Facts and Figures of Earth Observation Services from High Altitude Pseudo-Satellites (HAPS)

- Authors
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- Abstract

Most of the High Altitude Pseudo-Satellites (HAPS) are nowadays in design and development phases. Besides, many of them have Earth Observation (EO) as one of their target markets, where high resolution and persistent monitoring are considered quantum leaps with respect to current data providers.

In parallel, the aerospace industry is preparing the development of dedicated payloads, evolving the space and airborne concepts to the new operational environment. Both active and passive instruments are under study, with promising tests already developed in balloons and airplanes.

This paper presents a comprehensive analysis of the performance of EO services and products, to assess capabilities and limitations of platforms and sensors. This includes technology surveys, geometric and radiometric budgets, operational performance evaluation (e.g. revisit time), data processing and storage analysis, communication link budgets and mass/volume estimations.

Finally, a synthesis exercise from the above results provides simplified models to preliminarily evaluate the expected performance of several kind of instruments, together with their dimensioning figures, from the major technical and operational requirements.

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- Introduction
- Analysis of EO market for HAPS
- HAPS EO payload capability
- Payload concepts
- Conclusions

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1. Introduction
HAPPIEST Study

- HAPPIEST is a ESA General Studies Programme study to analyse the applications in which lighter-than-air pseudo-satellites can complement, augment or substitute current space-based or ground-based systems

