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HTV 搭載導電性テザー実証実験（KITE）について

Current Development Status of Electrodynamic Tether Experiment on HTV

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HTV6 号機への搭載を目指して、JAXA では導電性テザー（EDT）実証実験「KITE」の開発を進めている。EDT は、導電性のワイヤー（テザー）に流れる電流と地磁気との干渉によって生じる電磁気力を利用する推進剤不要の推進系であり、システムの小型軽量化が可能な点に加え、マヌーバ中の推力方向制御が不要であることやデブリへの固定の容易性などの点で、低軌道デブリのデオービット用推進系として有力である。KITE では 700m 級のテザーによる EDT 技術の実証を予定しており、EDT を使用したデブリ除去システム構築のための最初のステップとなる。

An on-orbit demonstration of electrodynamic tether (EDT) on H-II Transfer Vehicle (HTV) is planned in JAXA. This plan is called KITE, Konotori Integrated Tether Experiment. The KITE is the first step to develop active space-debris removal systems using EDT. EDT is a promising as the de-orbit propulsion of the debris removal systems on low-earth orbits because of its various advantages, such as no consumable and low electric power required, no thrust vectoring needed during the maneuver, and easy attachment to debris. The primary objective of the KITE is to demonstrate the key technologies of EDT for debris removal.

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Current Development Status of Electrodynamic Tether Experiment on HTV

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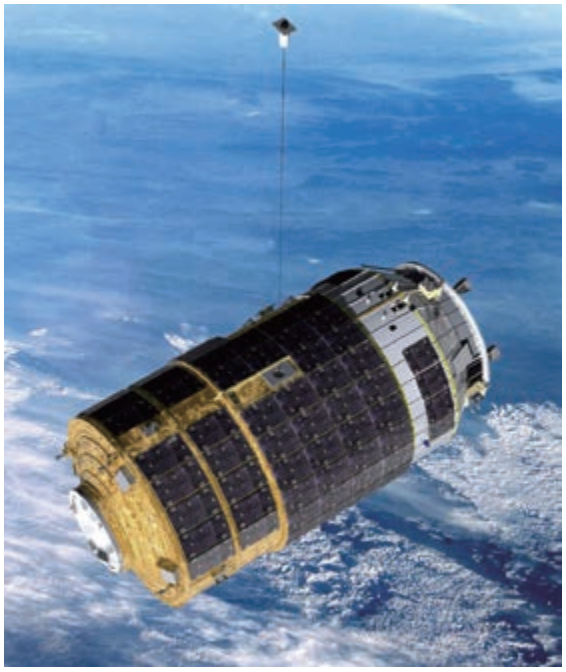
Presentation Outline

- *Introduction*
- *Overview & Objectives of KITE*
- *Mission Time Line*
- *Major Components*
- *Functions of Major Components*
- *Development Status*
- *Summary*



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Introduction

- Demonstration plan of electrodynamic tether (EDT) propulsion on H-II Transfer Vehicle 6 (HTV-6) is on-going
- The project is called *KITE*, Konotori Integrated Tether Experiment
- KITE-EDT mainly consists of bare-wire-tether for electron collection and field-emission-cathode for electron emission. This pair provides completely propellant-less propulsion system
- KITE is also equipped with other own components such as end-mass releasing mechanism, camera, magnetic sensor, electric potential monitor with plasma current probe, and data handling unit

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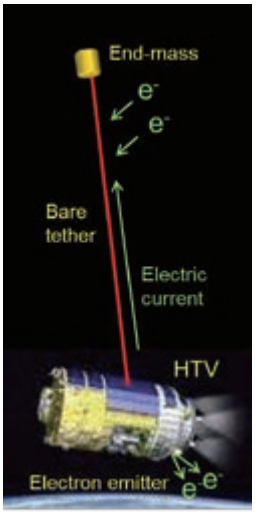
Overview of KITE



KITE Image on Orbit

KITE Specifications

Platform	H-II Transfer Vehicle (HTV)
Mission duration	7 days (planned)
Orbit	20 km (or more) below ISS orbit Altitude: 300 – 400 km Inclination: 52 deg.
Tether length	700 m (approx.)
Tether current	10 mA (approx.)
Electron collector	Bare tether
Electron emitter	Field emission cathode

Completely Propellant-less Combination

※EDT Thrust: ～0.1 mN (max.)

