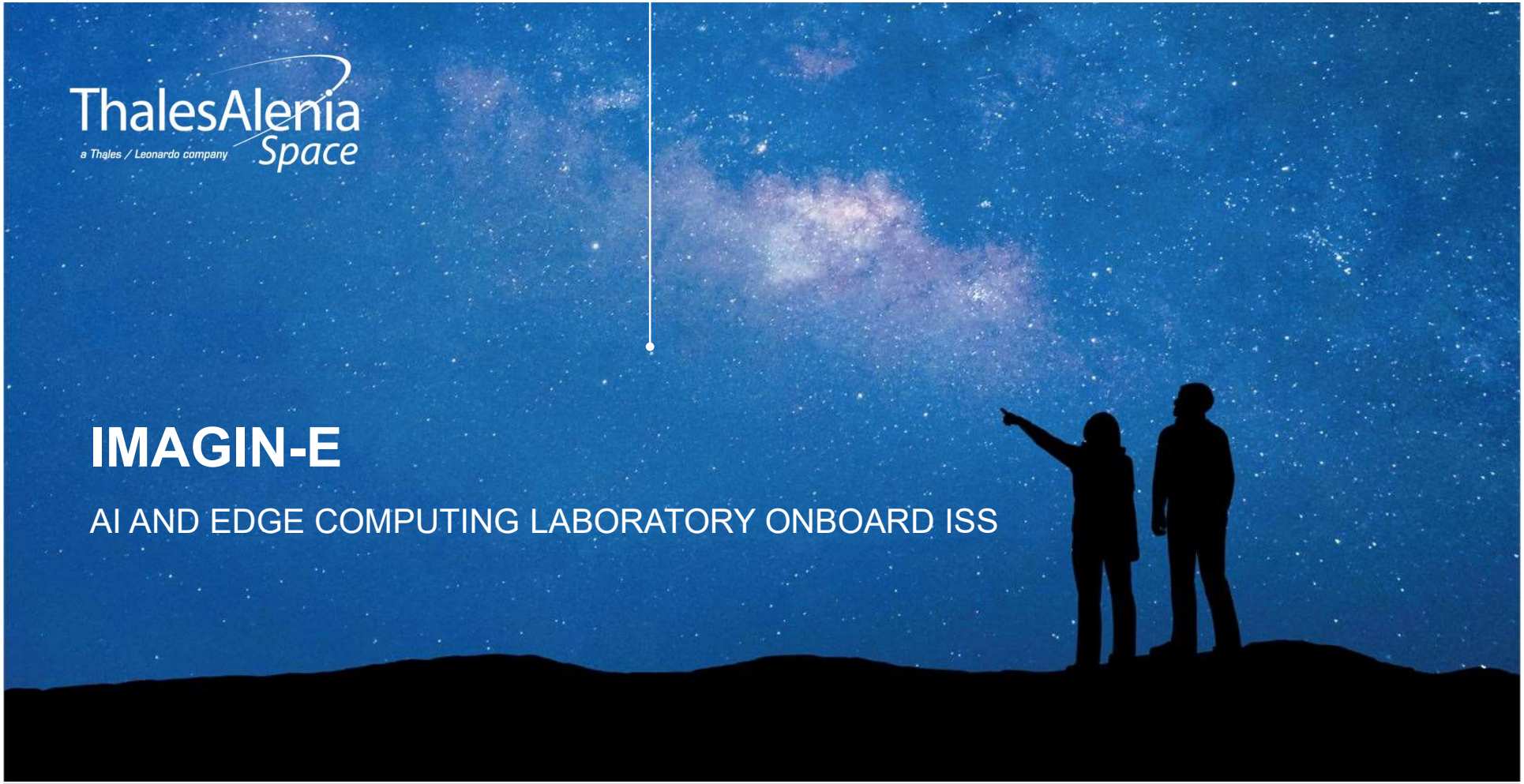

IMAGIN-E

AI AND EDGE COMPUTING LABORATORY ONBOARD ISS

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SPACE EDGE COMPUTING

/// **Space Edge Computing** is the processing of data in space, as close as posible to where it is generated, rather tan transmitting all the data to Earth for processing.

- In the future, there will also be Large Space Data Centers, to process large amounts of data in computing farms in space.

