Orbital debris removal by the active maneuvering spacecraft with tether net/gripper

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Outline

- Introduction
- Status of Home and Abroad
- Study Contents
- Current Status
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- Conclusions

Introduction

Background and Requirement

- **Increase in number.** Orbital debris will become a serious problem for low Earth orbit(LEO) and for the geosynchronous orbit(GEO).
  - Defunct satellites(either complete propellant reserve or fail)
  - Launch vehicle upper stages
  - Could not be re-orbited
- **Dangerous:**
  - Pose a serious collision risk
  - Generate a number of smaller bits of debris between large Orbit debris
- **Need for mitigation:**
  - Effective measures
  - Reasonable measures

Introduction

Objective

- **Active removal of large orbit debris (LEO,GEO):**
  - Avoid the excessive growth of orbit debris
  - One of most practical strategies

- **Active maneuvering spacecraft:**
  - Rendezvous and capture an inert,tumbling and non-cooperative target
  - Tow it to a graveyard orbit
  - Possess orbital maneuvering capability
  - Bus design
  - Payloads: tether net/gripper systems

Status of home and abroad

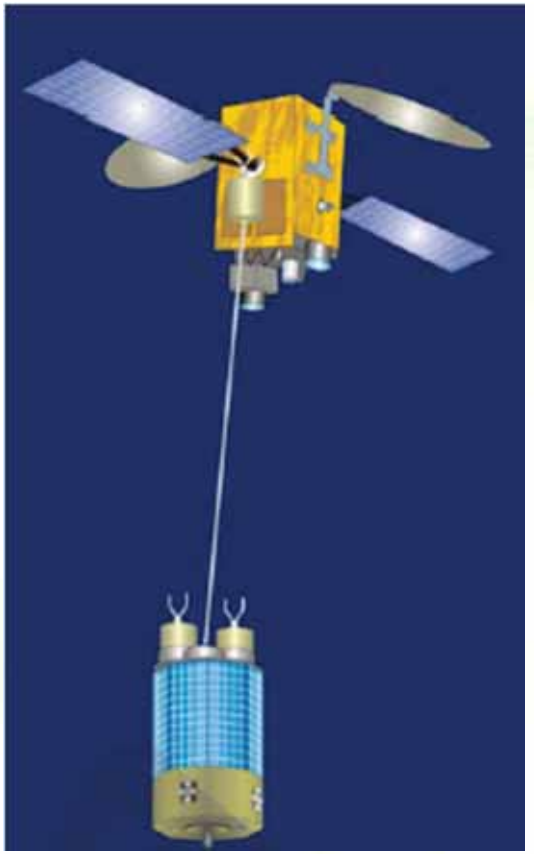
ESA:ROGER

- **Robotic Geostationary orbit Restorer:**
  - Arroach and capture defunct satellites in GEO
  - Transfer it to a graveyard orbit
- **ROGER study(payload):**
  - Tether -net system
  - Tether -gripper system

Status of home and abroad

- ESA:ROGER

Tether -net system

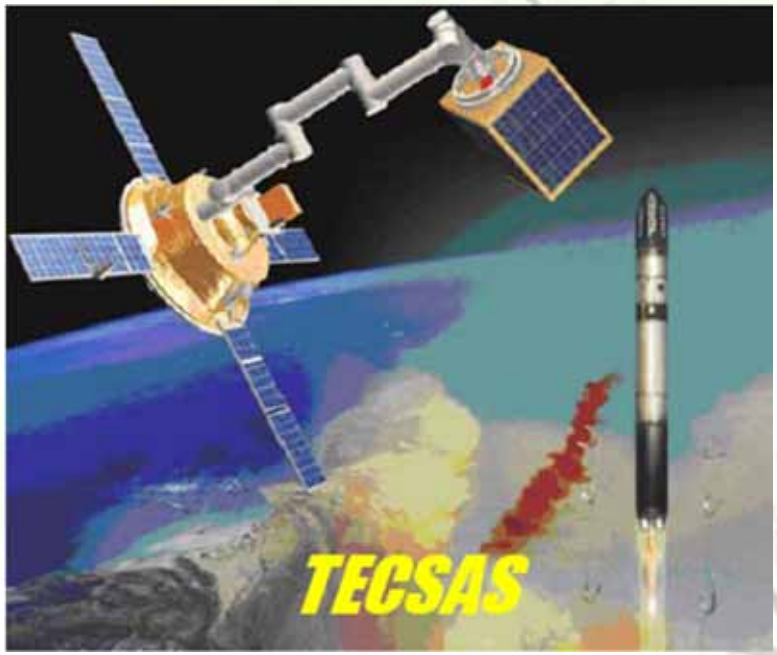


Tether -gripper system

Status of home and abroad

➢TECSAS

- **TEChnology Satellite for demonstration and verification of a Servicing System**
  - German Space Organization (DLR)
  - Canadian Space Agency (CSA)
  - Russian Mission Control Center(MCC)
- **Main objective:**
  - Unmanned on-orbit assembly
  - Unmanned on-orbit servicing



