# NSSAO(National Space Situational Awareness Organization)
# Re-entry Prediction Process

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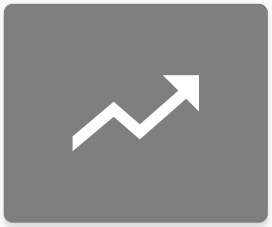
# KOREA's Space Situational Awareness

NSSAO
NATIONAL SPACE SITUATIONAL AWARENESS ORGANIZATION

## Increased risk from the Space

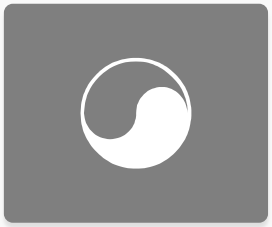
The fall of satellites and asteroids



Fast increase of Space debris

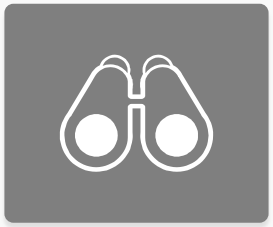
Change in awareness of the need for national space risk

## Increased Need for space risk response



Need national response to space risk situation

Need to establish measures to protect Human and space assests



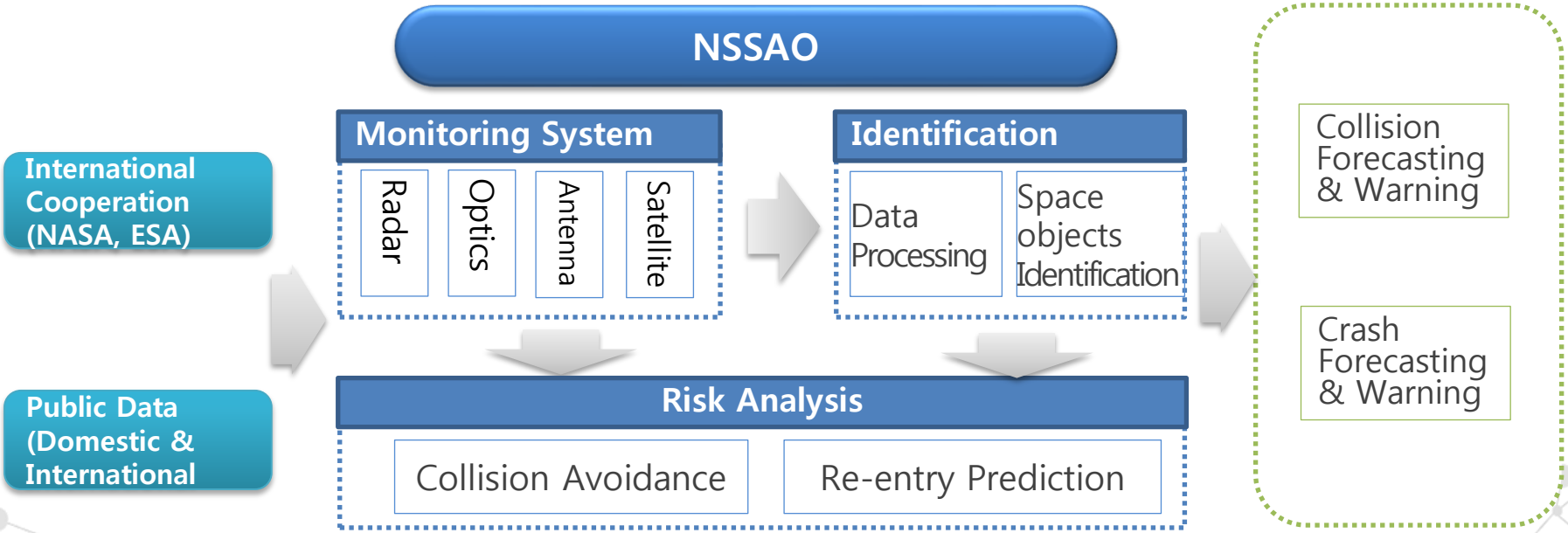
Need to acquire independent capability for space risk monitoring