/// Space Edge Computing for Earth Observation has many applications

- Wildfire prediction and detection
- Disaster monitoring
- Cloud detection
- Flood and Drought analysis
- Object detection and classification
- Ocean anomalies detection (oil spills, algae bloom, …)

/// Other potential applications

- Weather alerts (heavy rains, heat islands,…)
- Messaging/streaming over NTN
- ...

Date: 26/06/2026
Ref: Not referenced
Template: 83230347-DOC-TAS-EN-010

IMAGIN-E ISS Mounted Accessible Global Imaging Nod-e

/// IMAGIN-e is a mission to demonstrate the potential of **AI and Space Edge Computing**, allowing

- Rapid technology demonstration and validation
- On-board AI demonstrations
- Early adopter opportunities
- Roadmap for commercialization and large-scale deployment

/// For this purpose a **demonstration Payload** has been installed in the Bartolomeo Platform on the ISS, embarking

- An **Edge Computer**
- A **SW framework** for Edge Computing
- **Earth Observation sensors** :
  - RGB camera
  - Hyperspectral camera

/// Mission timeline

- Development: Q3 2022 – Q4 2023
- Launch: 21st March 2024
- Deployment: end of August 2024
- Operational phase: since May 2025

Date: 26/06/2026
Ref: Not referenced
Template: 83230347-DOC-TAS-EN-010

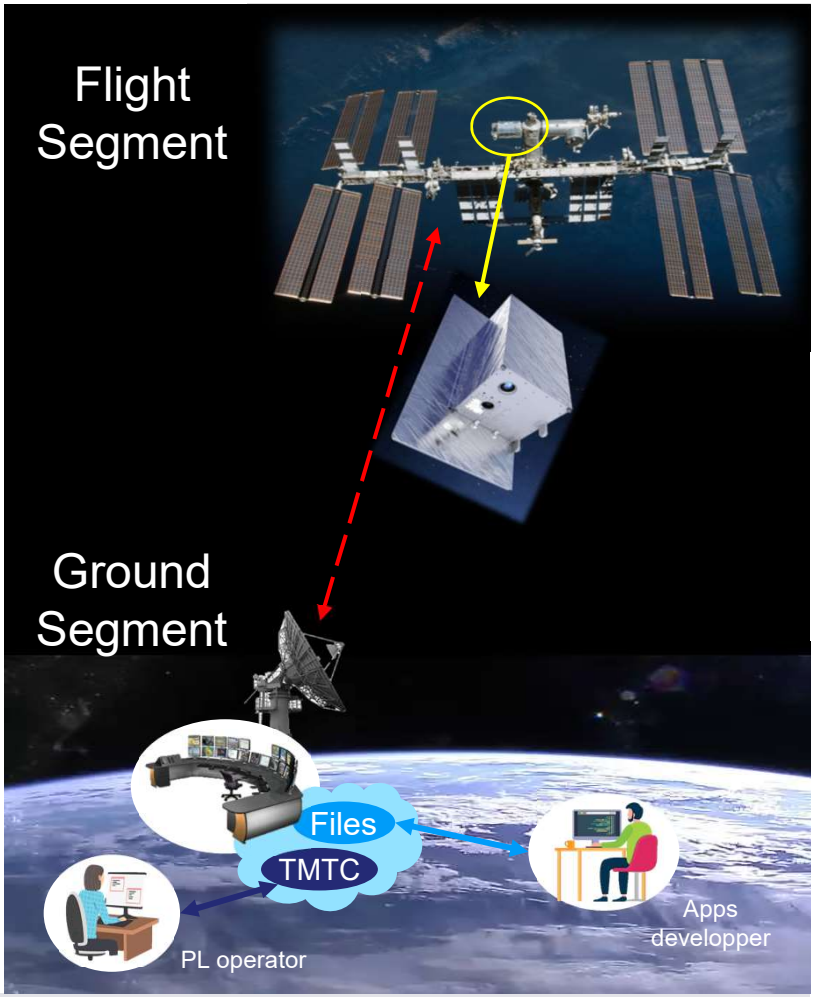
IMAGIN-E MISSION

/// IMAGIN-e is an End-2-End demonstration. The users are be able to :

- Develop their applications in a dedicated Software framework
- Upload and update their applications to the Payload
- Download relevant insights obtained by their applications

/// The advantages users seek with Space Edge Computing

- Improved response time
- Optimization of frequency usage
- Greater control of the data and its value
- Privacy and security
- Space Missions with multiple applications



