/30 15:17:55 UTC.
- Targeting 6:** Optimization Goal: Del -V (checked). Lower Limit: -1.0 m/s, Upper Limit: 1.0 m/s. Other options: Burn Duration (Max. 0.0 sec), Ground-Track Deviation (0 km).

COLA – LEO CASE

Number of Solution: No1

Orbit before COLA

COLA Plan

Result of COLA

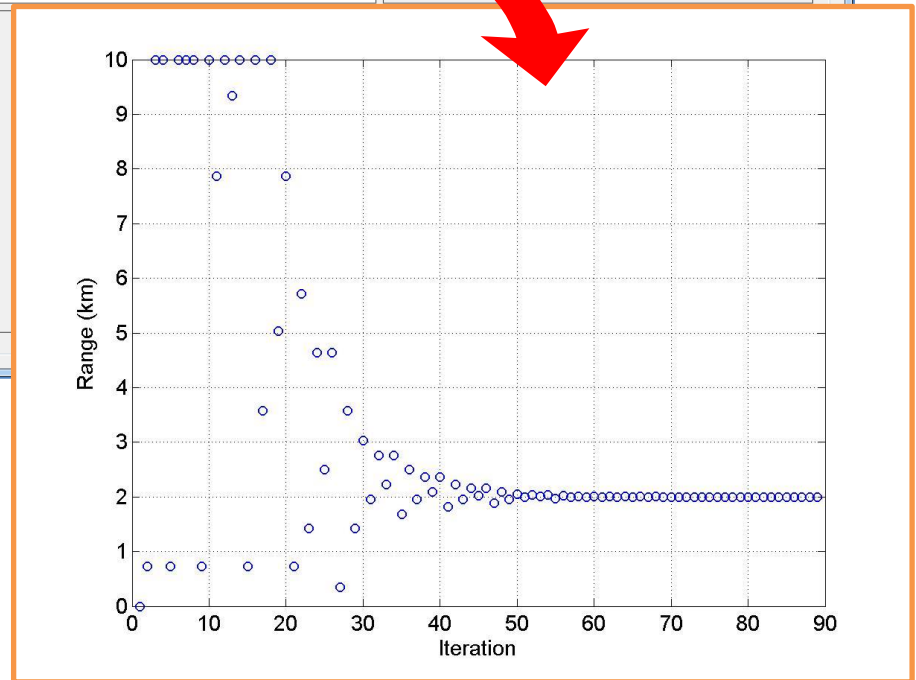
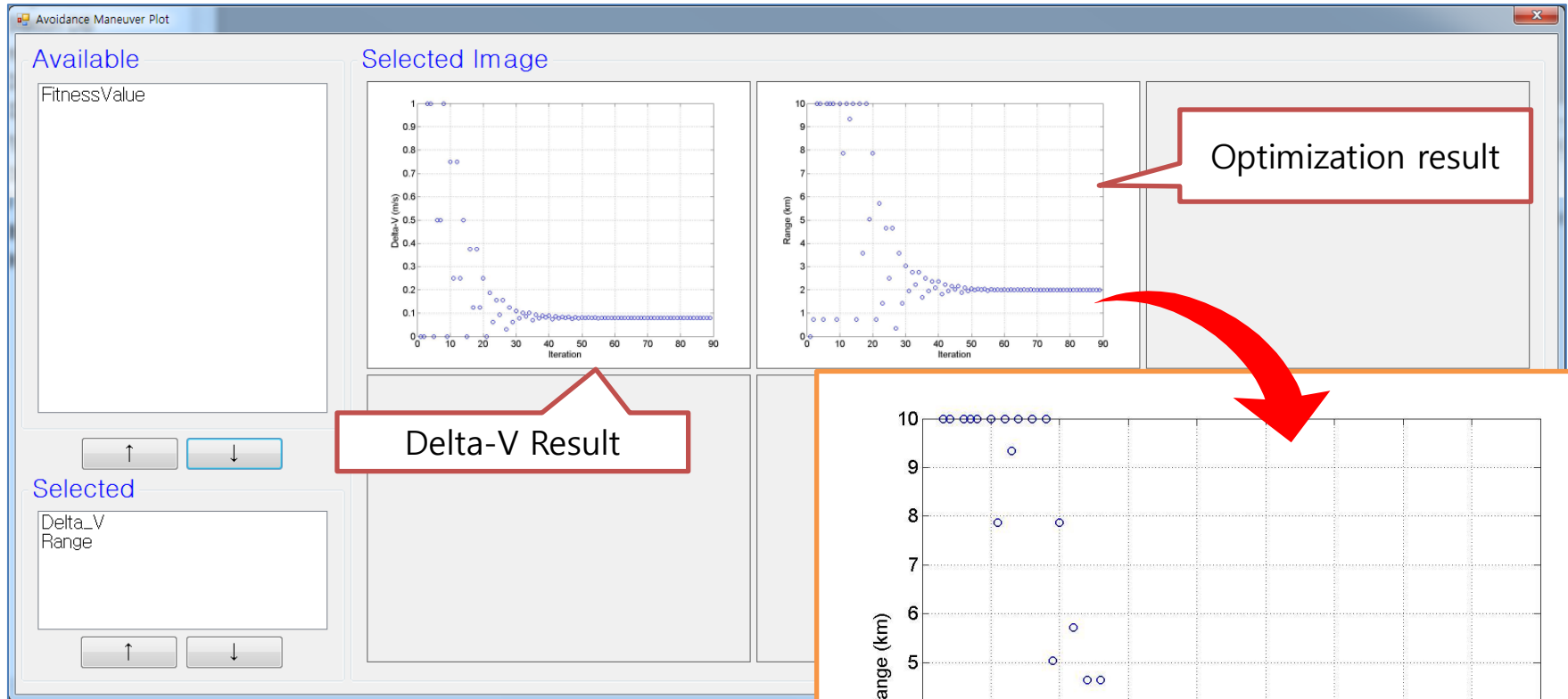
Orbit after COLA

