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THE IBEX FUSED SATELLITE TRACKER

DEVELOPMENT AND DEMONSTRATION

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31 August 2022

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INTRODUCTION

- Orbit Determination Enables
  - ISAR Imaging
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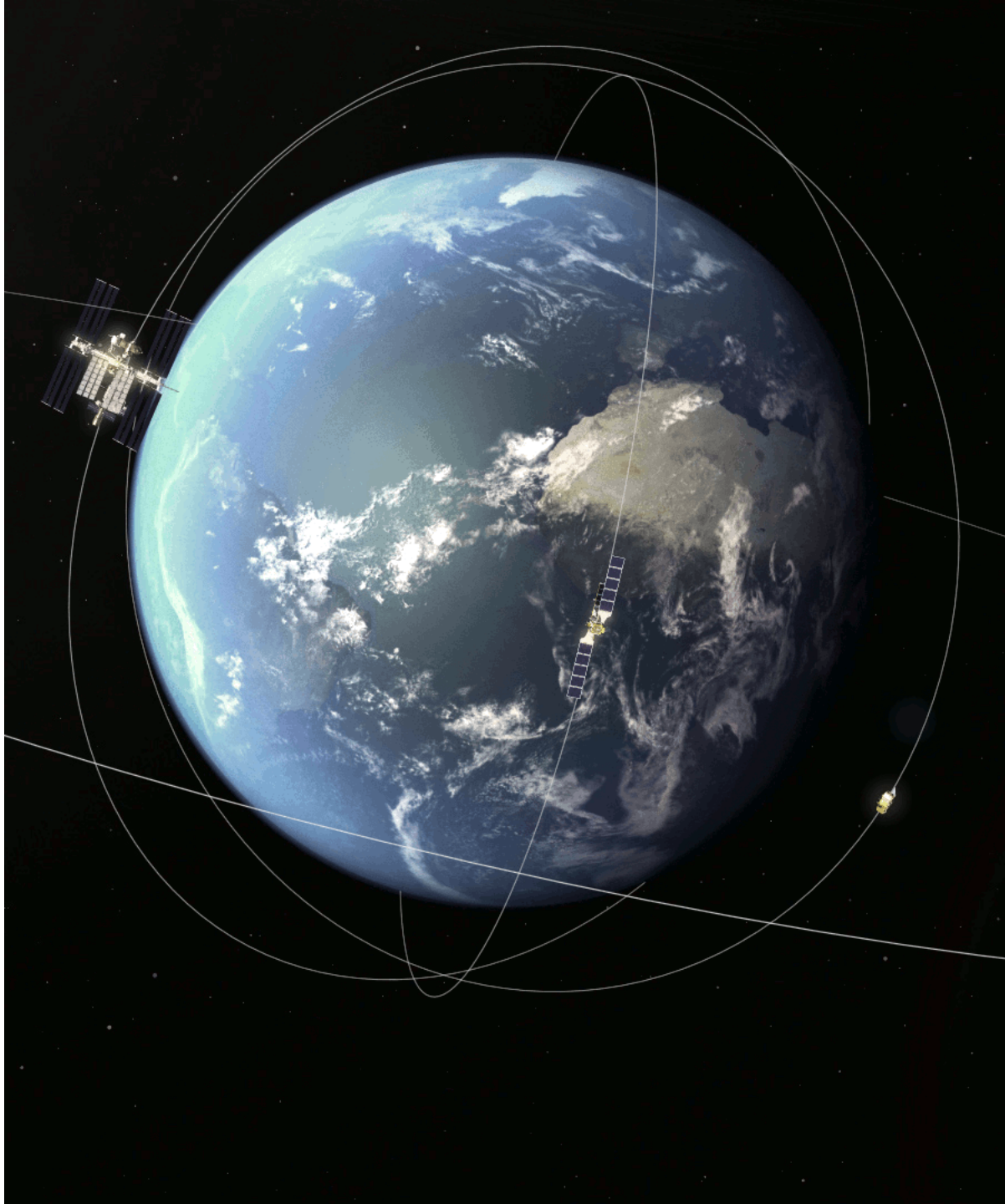
  - SSA
- Image Based Ephemeris eXtractor
  - IBEX
  - More than images



PROBLEM STATEMENT

“Determine the orbits of satellites with unknown properties as precisely as possible from observations by heterogenous sensors without a-priori knowledge.”