**For safety and protection from Space Hazards**
**: Provision of timely and accurate information regarding the space hazards to people and infrastructure in orbit and on the ground**

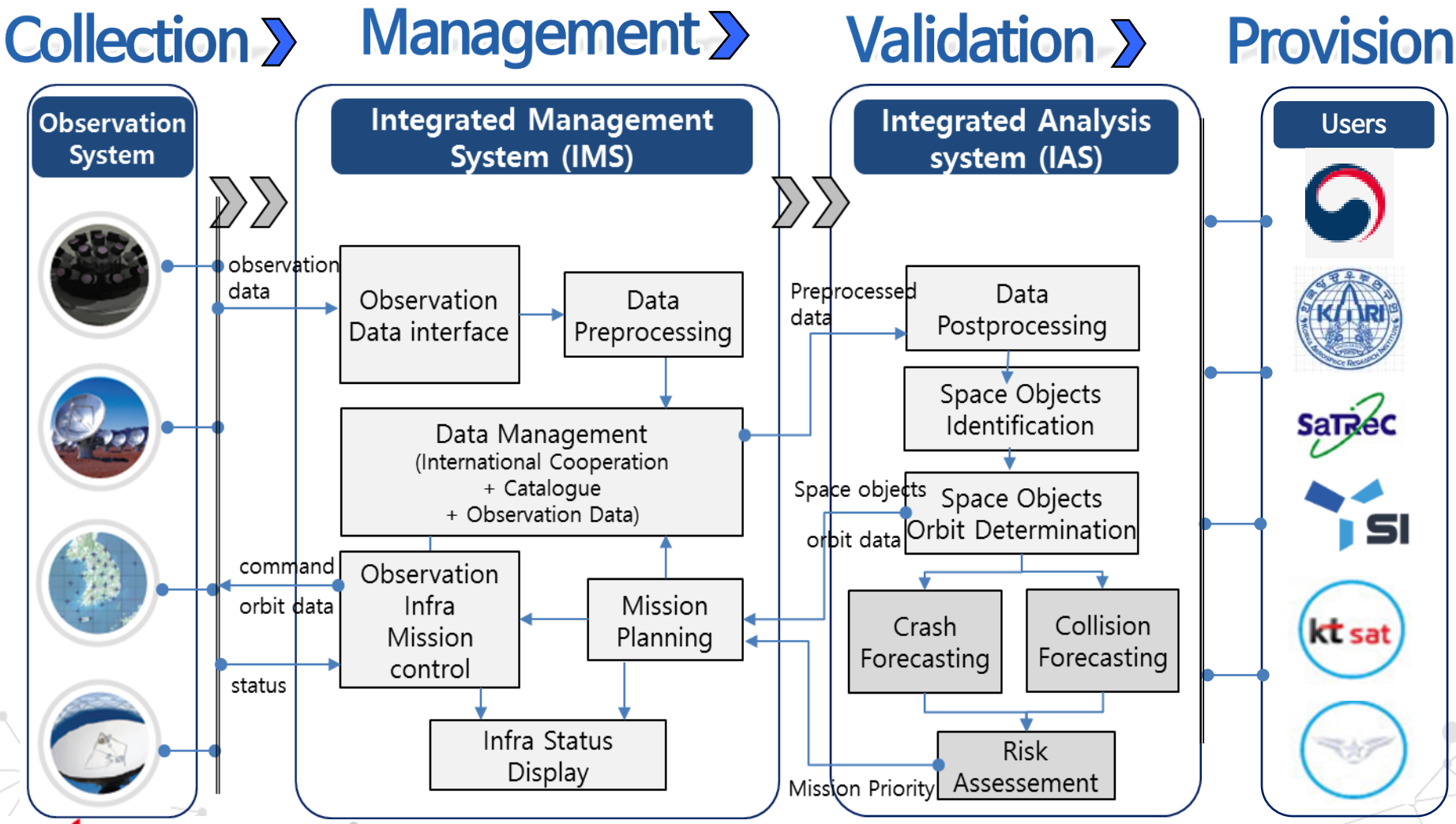
KASI Korea Astronomy and Space Science Institute