Before Maneuver			After Maneuver		
Semimajor Axis	7068.014	km	Semimajor Axis	7068.163	km
Eccentricity	0.00214		Eccentricity	0.00213	
Inclination	98.13200	deg	Inclination	98.13200	deg
RAAN	150.27400	deg	RAAN	150.27400	deg
Argument of Perigee	104.11200	deg	Argument of Perigee	103.70200	deg
True Anomaly	226.01200	deg	True Anomaly	226.42200	deg

Avoidance Maneuver1			Avoidance Maneuver2		
Burn Start	2014-07-30 15:17:55	UTC	Burn Start		UTC
Intrack DeltaV	0.07940	m/s	Intrack DeltaV		m/s
Radial DeltaV	0.00000	m/s	Radial DeltaV		m/s
Crosstrack DeltaV	0.00000	m/s	Crosstrack DeltaV		m/s
Burn Duration	4.09151	sec	Burn Duration		sec
Used Fuel	0.03593	kg	Used Fuel		kg

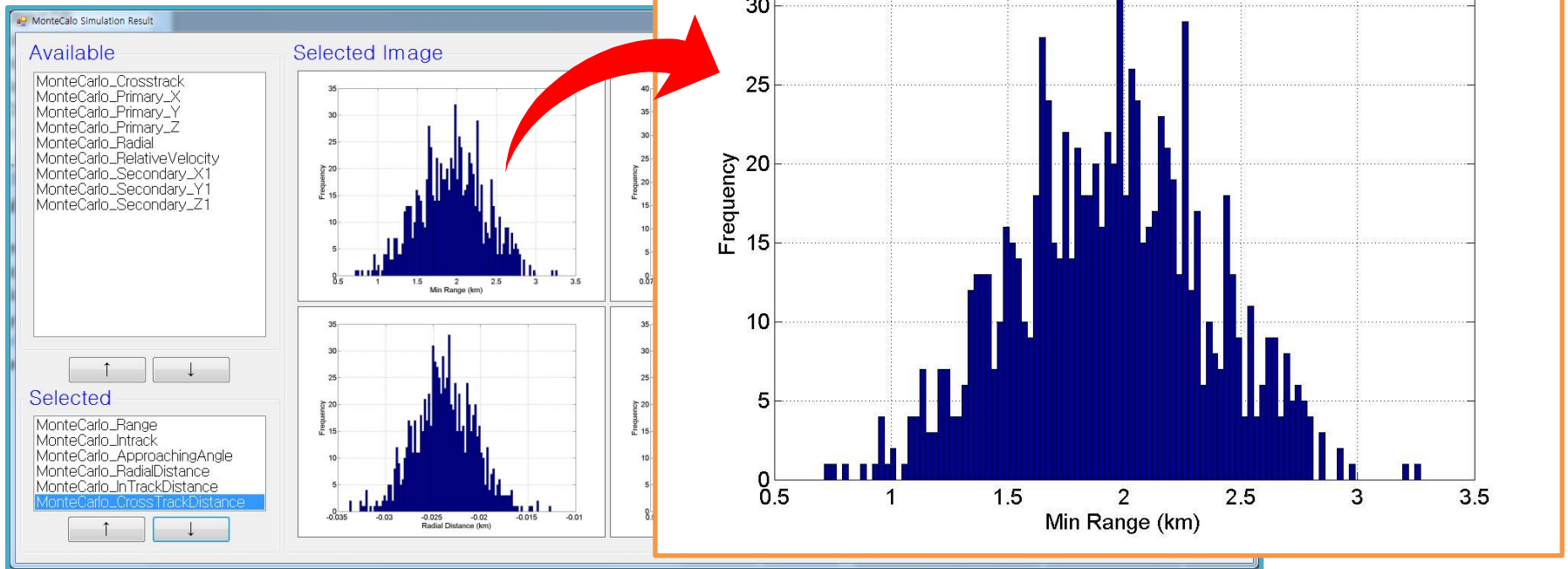
Maneuver Result		
Fit1	0.07940	
Fit2		
Min Range	2.00001	km
Maneuver Cycle	0.06111	Day
Radial Distance	-0.02361	
DeltaV	0.07940	m/s
Chan's Probability	0.00000	
Patera's Probability	0.00000	
Alfano's Probability	0.00000	
Max. Probability	0.00000	

COLA – LEO CASE



Monte Carlo Simulation

- Orbit uncertainty
- Thruster error



Normal Maneuver - LEO CASE

Orbit by o/o

Satellite: KOMPSAT-3 Orbit Type: LEO

Simulation Time
Start Time: 2014/07/30 00:00:00 Stop Time: 2014/07/31 00:00:00

Maneuver Planning
Analysis Time