SOLUTION APPROACH

- Abstracted Sensor Inputs
- Initial Orbit Determination
- Accurate Orbit Determination
  - Generic Satellite Model
  - Environment Model

SOLUTION APPROACH
ABSTRACTED SENSOR INPUTS

Abstracted sensor inputs allow IBEX to be easily expanded with new sensors. Currently IBEX supports the following abstracted inputs:

- Cartesian Position
- Cartesian Velocity
- Azimuth / Elevation
- Range to observer
- Range rate
- Right Ascension / Declination


Photo: ESA

SOLUTION APPROACH
IMAGE BASED EXTRACTION

Angular measurements are extracted from time series of 2D pixel data of observations. The following procedure is used:

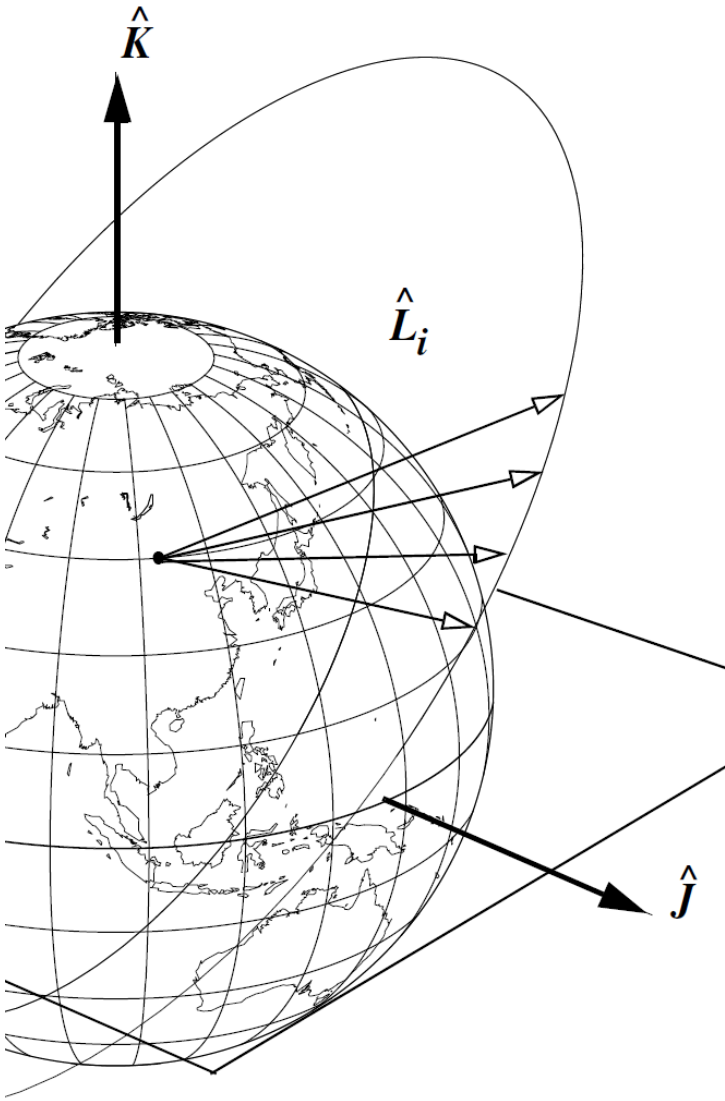
1. Determine the viewfinder angular coordinates
2. Determine 2D-pixel offset of satellite relative to viewfinder
3. Rotate 2D-pixel offset to account for sideways reflection of light in TNO's Nasmyth telescope
4. Convert 2D-pixel offset into angular offset
5. Combine angular offset and viewfinder coordinates to determine satellite angular coordinates

