Satellite mission ideas using EISCAT_3D

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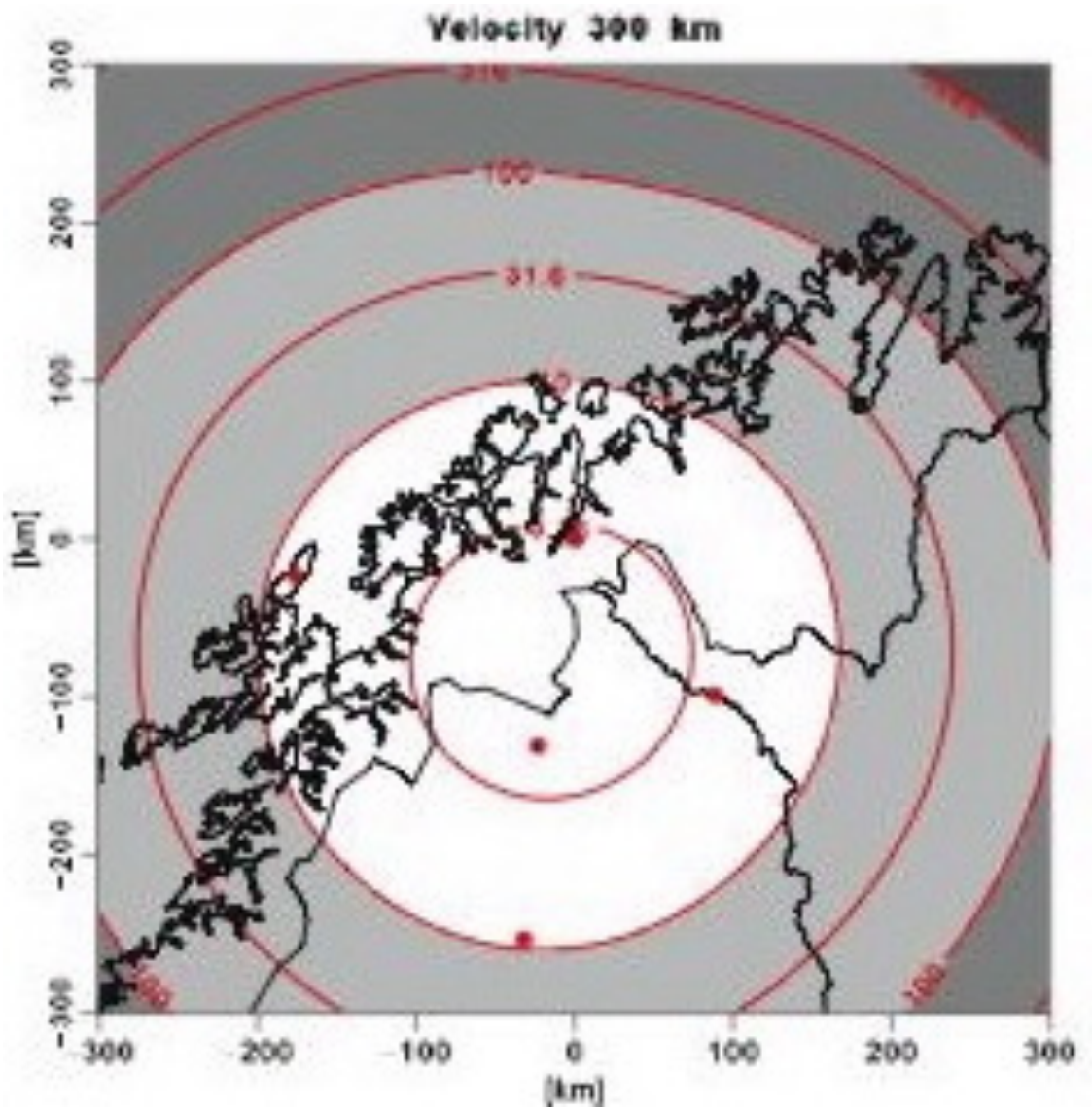
I3sat *(Ionospheric 3D observation satellite)* ***for Swedish InnoSat***

Low-altitude formation flight ***for Japanese M3/M4***

ESCAPE *(European SpaceCraft for the study of Atmospheric Particle Escape)* ***for ESA M5***

EISCAT_3D is an important part



3D volume observation instead of scanning specific direction

⇓

High sensitivity region covers more than 300 km diameter (white area) ≈ 10° longitudinal range.