Date: 26/06/2026
Ref: Not referenced
Template: 83230347-DOC-TAS-EN-010

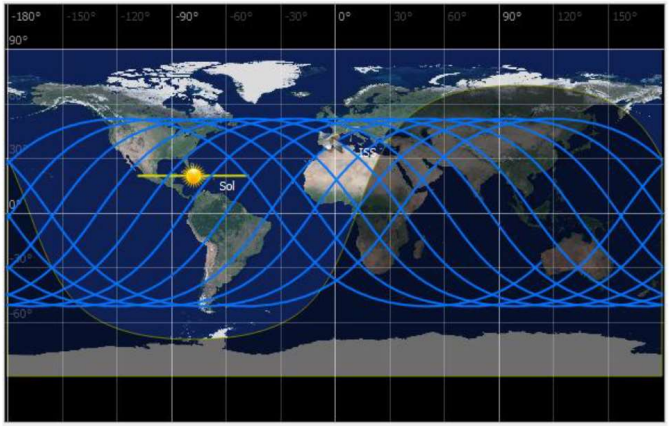
ISS ORBIT CONSTRAINTS

/// The IMAGIN-e mission orbit and attitude are always determined by the ISS orbit and attitude

- The ISS orbit is an approximate, but not exact, 3-day repeating orbit
- The ISS attitude has a time-varying error due to thermal bending of the structure

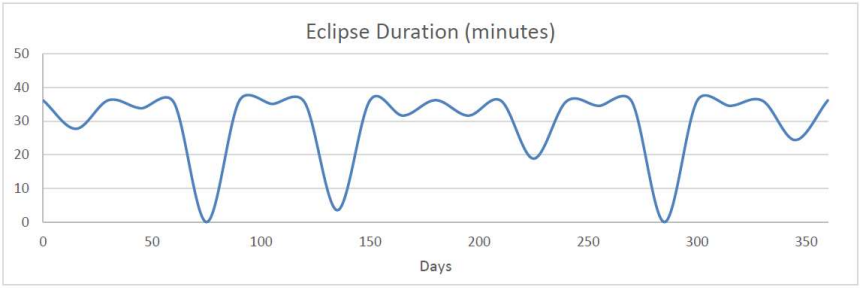
/// Unlike most Earth Observation mission orbits, the ISS orbit is **not** a Sun-synchronous orbit, so the solar beta angle, i.e. the angle between the orbital plane and a line drawn from the Sun to the Earth, undergoes a sinusoidal variation.

- The **eclipse duration of the orbit varies** with beta, and for a range of beta angles, there is no eclipse.
- The images taken over a point on ground will have **different illumination conditions each time**.



ISS Ground-Track over 24h (22/07/2022, 17:17:35 UTC)

Altitude	370 to 460 km
Inclination	51,64 deg
Period	92.89 min
Beta Angle variation	-75 to 75 deg
Eclipse time	0 to 36,2 min



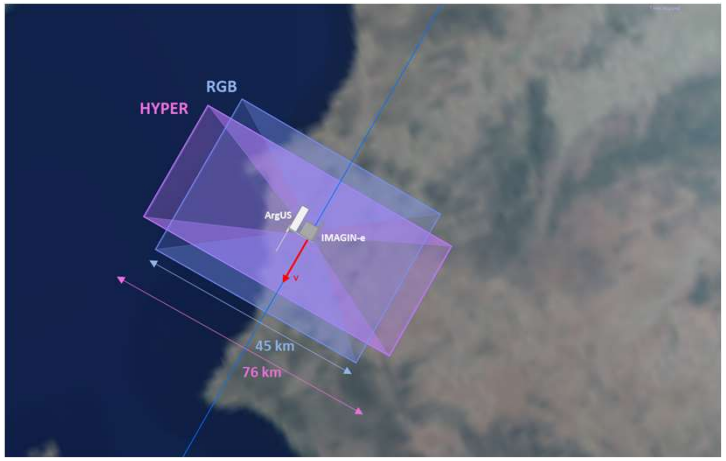
ISS orbit eclipse duration variation over one year