SOLUTION APPROACH
INITIAL ORBIT DETERMINATION

To accurately estimate a satellites orbit, an initial orbit must be set. The following options for IOD have been implemented:

- One position and velocity observation
- Two position observations
- Two Range-Azimuth-Elevation observations
- Three angular observations
- Two-line elements (TLE)

Image obtained from "D. A. Vallado and W. D. Mcclain, Fundamentals of Astrodynamics and Applications, 4th ed. Hawthorne: Microcosm Press, 2013."



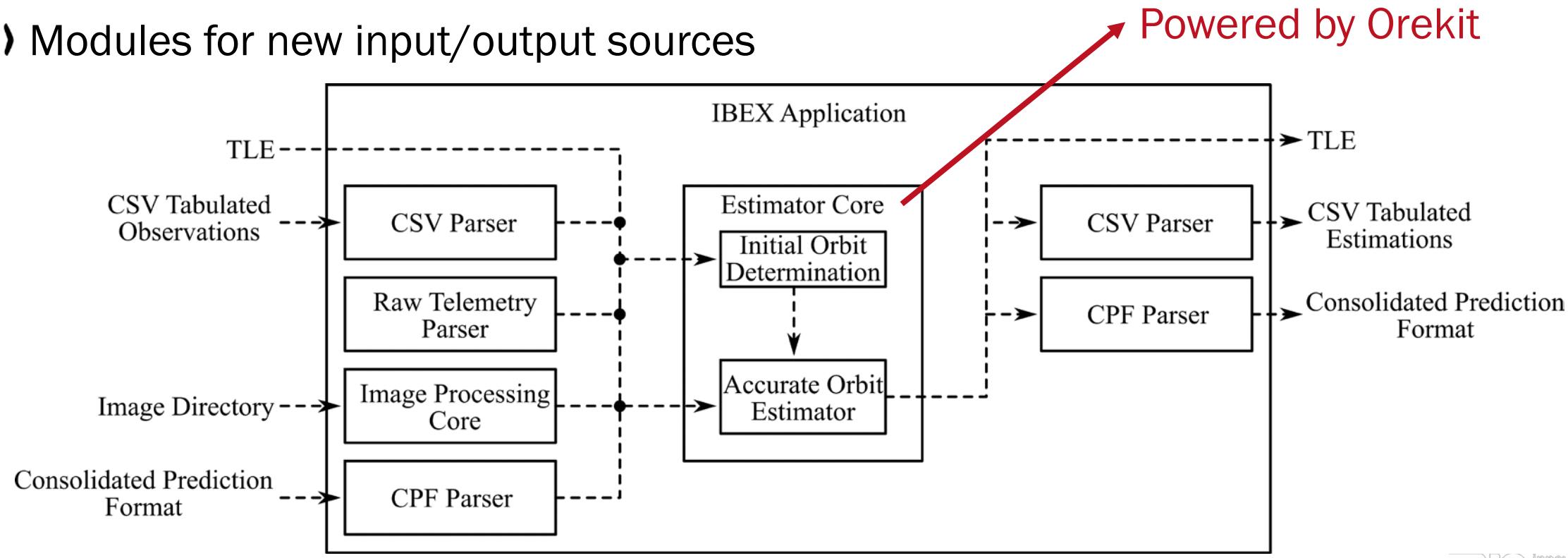
SOLUTION APPROACH
ACCURATE ORBIT DETERMINATION

IBEX's goal is to estimate generic satellite orbits. The near Earth orbit is estimated using a least squares estimator in conjunction with a Levenberg-Marquardt optimizer. The following effects are currently modelled:

- Gravity field including spherical harmonics
- Atmospheric drag using a generic satellite model
- Relativity
- Lunar Attraction
- Solar Attraction

APPLICATION STRUCTURE

- Modular Architecture
- Separation of Estimator Core
- Modules for new input/output sources



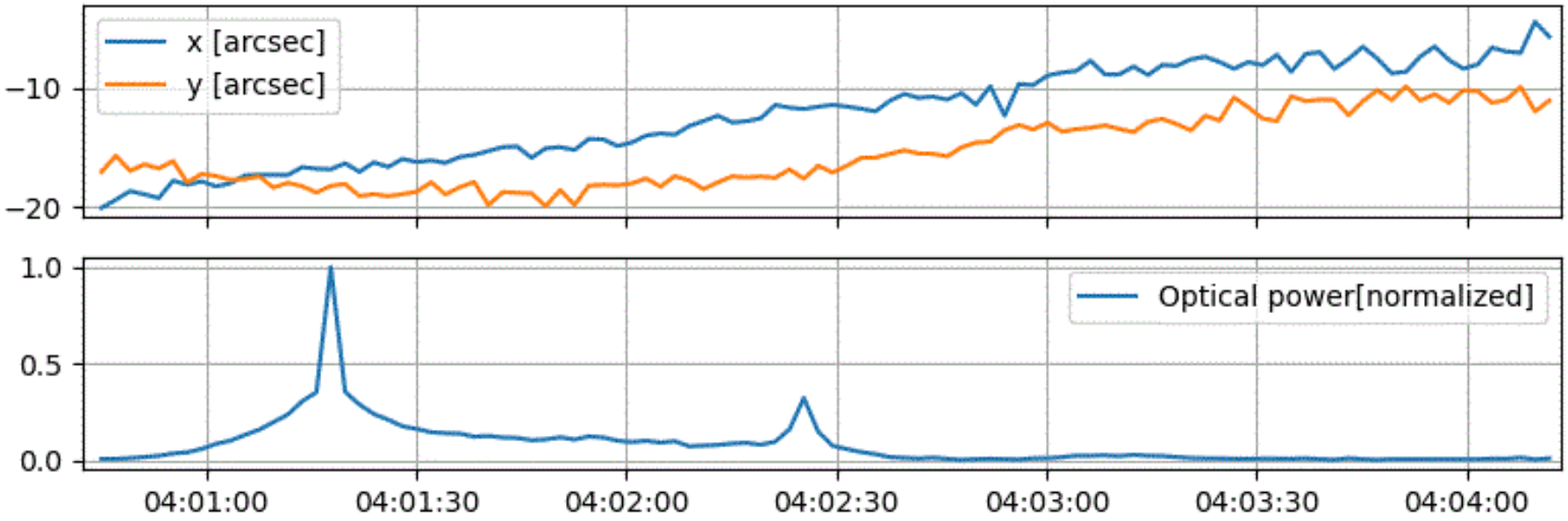
VALIDATION
SETUP

"Estimate an orbit and generate a Consolidated Prediction Format file that can be used by a telescope to track the satellite."

- Estimate an orbit based on GNSS data.
- Propagate the orbit to the intended time of tracking.
- Generate a CPF file for tracking the satellite with a telescope.
- Track the satellite based on the CPF file.
- Determine deviation of satellite from computed track with telescope images gathered during tracking.

VALIDATION
RESULTS

Tracking of the Aerocube 14A satellite (COSPAR ID 2019-071D) was planned and executed at the 21st of September 2021 at 03:58Z.