# National SSA Organization (KASI)

- Technical expertise to develop SSA capability and to support risk management (on orbit and during re-entry)
- Operation the self-contained equipment to observe the space situation
- Data processing and identification of space objects
- Analysis of risk assessment

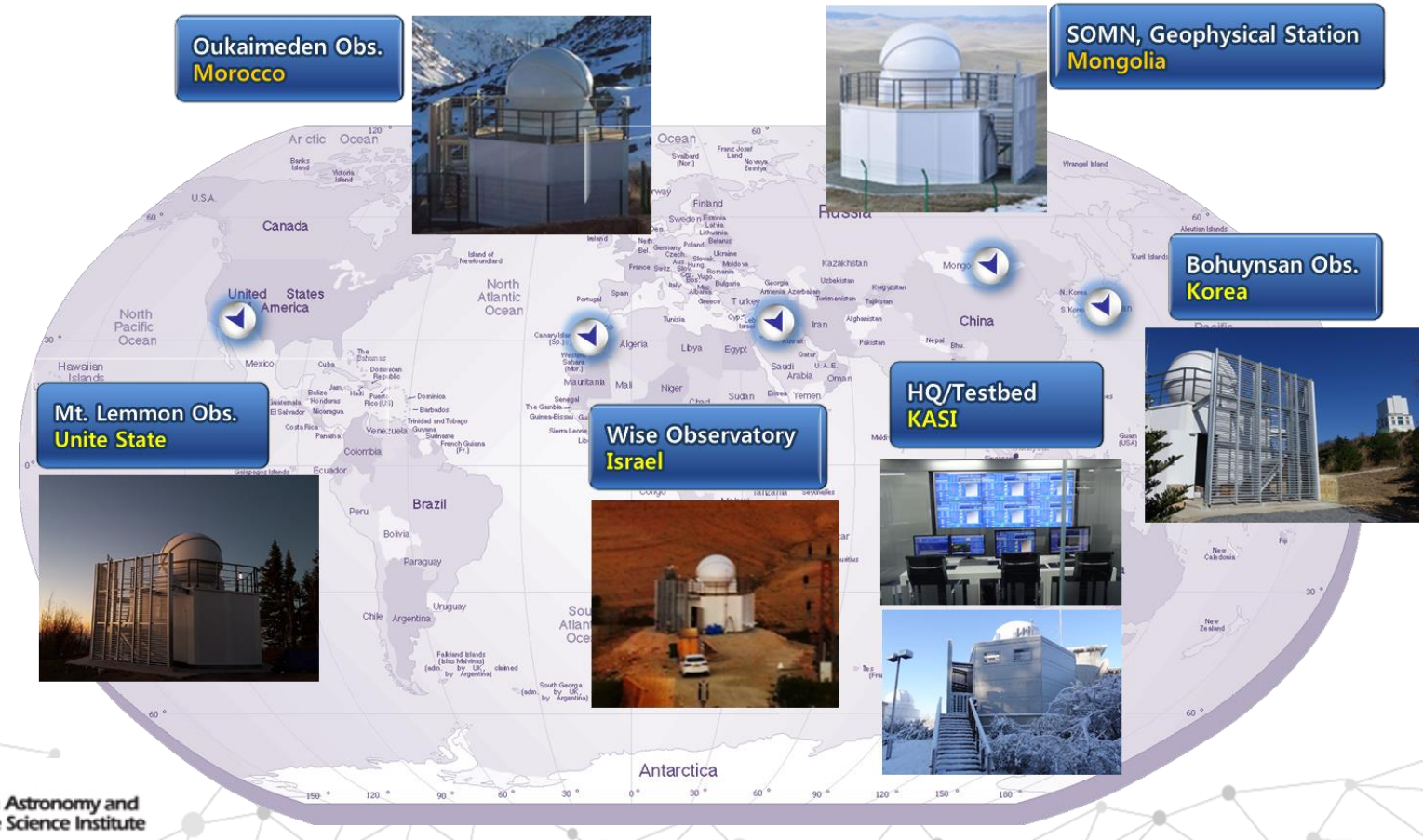


# SSA Mission (CMVP)



# OWL-Net (Optical Wide-field patroL-Network)

- 0.5m wide-field optical telescopes spread over the globe.
- Fully automated satellite tracking system
- Main mission: track domestic LEO satellites and monitor GEO region