⇓

3% of polar orbits traverses this region in average.

Swedish InnoSat + ESA M-class

InnoSat: series of small satellites every < 3 year, and launch in 4 years from proposal deadline

ex., Innosat-2: 15 kg payload @ 500-650 km

2016-6-30: deadline ⇒ launch Oct. 2020

Innosat-3: 2023 = I3Sat: calibration of EISCAT_3D?

Innosal-4: 2025-2026 = part of Japanese formation flight FF-MIT?

ESA M-class: series of science mission (~ 550 MEur) every 3 year, and launch 13 years after proposal deadline

M5 (launch 2029-2030) ⇒ ESCAPE uses EISCAT_3D (one of 12 candidate).

FF-MIT & I3aat

FF-MIT (integrated version of I3sat):

- small-scale plasma phenomena in the magnetosphere-ionosphere-thermosphere
  ⇒ a central to the purpose of ALIS_4D and EISCAT_3D.
- minimum spacecraft distance + high time resolution ion/electron (< 20 ms/2π)
  ⇒ 150 m resolution ~ spatial resolution of ALIS_4D and EISCAT_3D.
  ⇒ resolving the wave-particle interaction such as kinetic Alfvén.
- FF-MIT would be the first mission under discussion that takes full advantage of the capability of ALIS_4D and EISCAT_3D,
  ⇒ worth to reinforce the mission by adding a Swedish InnoSat
  (budget-shielding ~ 100 MEUR, Japanese can provide only 2-3 spacecraft)
- pre-phaseA study (equivalent to ESA's PhaseB1) during 2018-2020

InnoSat part payloads candidates

- ion instrument (IRF or SSL)
- neutral instrument (IRF or SSL)
- Langmuir probe (IRF)
- electric field antenna (KTH)
- magnetometer (KTH)