CONCLUSION

- The IBEX fused satellite tracker is shown to be accurate on real-world GNSS data
- IBEX is in use for multiple projects, e.g.,
  - ISAR image generation
  - Sensor fusion experiments
  - Tracking of laser-based telecommunication satellites
- Estimating orbits using azimuth and elevation is shown to be viable
- Future experiments are planned

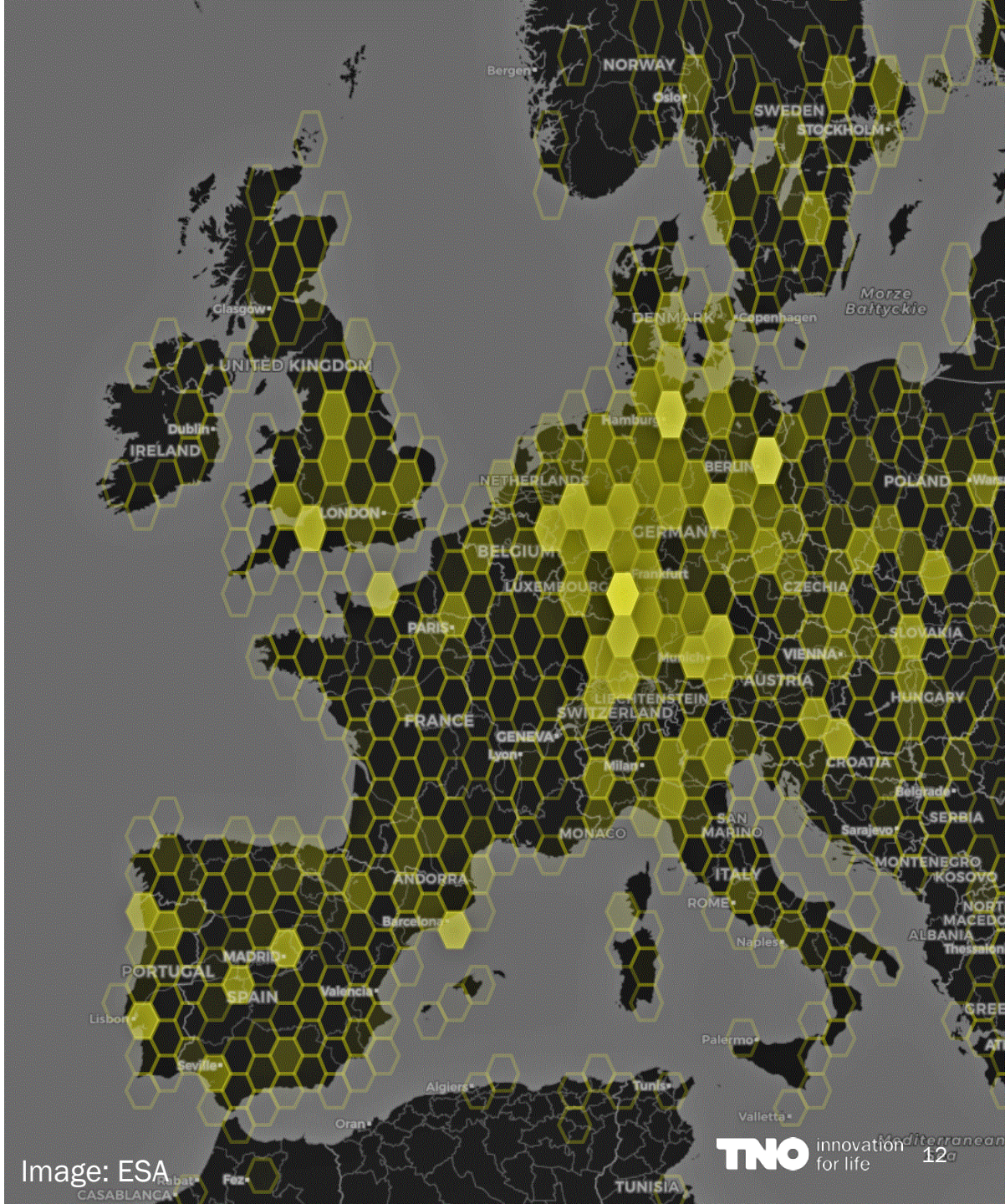
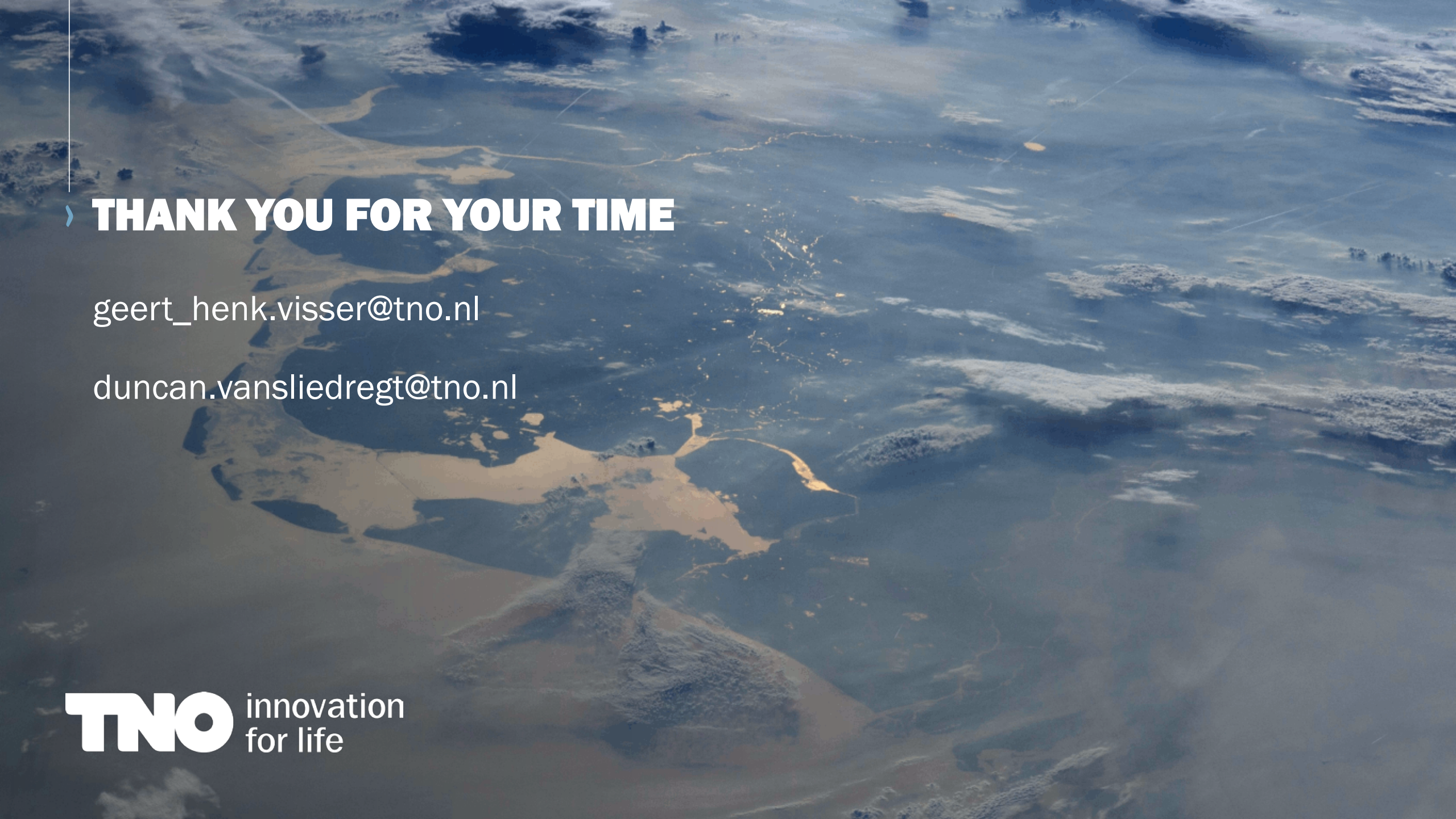


Image: ESA



THANK YOU FOR YOUR TIME

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