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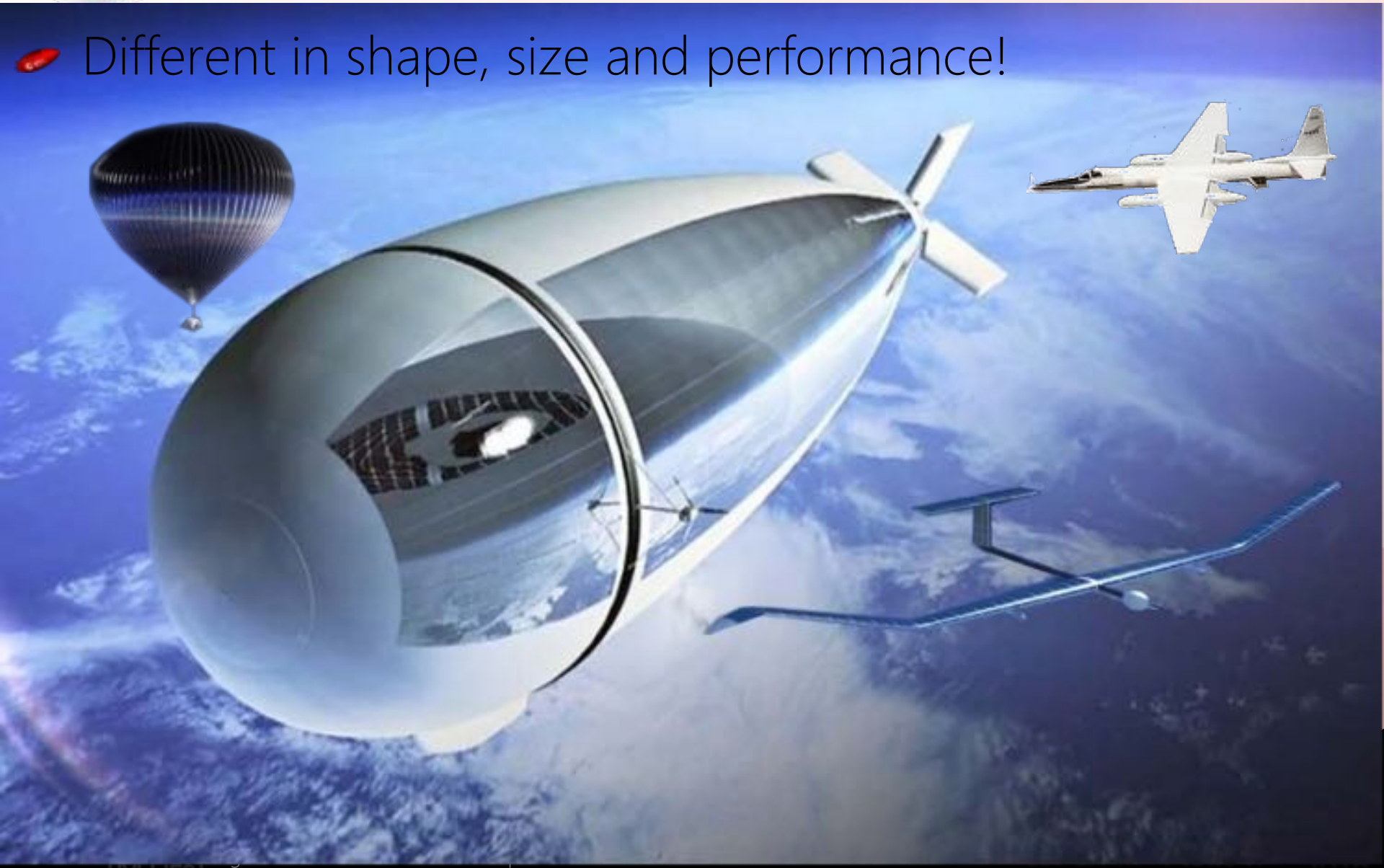
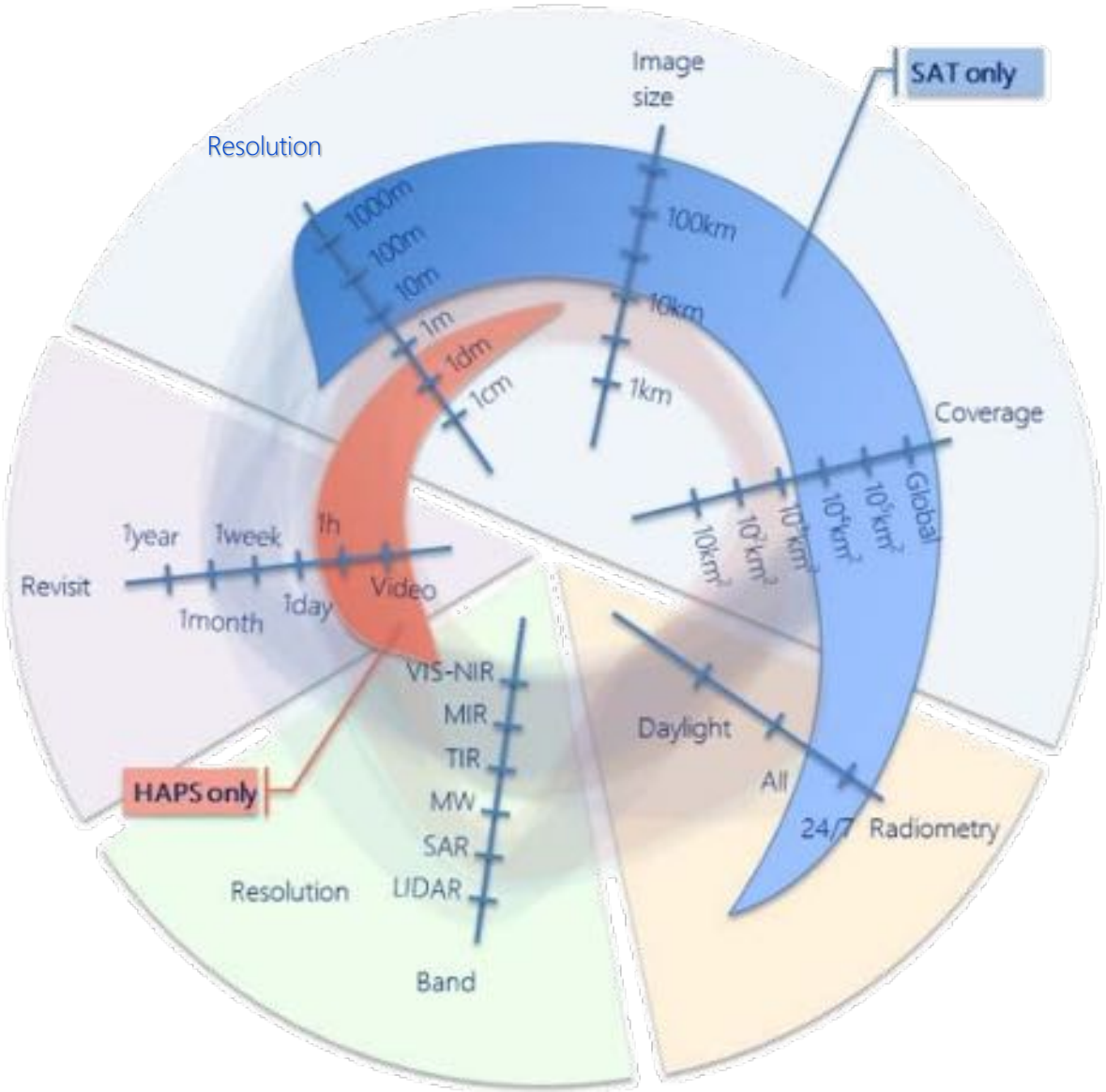
1. Introduction
What a HAPS is