Start Time: 2014/07/30 00:00:00 Stop Time: 2014/07/31 00:00:00

Goal
LEO Semi-major Axis: 7085.000 km

Maneuver Start Time
 Fix 2014/07/30 12:00:00 UTC
Maneuver Search Interval: 0 hour
2014/07/21 15:55:12 ~ 2014/07/21 15:55:12

Options
Tolerance: 0.01000 Max. Iteration: 50
Perturbation: 1.0e-02 Max. Step: 1.0e-03
Engine Model: View

Graphs:
Ephemeris Path: C:\W\Karisma\WFA_Ephemeris\WKOMPSAT-3.e
Before Maneuver: Graph (Semi-major Axis(km))
After Maneuver: Graph (Semi-major Axis(km))

Targeting Setup

After maneuver

Before maneuver

Event Log
(2014-07-21 15:56:15)S - InitialState */Satellite/NM_Simulation_Sat Import STKFile C:\W\Karisma\WFA_Ephemeris\WKOMPSAT-3.e
(2014-07-21 15:56:15)S - Propagate */Satellite/NM_Simulation_Sat "30 Jul 2014 00:00:00.000" "31 Jul 2014 00:00:00.000"
(2014-07-21 15:56:14)S - SetAnimation * EndTime "31 Jul 2014 00:00:00.000" TimeStep 10 RefreshDelta 0.01 RefreshMode RefreshDelta
(2014-07-21 15:56:14)S - SetAnimation * StartTimeOnly "30 Jul 2014 00:00:00.000" TimeStep 10 RefreshDelta 0.01 RefreshMode RefreshDelta
(2014-07-21 15:56:14)S - SetEpoch * "30 Jul 2014 00:00:00.000"
(2014-07-21 15:56:14)S - SetTimePeriod * "30 Jul 2014 00:00:00.000" "31 Jul 2014 00:00:00.000"