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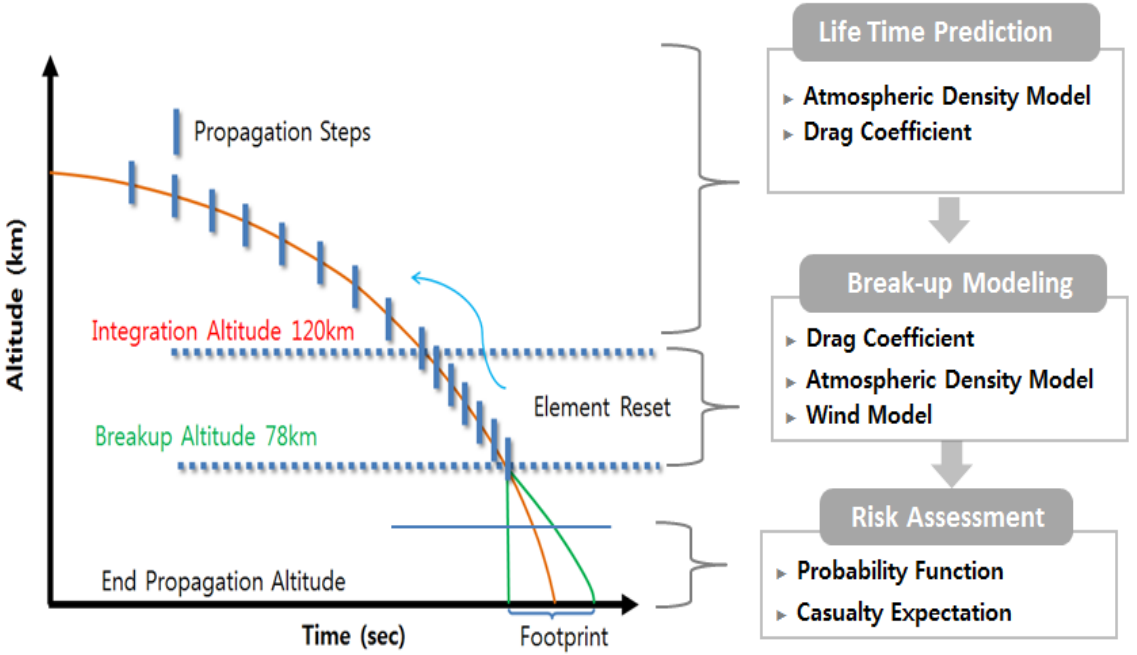
# Re-Entry Prediction Process

- OWL-Net observation data or TLE from Space-track
- < 250km, the estimated position and velocity is propagated by high precision orbit propagator using a numerical integration model until the break-up point.
- Based on the results of propagated the position and velocity information, the debris dispersion could be modelled by using break-up modelling approaches.



# Re-Entry Prediction (Alt. 250~100km)

- Orbit determination process was done with validated metric data from OWL-Net observation data.

- High Precision Orbit Propagator(HPOP) and Drag Scale Factor Estimation (DSFE) are used for re-entry prediction

- CHPOP: Numerical propagator for space objects with short lifetimes (within 2 months before re-entry)
  - 7(8)th-order Runge-Kutta high precision numerical integration
  - 70x70 geo potential model
  - The gravity of the Sun and Moon, solar radiation pressure
  - The atmospheric drag

- DSFE: Estimation of the drag scale factor including the ballistic parameter with mass, area to mass ratio and drag coefficient
  - using the orbital history from OWL-Net