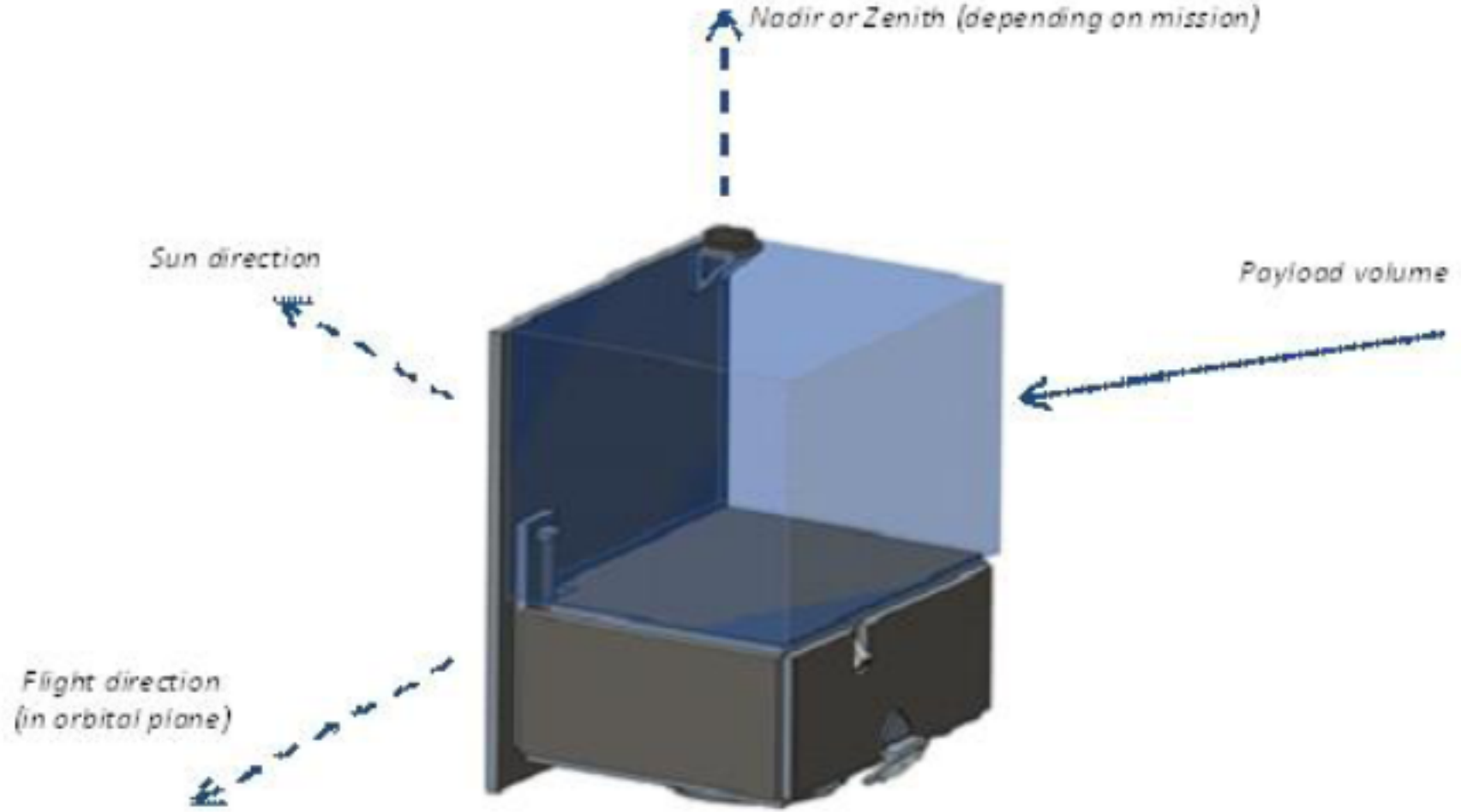
InnoSat : spec

attitude 3-axis stabilized

orbit altitude < 500-650 km
constant local time
depends on piggy-back opportunity

payload size < 53 cm x 65 cm x 48 cm
weight < 15kg
power < 25-100 W depending on orbit
downlink < 2.3 Mbps

InnoSat : platform



53 cm x 65 cm x 48 cm, < 15kg payload

The Ionospheric-3D observation Satellite (I3Sat)

Science Theme

* How does the ionosphere and upper atmosphere respond to particle injections from the space: from electrons to cosmic dusts.

Technology Theme

* Initial test for EISCAT_3D radar system (10000 dipole antenna array) toward full operation and correct interpretation.

Critical collaboration:

* EISCAT_3D
  - commission phase is planned 2020
  - full operation phase is planned 2023

Two options for payload

2023 launch option:
(a) "STEIN" keV particle, the same as above.
(b) modified "IMA"-type ion mass analyser with higher mass resolution (IRF, Kiruna)
(c) Astrid-2-type electron spectrometer (IRF, Kiruna, or any foreign instrument)
(d) Astrid-2-type Langmuir probe with 1.1 m rigid booms (either Uppsala or foreign)

2026 launch option as a part of Japanese formation flight :
(a) Modified ion mass or lowest energy ENA analyser (IRF, Kiruna)
(b) Electric field (KTH and Uppsala)
(c) Japanese instruments
(d) European instruments