COLA – GEO CASE

- Example Setup for GEO COLA

Analysis Time	2013.06.01 12:00:00.000 ~ 2013.06.10 12:00.000
TCA	2013.06.03 12:00:00.346
Number of Debris	4
CPA	100 m
Orbit	GEO
Desired Property	Min Range > 5km
Control Parameter	Maneuver start time, R.I.C Direction Delta-V
Delta-V Constraint	Max. +/- 1m/s
Maneuver Start Boundary	TCA-361 ~ TCA -12 hr
Max Burn Duration	30sec
Function Evaluation	GA, PSO, DE : Generation = 25, Population = 30
	SA : Iteration = 750
Burn Strategy	One Burn or Two Burn
Station Keeping Maintenance	$\pm 0.05\text{deg}(128.2\text{deg E, } 0 \text{ deg N.})$

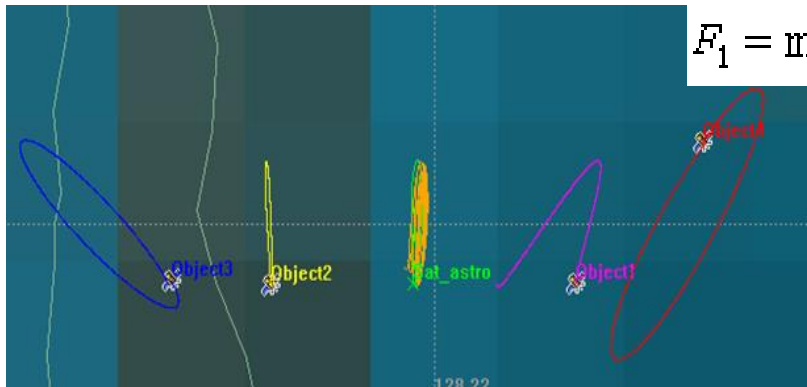
COLA – GEO CASE

- GEO COLA Result (1 Burn Case)**

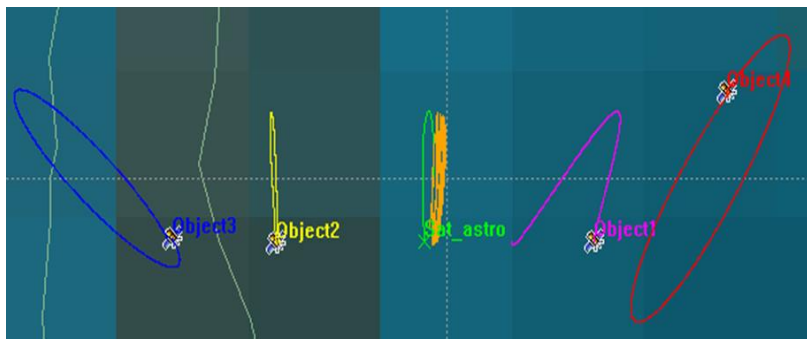
GA Fitness Function

$$F_1 = \min \sum |\Delta V_1| \cdot P \quad \begin{cases} \text{if } MinRange > 5 & \text{then } P = 1 \\ \text{if } MinRange < 5 & \text{then } P = 10 \end{cases}$$

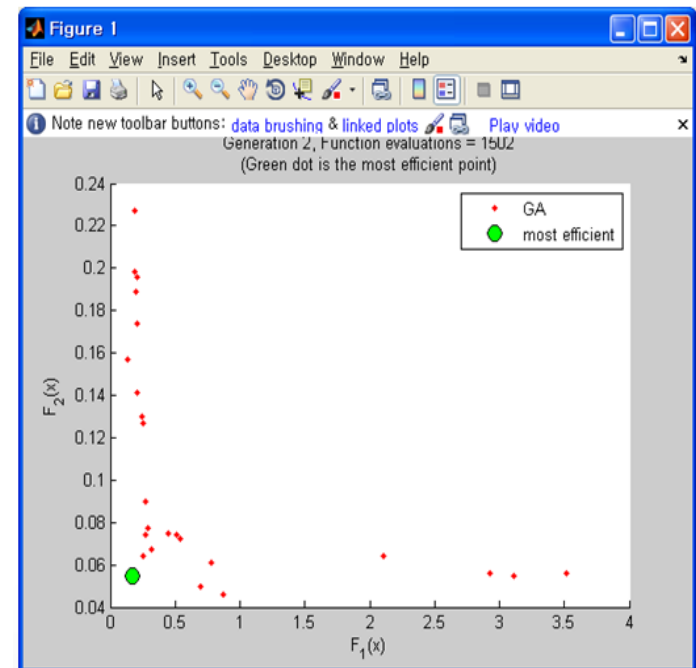
$$F_2 = |\Delta L| \cdot S_c, (S_c = 1)$$