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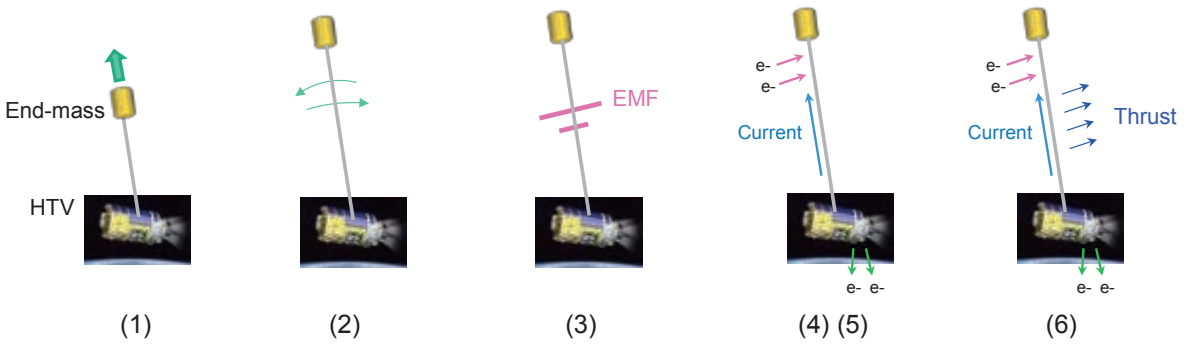
Objectives of KITE

- Primary objective of KITE is “To demonstrate key technologies of EDT preparing for future debris-removal application”
  - (1) Deployment of bare tether
  - (2) Motion monitoring of tether and end-mass
  - (3) Electric potential generation by electromotive force
  - (4) Electron collection by bare tether
  - (5) Electron emission by field emission cathode
  - (6) Thrust measurement



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Mission Time Line (1)

Day	Event	Image
Day 1	①Checkout of KITE Components	② Deployment ③ =3
	②End-mass Ejection (Tether Deployment)	
	③Tether Motion Stabilization by HTV Maneuver	
Day 2	④Observation of Tether Dynamics & ⑤Measurement of Electromotive Force	④ Vibration ⑤ EMF
Day 3	⑥Checkout & Characteristics Measurement of Field Emission Cathode	⑥⑦ Electron emission e-e-
	⑦Measurement of HTV Electric Potential with and w/o Electron Emission	

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Mission Time Line (2)

Day	Event	Image
Day 4	⑧Repetitive Measurement of Tether Electric Potential & Current for EDT Fundamentals	⑧ Electron collection, Current, Electron emission
Day 5	⑨Tether Motion Stabilization by HTV Maneuver (If required) ⑩Autonomous EDT Operation at Several Settings	⑩ Electron collection, Current, Electron emission
Day 6	⑪Autonomous EDT Operation at Maximum Electron Emission for EDT Thrust Measurement by Tether Vibration Monitoring	⑪ Observation of end-mass motion
Day 7	⑫Extra Time for Additional Tests ⑬Cutting of Tether from HTV	⑬ Cutting

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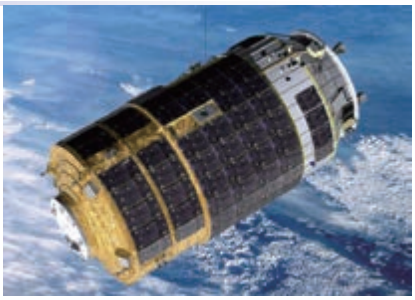
Major Components



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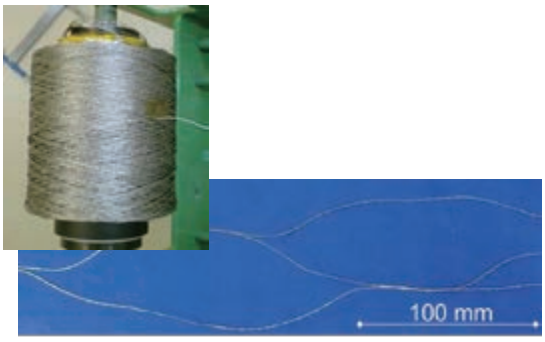
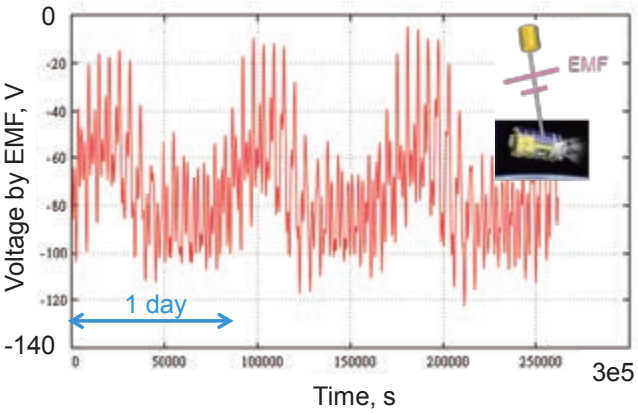
Bare Tether