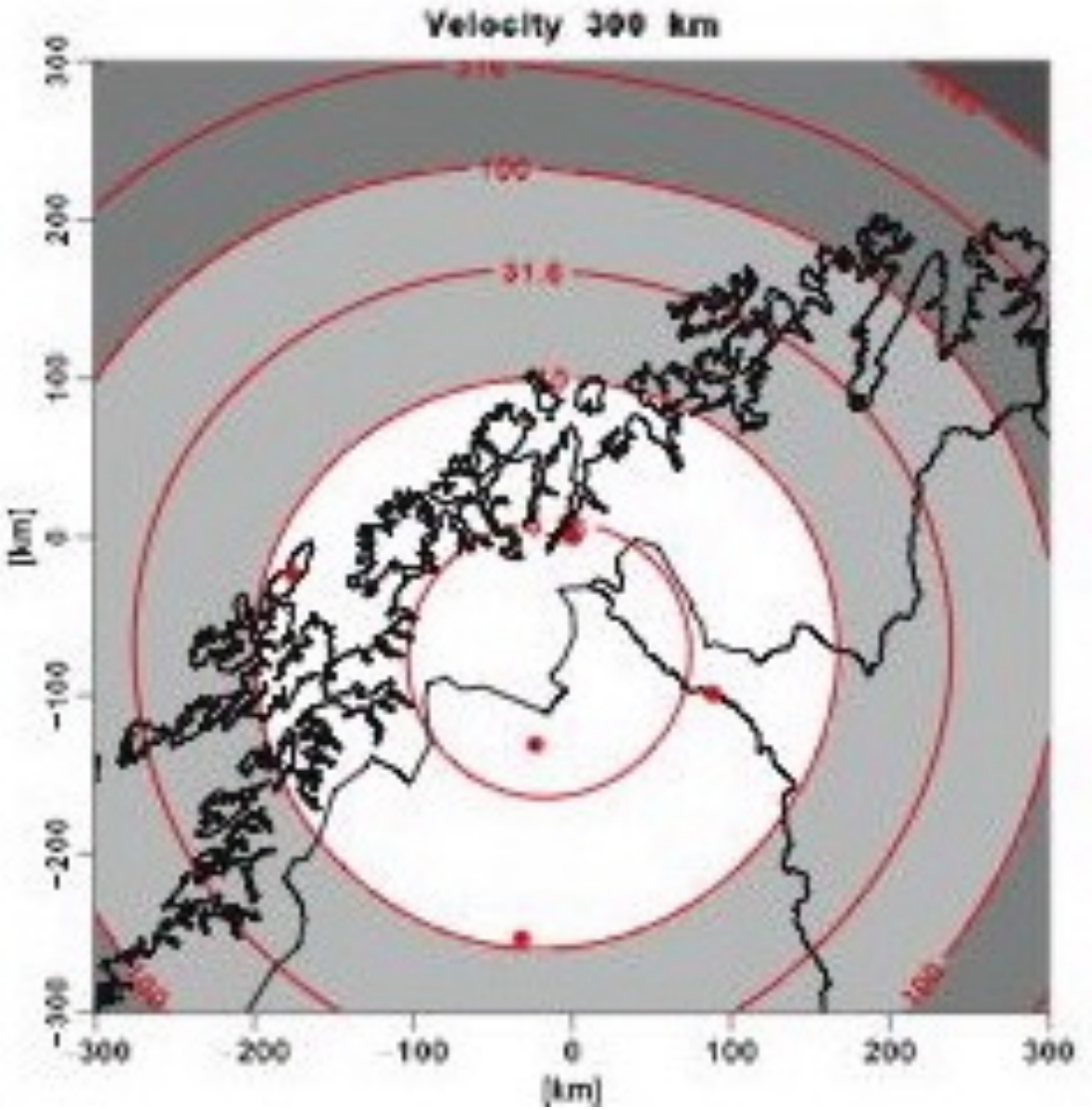
Limitation of satellite conjugate studies at present

Altitude-range problem
Difficult to make comparison > 500 km except parameters that can be mapped along geomagentic field.

Volume monitoring problem
The traditional ground-based measurement including current EISCAT radars cannot scan as quick as the satellite traverses over the region (point conjugacy instead of line conjugacy along the spacecraft traversal.

Scale size problem
Satellite measurements of the horizontal variation are not easily confirmed as quasi-stationary from the ground-based measurement for horizontal scale less than 10 km. Furthermore, the satellite does not cover the same longitude over two consecutive.