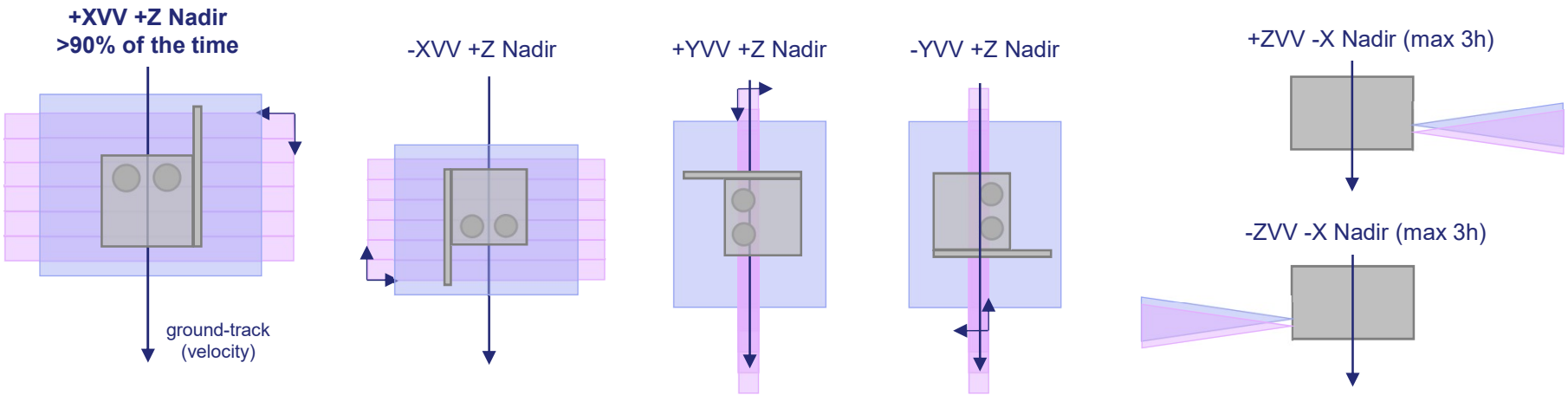
Date: 26/06/2026
Ref: Not referenced
Template: 83230347-DOC-TAS-EN-010

ISS ORBIT CONSTRAINTS

/// At the ISS orbit altitude, the two Nadir-pointed Earth Observation sensors on the IMAGIN-e payload will capture images with a swath ACT of ~76 km (RGB) and ~45 km (hyperspectral).

/// The Payload will be in its nominal attitude >90% of the time, but may also be found in other orientations due to ISS maintenance.





Date: 26/06/2026
Ref: Not referenced
Template: 83230347-DOC-TAS-EN-010

CAMERA CHARACTERISTICS AND IMAGING LIMITATIONS

/// Cameras

- Hyperspectral
  - GSD: 45 m @ 405 km altitude & Nadir
  - Swath ACT: ~ 45 km
  - Swath ALT: ~77 km (baseline value)
  - Spectral range: 450 - 950 nm
  - Number of spectral bands: 50
  - Image product: L1C level, 12 bits
  - Frame : 1024x1856 pixel
- RGB
  - GSD: 37 m @ 405 km altitude & Nadir
  - Swath ACT: ~76 km
  - Swath ALT: ~ 57 km
  - Spectral range: 400 - 750 nm
  - Number of spectral bands: 3 (RGB)
  - Image product: JPEG, 10 bits

/// What we can be configured in the cameras

- Hyperspectral
  - Up to 7 spectral bands from 50 can be selected
  - The rest of parameters will be fixed
- RGB
  - All parameters will be fixed

/// Possibilities due to the orbit, ilumination, revisit, transfer rates, mission duration…

- Number of image acquisitions per camera
  - Hyperspectral
    - The number of acquisitions per orbit is limited by acquisition only during the “day” and by the downloading speed
      - Baseline: 1 image per orbit
  - RGB
    - Number of acquisitions per orbit limited by acquisition during the “day” and by the memory storage capability
      - Imaging synchronized with hyperspectral: 1 image per orbit
      - Free imaging: up to ~ 100 images per orbit
- Revisit
  - Driven by the ISS orbit
    - Orbital period: ~ 92 minutes → ~ 15 orbits per day
    - From West to East
    - Maximum accessible latitude: ± 51°
    - Average revisit time: ~ 3 days
    - Revisit time with the same illumination: ~ 63 days

Date: 26/06/2026
Ref: Not referenced
Template: 83230347-DOC-TAS-EN-010

APP LIMITATIONS

/// Applications are executed in a Kubernetes cluster and are isolated in dedicated namespaces.

/// Applications do not have any design limitations. An application could be contained in a monolithic container or splitted in multiple containers.

/// Although the applications can use a downlink folder to output their results, no internet connection is available for them during operation.