Before COLA Maneuver



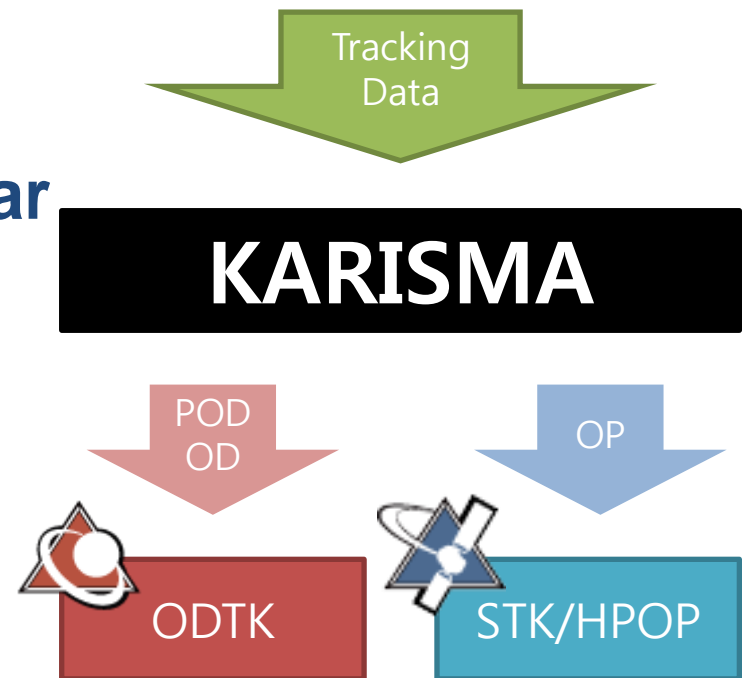
After COLA Maneuver



GA Fitness Value

ODM : Orbit Determination Module

- Precise orbit determination using ODTK
- Precise orbit prediction using STK/HPOP
- Processing GPS data, Radar data, Optic data
- Automatic OD processing (Optional)
- Comparison study
 - KARI, ESA data
 - * We do not show any result using restricted data



ODM UI

- ODM Main Windows

The screenshot displays the ODM Main Windows interface. On the left is a navigation tree with categories: System Management, Conjunction Analysis, Orbit Analysis, Maneuver Planning, and Output. The main area is divided into two sections: 'Current Status' and 'OD Status'. The 'Current Status' section contains a table with columns: Satellite, ID, Object, ID, No. Event, Time To TCA, TCA, Min. Range(km), Max. Probability, Radial(km), In-Track(km), and G. The 'OD Status' section contains a table with columns: Satellite, Start Time, OD Cycle, Processing Time, and Remaining Time. Two red callout boxes with arrows point to specific data points in these tables.

Current CAM Report

Satellite	ID	Object	ID	No. Event	Time To TCA	TCA	Min. Range(km)	Max. Probability	Radial(km)	In-Track(km)	G
KOMPSAT-1	26032	Unknown	39213	5	37:07:30	2013-11-19 04:58:51	1.41	1.538E-06	-1.15	-0.134	-0

Current Automation OD Schedule

Satellite	Start Time	OD Cycle	Processing Time	Remaining Time
KOMPSAT-1	2013-04-16 18:49:22	24	2013-11-19 18:49:22	01:49:29
KOMPSAT-3	2013-04-16 18:49:22	6	2013-11-19 12:49:22	01:49:29
KOMPSAT-3	2013-04-16 18:49:22	3	2013-11-19 18:49:22	01:49:29
KOMPSAT-3	2013-04-16 18:49:22	3	2013-11-19 12:49:22	01:49:29

ODM UI

- Orbit Determination Windows

The screenshot displays the ODM UI interface. On the left is a navigation tree with categories like System Management, Conjunction Analysis, Orbit Analysis, Maneuver Planning, and Output. The 'Orbit Determination Setup (Tap Menu)' is highlighted in the tree. The main window is titled 'Setup' and contains a table of satellite data and several configuration panels.