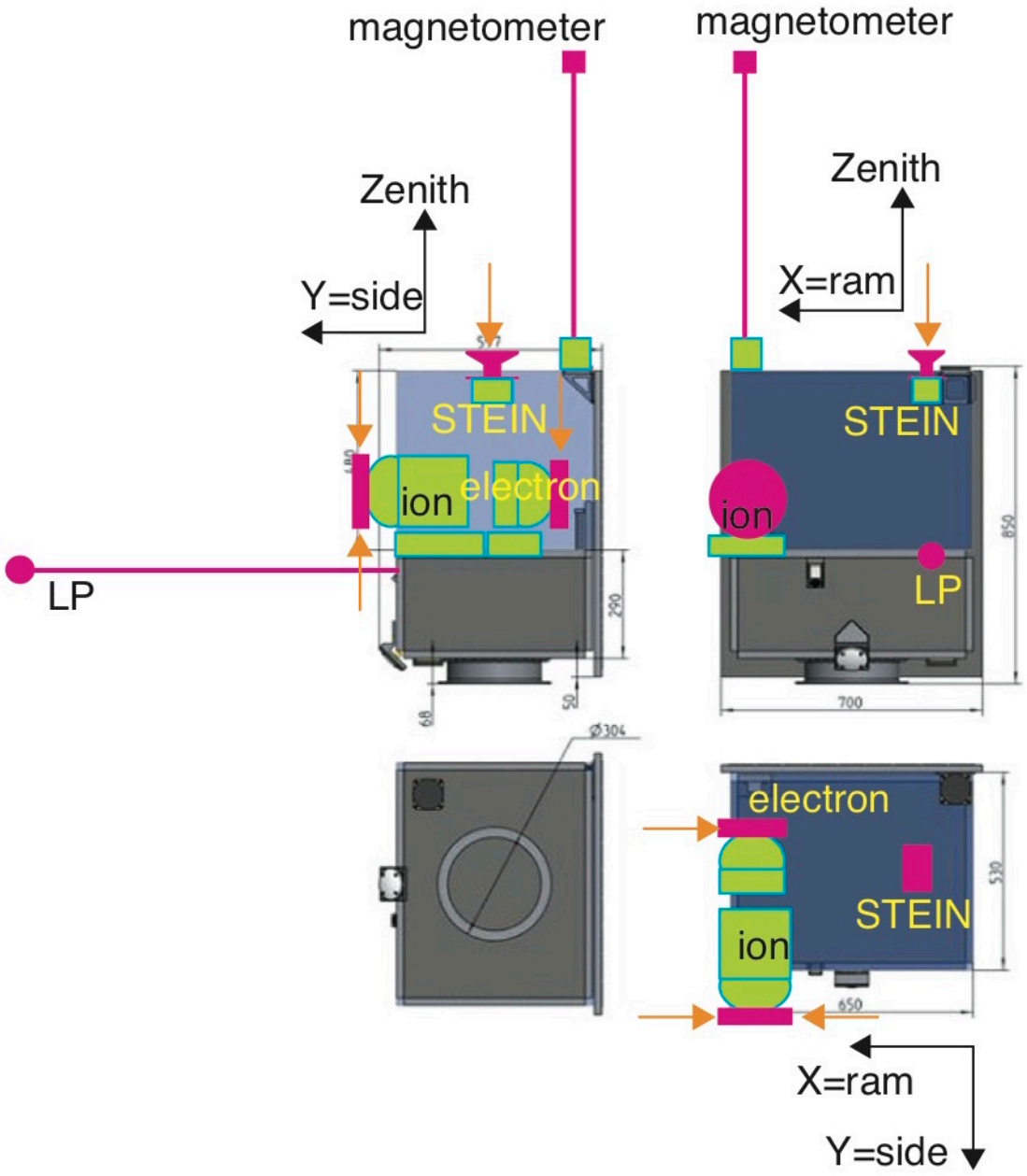
Combination of EISCAT_3D and low-Earth satellite at 500 km altitude



EISCAT_3D's ability to resolve < 10 km is equivalent to < 1.5 sec satellite traversal time.

Therefore, s small low-Earth satellites with very simplified instrumentation can contribute understanding unsolved meso-/ small-scale sciences.

Accommodation for “single” option



For option together with Japanese formation flight, InnoSat needs next-generation technology with propulsion and radiation belt protection (for > 800 km)

l3sat : What is to be measured

#1: How does EISCAT_3D recognize the small-scale structures (that is seen in the satellite observation) at 500 km altitude?

#2: In what 3D ionospheric condition, what-types of small scale structures appears (detectable satellite)?

#3: How does the ionosphere respond to energetic (>10 keV) ions, electrons, and neutrals, respectively?

#4: EISCAT observation of artificial meteor or barium (released by satellite)

(**vers. 2016-5-18**)

----- continued traditional task -----

#5: Can we extract temporal change by low-altitude satellite?

I3sat : action items

- **Do we have more science case with detailed examples?**

- **What is the realistic EISCAT_3D ability during 2021-2022?**

- **Are there any instrument provider?**
(Both IRF-Kiruna and IRF-Uppsala are fully occupied by JUICE and cannot provide any.)

- **Is the set A (cold ion, electron, LP) sufficient or should we have different set?**

- **Where can we buy the instrument within budget?**