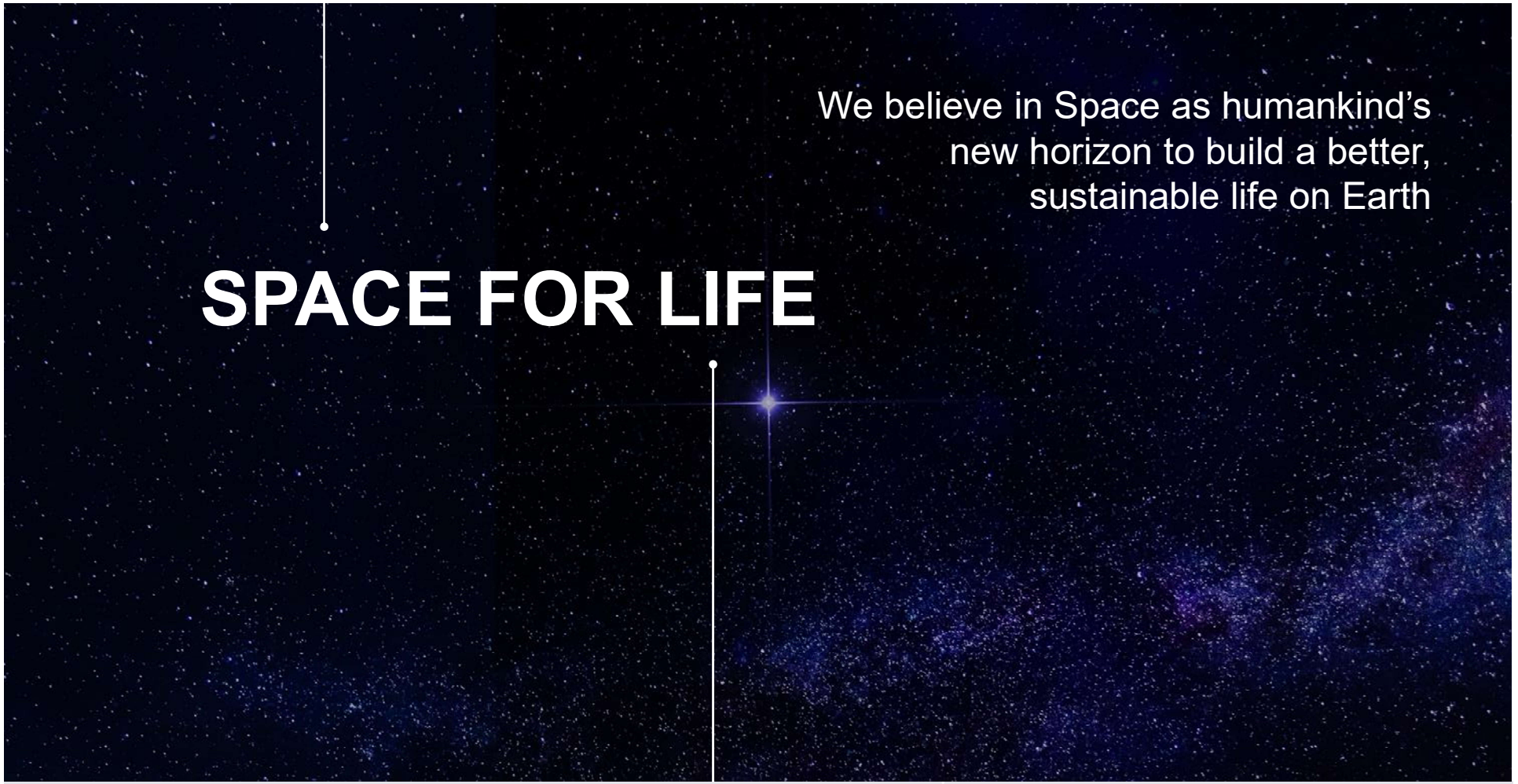
/// Although the applications do not have design constraints, they have a limited quota[1] from the total resources available which are:

- Temporal/Scratch Storage: 2GB
- RAM: 8GB
- CPU: 4 cores running at up to 2GHz[2]

[1] *Apps that require additional resources are not explicitly prohibited, but will require additional deconfliction with other resident applications.*

[2] *Frequency might be limited to a fixed 1 GHz during operation due to power budget limits*

/// The shared uplink/downlink storage folders have a limitation of ~100GB



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