- Functions
  - Electron collection from ambient space plasma
  - Voltage generation between tether ends by Electromotive force
  - Thrust generation by interaction between current and geomagnetic field



- Tether Length of 700 m
- Having "net" shape for tolerance to small debris impact and efficient electron collection



Estimated EMF variation on orbit

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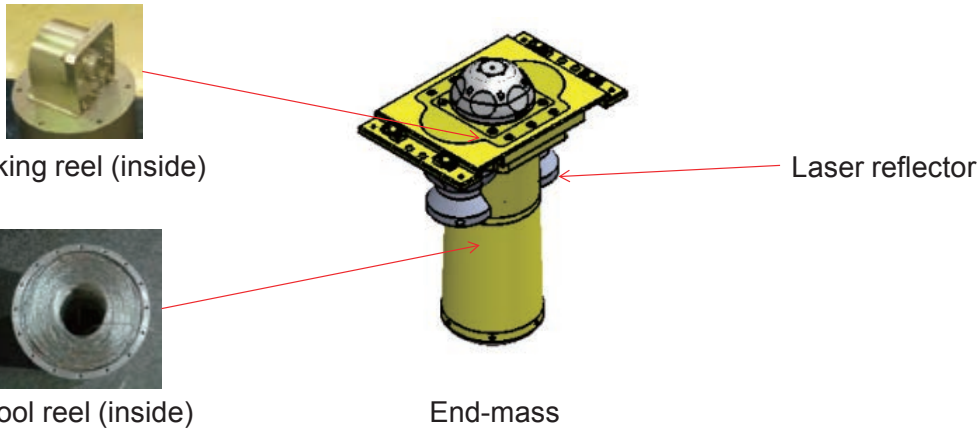
End-mass

- Functions
  - Mass for tether motion stabilization
  - Storing bare tether before deployment ⇒ Spool reel
  - Smooth termination of tether deployment ⇒ Braking reel
  - Target of HTV LIDAR ⇒ Laser reflector



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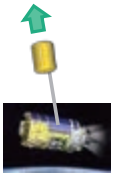
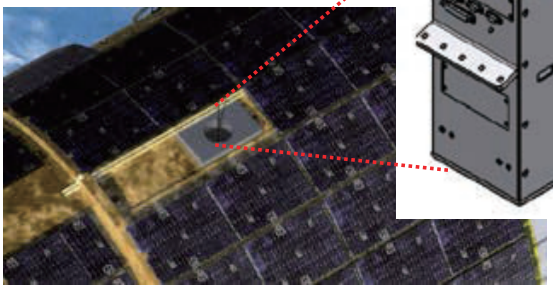
End-mass Releasing Mechanism

- Functions
  - Holding end-mass until KITE mission start ⇒ Actuators
  - Releasing end-mass with initial velocity ⇒ Spring





End-mass

Non-explosive actuators for holding and releasing end-mass (inside)

Spring for giving initial velocity to end-mass (inside)

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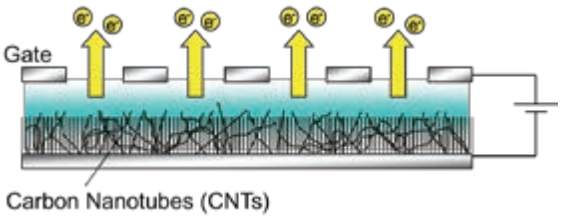
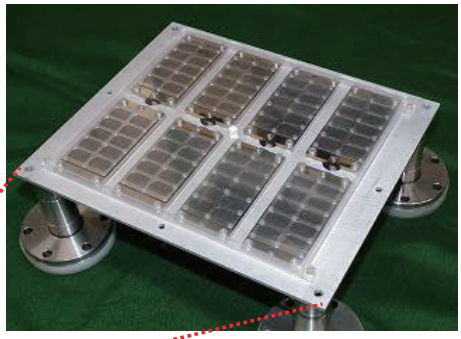
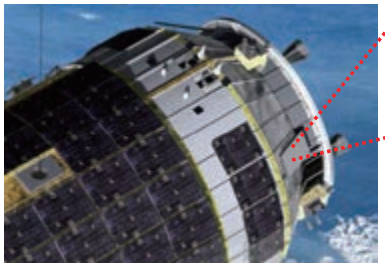
Electron Emitter

- Functions
  - Emitting electrons from HTV to ambient space plasma for tether current driving ⇒ Field Emission Cathode (FEC)



Conceptual image of FEC





FEC Head for KITE

Electron emission current of 10 mA (max.)