- Different in shape, size and performance!

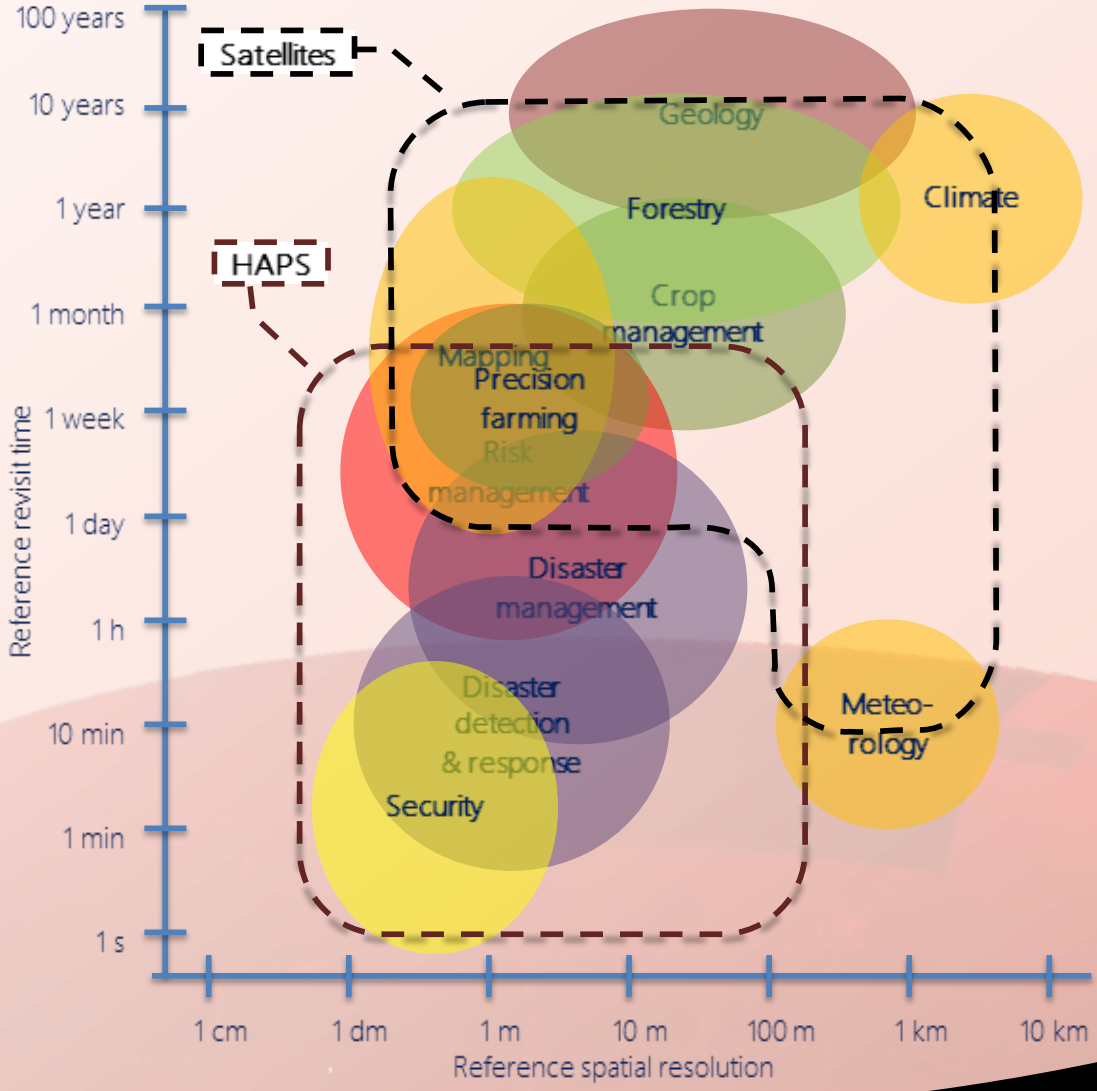


1. Introduction
What HAPS can offer in EO



1. Introduction
What that is for

- Applications:



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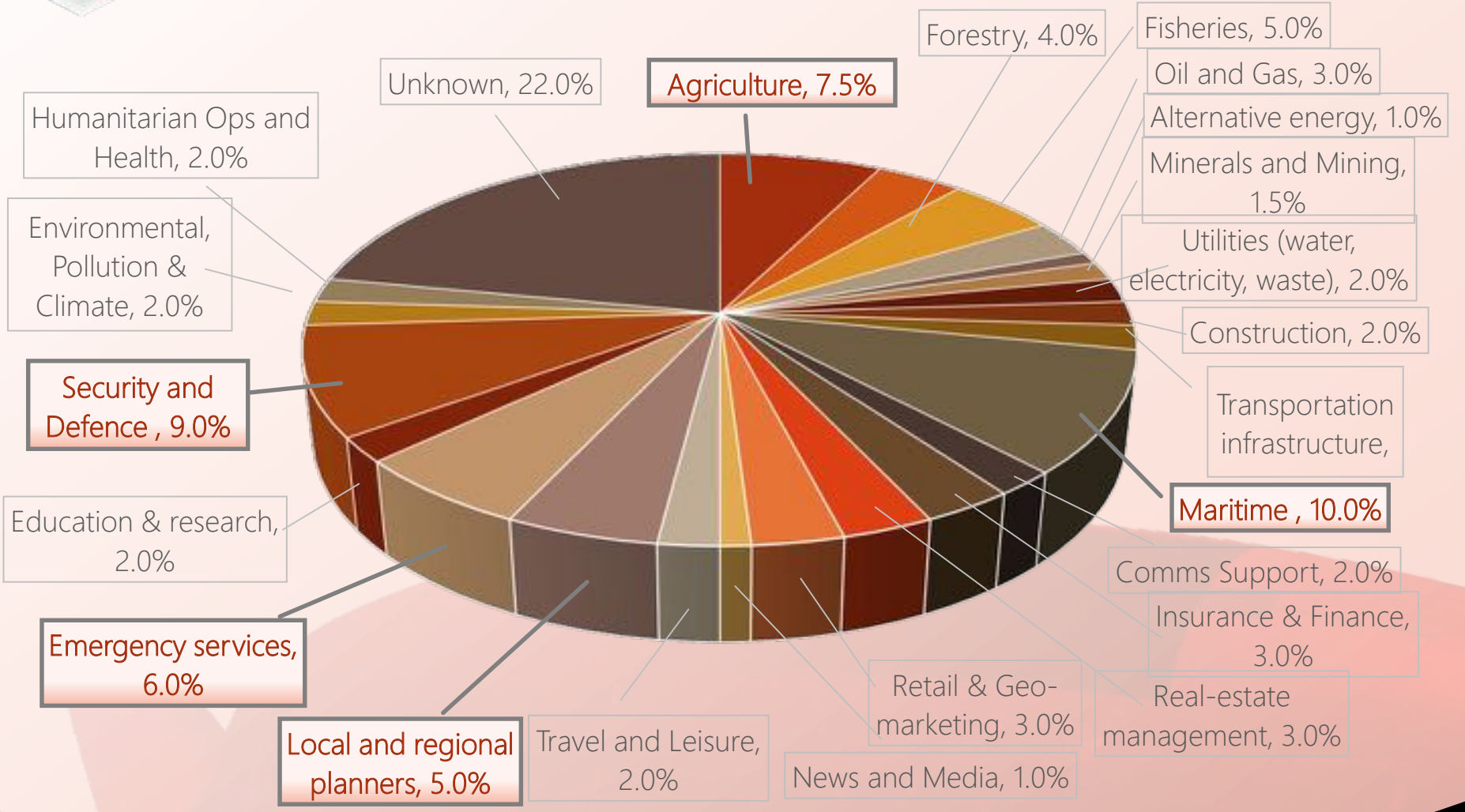
2. Analysis of EO market for HAPS