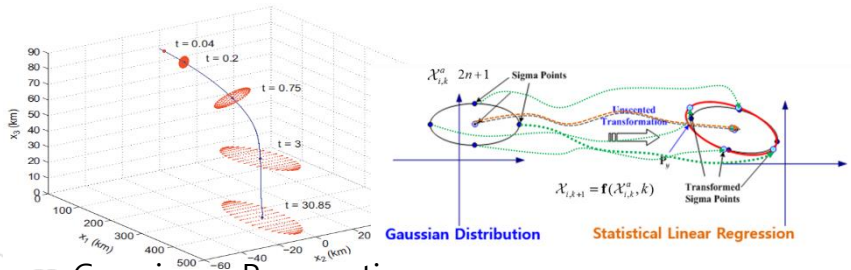
# Re-Entry Prediction (Alt. 100~0km)

- The effects of uncertainties due to atmospheric density models and drag coefficient should be considered.

## Re-entry Analysis

### Break-up Modeling

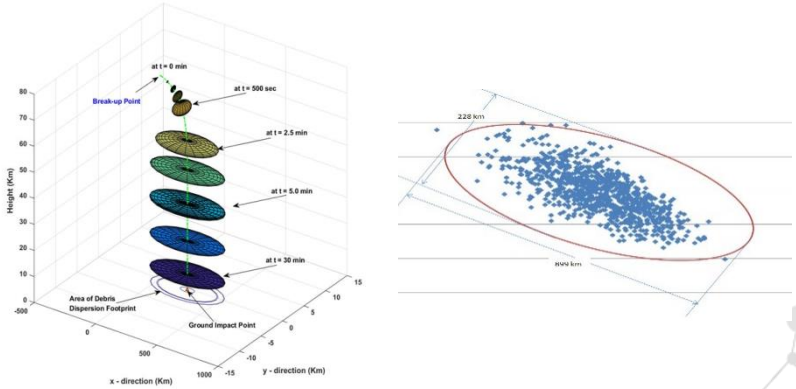
- ❖ Monte-Carlo Simulation Method
- ❖ Statistical Covariance Based
  - ✓ Lyapunov Equation Based Covariance Propagation Method
  - ✓ Statistical Regression Based Covariance Propagation Method




Covariance Propagation

### Risk Assessment

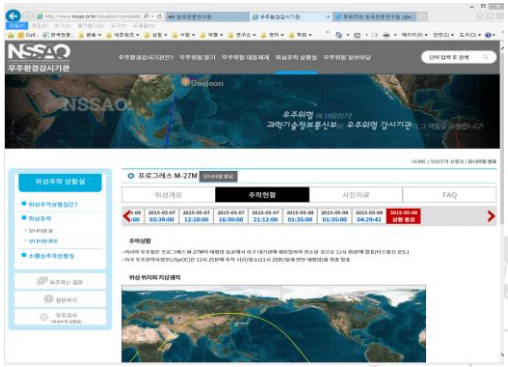
- ❖ Probability to fall on land
- ❖ Impact probability
- ❖ Casualty probability based on population density data



# Satellite Re-Entry Monitoring Room

- If the possibility of re-entry of an artificial space objects that may cause ground damage is recognized and the altitude of the space object is less than 250km.

- Official satellite re-entry monitoring room
  - The German satellite ‘Roentgen’ in 2011
  - The Russian space explorer ‘Phobos-Grunt’ in 2012
  - The Russian satellite ‘Cosmos 1484’ in 2013
  - The European geodetic satellite ‘GOCE’ in 2013
  - The Russian cargo for the ISS ‘Progress M-27M’ in 2015
  - The Chinese space station ‘Tiangong 1’ in 2018 (Expected)

# SUMMARY

- The preparedness plan for space hazards is steadily being implemented through National Space Situational Awareness Organization (NSAAO).
- The process for re-entry prediction is undergoing as research phase and now faces many problems that need to be addressed.
- However, the level of current knowledge may provide an important clue for upcoming re-entry events
- The re-entry prediction for national space situational awareness is mandatory for a rapid response and It will be continued through improvements in OWL-Net observation data and analysis algorithm

# THANK YOU

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