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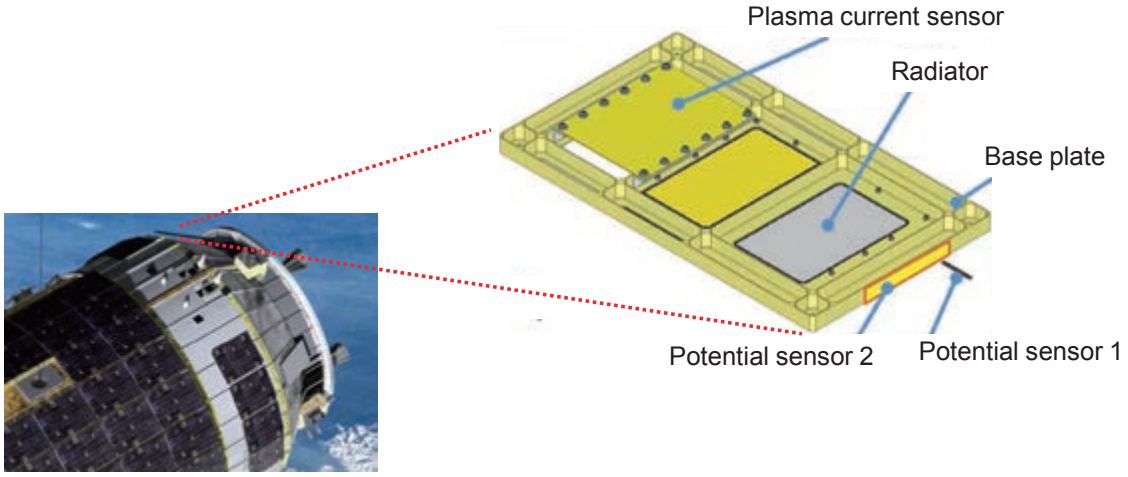
Plasma Potential & Current Monitor

- Functions
  - Monitoring HTV potential with reference to space plasma
  - Monitoring ambient plasma current



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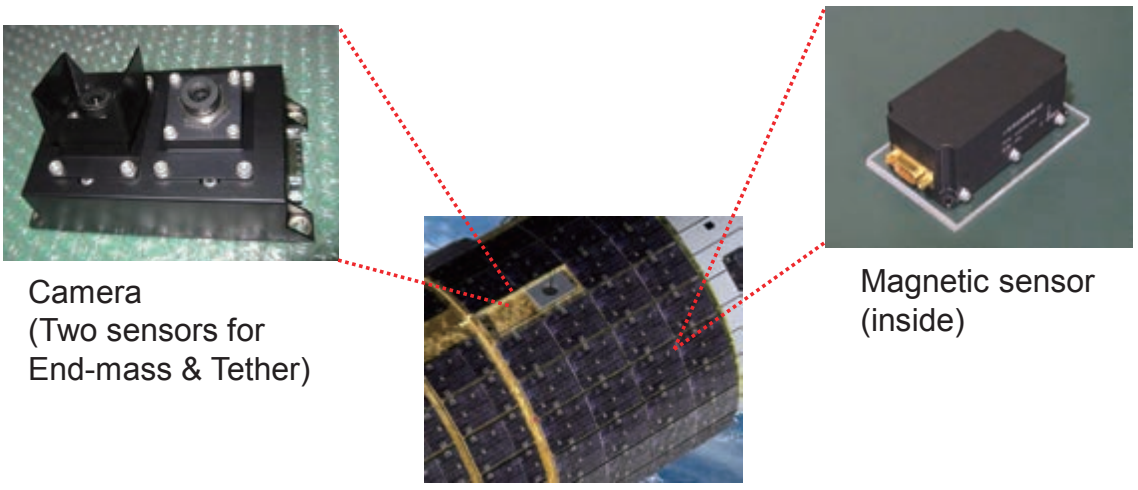
Camera & Magnetic Sensor

- Functions of Camera
  - Monitoring End-mass & Tether motion (Back-up of HTV LIDAR)
- Functions of Geomagnetic Sensor
  - Monitoring geomagnetic field



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Development Status & Summary

- Test phase of engineering model was almost completed and flight unit development of some components was started in this fall

Major milestones of KITE

Event	Date
Mission Definition & System Requirement Review	October, 2012
System Definition Review	February, 2013
Critical Design Review	September, 2014
Flight Unit Manufacturing	Start on October, 2014
Post Development Review	July, 2015 (planned)
HTV-6 Flight	Late 2016 (planned)

- Development is on-going for the flight on HTV-6 !!

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