Status of home and abroad

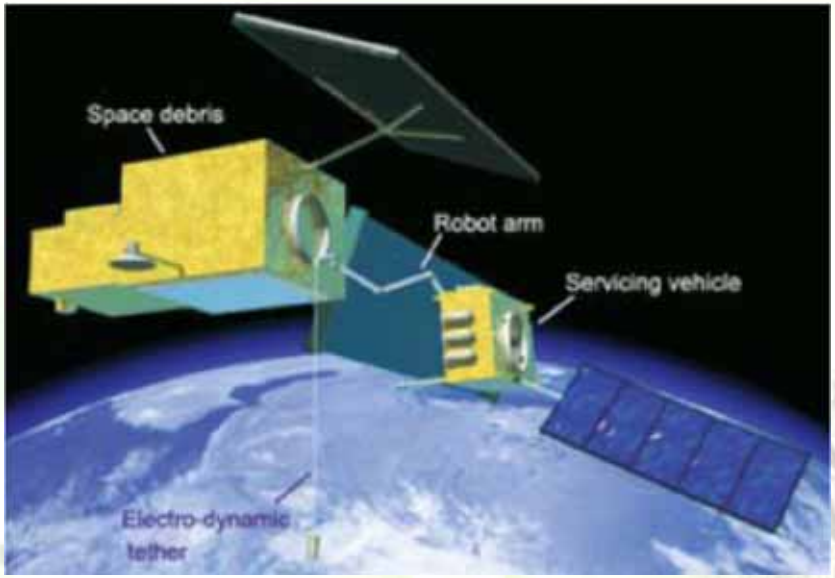
➢TECSAS

- **Demonstrate:**
  - Far rendezvous
  - Close approach
  - Inspection fly around
  - Capture of a non-cooperative and cooperative client
  - Stabilization and identification of the behavior of the coupled satellites
  - Flight maneuvers
  - Manipulation on the captured client
  - Attitude changes by manipulator motions
  - Decoupling of service and client satellites
  - Formation flight

Status of home and abroad

➢Japan:Space debris removal system

- **Mission**
  - Rendezvous with a target
  - Fly around it for inspection
  - Transfer the target to a disposal orbit
- **Key technologies:**
  - Cost-effective orbit transfer (electrodynamics tether)
  - Rendezvous
  - Angular momentum dissipation
  - Robot operation



Status of home and abroad

- Trend (Large orbit debris)
  - **Active removal**
    - Active maneuvering spacecraft
    - Possible measure
  - **Key technologies:**
    - Orbit rendezvous
    - Close approach and Station keeping
    - Capture
    - Transfer
  - **Payloads:**
    - Tether net system
    - Tether gripper system
    - Robotic arm

Study contents

- General system argumentation
  - **Concepts design and technical index**
  - **Spacecraft bus design**
    - Based on a new design, payload accommodation
  - **Payloads:**
    - Tether net system
    - Tether gripper system
- Key component technologies
  - **Exploration and identification of large orbit debris:**
    - Radar sensors
    - Vision sensors(optical and infrared sensors)
  - **Orbital rendezvous of large orbit debris:**
    - Long-range(absolute navigation)
    - Short-range(relative navigation)

Study contents

- **Close approach and station keeping of large orbit debris:**
  - A very close distance (within the reach of tether net/gripper)
  - Strictly control to avoid collision
  - Satisfy the requirements of releasing attitude
- **Capture operation of large orbit debris:**
  - Tumbling and non-cooperative target ,capture device
  - Attitude stabilization
- **Orbit transfer of large orbit debris:**
  - Transfer to a disposal orbit
  - Short tether
  - Pose a serious collision risk
  - To avoid collision
  - To tow the target, adjust the control system

Study contents

- Simulation
  - **Numerical Simulation:**
    - Verify key technologies
    - Evaluate the controller's performance
  - **Hard in the loop Simulation:**
    - Exercise hardware-software interfaces
    - Assess the efficacy of algorithms
    - Expose algorithm to hardware error characteristics
- Experimental verification
  - **Capture operation experiment**
  - **Payload releasing experiment**

Current Status

- **The major assumptions and requirements are as follows:**
  - Removal targets: large orbit debris
  - Types of debris orbit: GEO, LEO
  - Graveyard orbit: IADC guidelines
  - Mass of targets: 1000kg~3000kg
  - Number of targets: approximately 5
  - Payloads: tether net/gripper systems
- **Current work:**
  - General system argumentation
  - Key technology

Next Steps

- **Numerical Simulation :**
  - Software design
  - Software test

- **Hard in the loop Simulation :**
  - Navigation devices
  - Payloads

Conclusions

- **Main missions**
  - Active maneuvering spacecraft with tether net/gripper system
  - Controlling the threat from large orbit debris
- **Review**
  - Related studies
- **Discuss**
  - Study contents, Key technologies, Next steps
- **Development issues**
  - Payload design
  - GNC during rendezvous, capture and towing phase

Thank you for your attention !