Satellite DB & CAM Object List

Satellite	Operational Mode	Reference Time	OD Cycle	...
COMS-1	Manual	None	None	None
KOMPSAT-1	Manual	None	None	None
KOMPSAT-2	Manual	None	None	None
KOMPSAT-3	Manual	None	None	None
KOMPSAT-5	Manual	None	None	None

Orbit Determination Manual

General | Measurement | Initial Orbit | Maneuver | Output

Filter Type: Filter Only

Force Modeling

Satellite Mass: 1800.0 kg Sectional Area: 7.0 m²

Gravity Model: JGM2 Gravity Model Order: 70

Drag Model: Jacchia 1971 Drag Coefficient: 2.2

SPP Coefficient: 1.5

OD Analysis

OD Analysis Method: POD Comparision Insert... Delete

Reference Data File

OP Setup

Stop Time: 2013/11/19 09:47:41 Time Step: 60 sec

Buttons: Load ODM XML..., OD Processing, Result

Event Log

ODM UI

- ODM Automation OD Setup Windows

The screenshot displays the ODM UI interface. On the left is a tree view with categories: System Management, Conjunction Analysis, Orbit Analysis, Maneuver Planing, and Output. The main window shows a table of satellite data and configuration panels for 'Satellite OD Setup' and 'Automatic Processing Setup'. Three red callout boxes highlight specific areas: 'Satellite Setup' points to the 'Satellite OD Setup' panel, 'Automation Setup' points to the 'Automatic Processing Setup' panel, and 'Current Automation OD Schedule' points to the table of satellite data.

Satellite	Start Time	OD Cycle	Processing Time
KOMPASAT-1	2013-04-16 18:49:22	24	2013-11-20 18:49:22
KOMPASAT-3	2013-04-16 18:49:22	6	2013-11-20 18:49:22
KOMPASAT-3	2013-04-16 18:49:22	3	2013-11-20 18:49:22
KOMPASAT-3	2013-04-16 18:49:22	3	2013-11-20 18:49:22

Satellite Setup

Automation Setup

Current Automation OD Schedule

ODM UI

- Orbit Prediction Windows

Orbit Prediction Setup

Satellite DB & CAM Object List

Satellite	Operational Mode	Reference Time	OD Cycle	Remaining Time
ODMS-1	Manual	None	None	None
KOMPSAT-1	Manual	None	None	None
KOMPSAT-2	Manual	None	None	None
KOMPSAT-3	Manual	None	None	None
KOMPSAT-5	Manual	None	None	None

Propagator: HPOP Start Time: 2013/11/19 09:47:42 Stop Time: 2013/11/19 09:47:42 Time Step: 60 sec

Force Modeling

Satellite Mass: 1800.000 kg Sectional Area: 7.000 m² Gravity Model: JGM2 Gravity Model Order: 70

Drag Model: Jaccchia 1971 Drag Coefficient: 2.2 SRP Coefficient: 1.5

Initial Orbit Information

Epoch Time: 2013/11/19 09:47:42 Keplerian

Coordinate System: J2000 Semimajor axis: 0.0000 km Arg. Periaapsis: 0.0000 deg

Coordinate Type: Keplerian Eccentricity: 0.00000000 RAAAN: 0.0000 deg

Covariance Info: ... Inclination: 0.0000 deg True anomaly: 0.0000 deg

Output File: ... Output Coordinate System: J2000

Buttons: Load ODM XML... OP Processing Report

Event Log

Summary

- Today, 'Must-Have Item' for Space Operations
- Cost-effective solutions as a decision maker software for space debris conjunction risk
- Automated and Easy Operations for 24hours/7day/365 days
- Easily Applied to Flight Dynamics System
- Very User Friendly, Intuitive and Powerful
- Commercial version of the KARISMA, **CHARISMA**, is released via AGI and KCEI (Korea)

Thank you for your attention!
Any Questions?