Taxonomy of EO sector revenues



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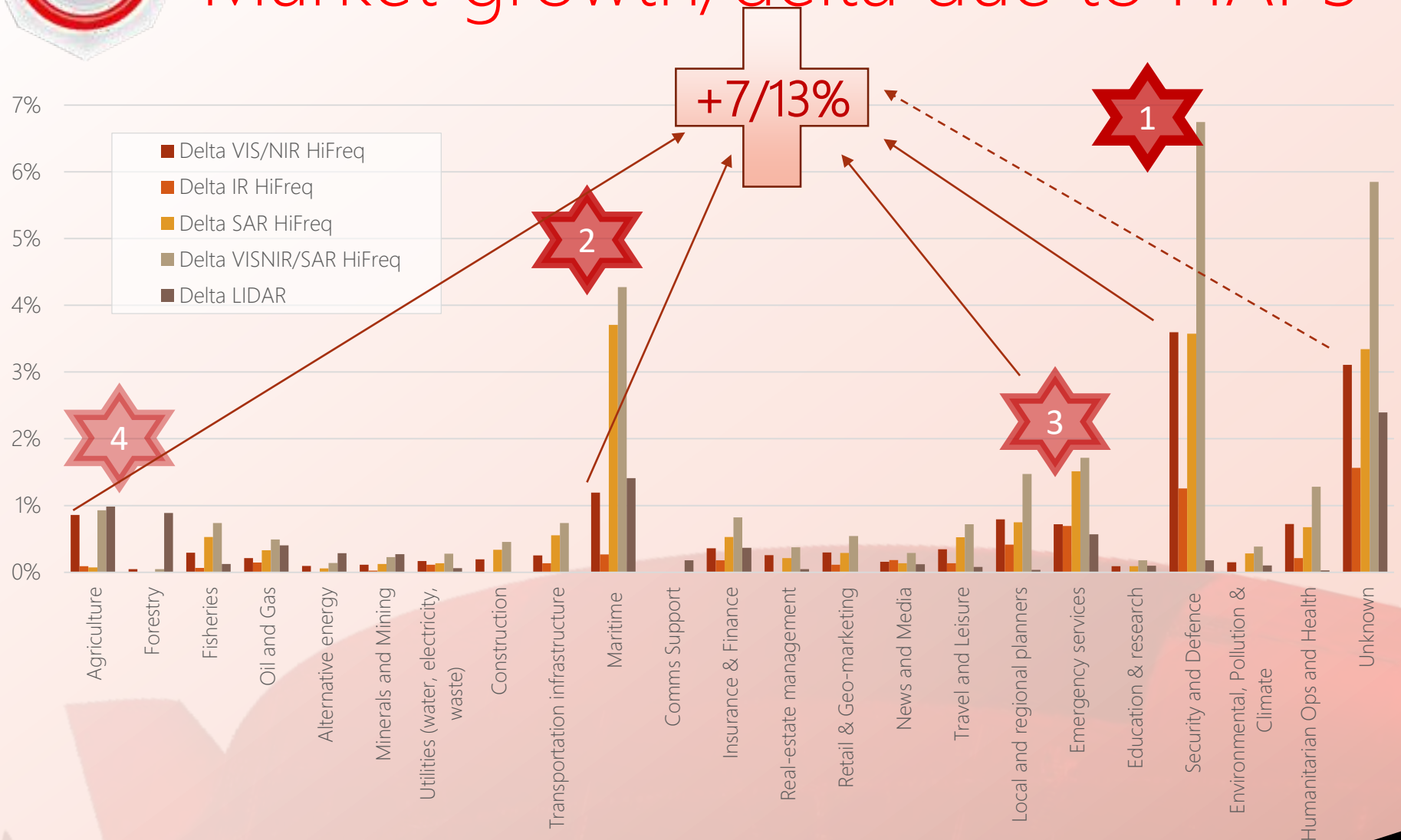
2. Analysis of EO market for HAPS

Market growth/delta due to HAPS



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3. Target EO services
Market analysis summary

- Complement existing services
  - Ad-hoc missions
  - Rapidly changing scenarios
  - High-value areas (larger GDP within HAPS coverage)
- Exploit disruptive services (HiRes persistent video)

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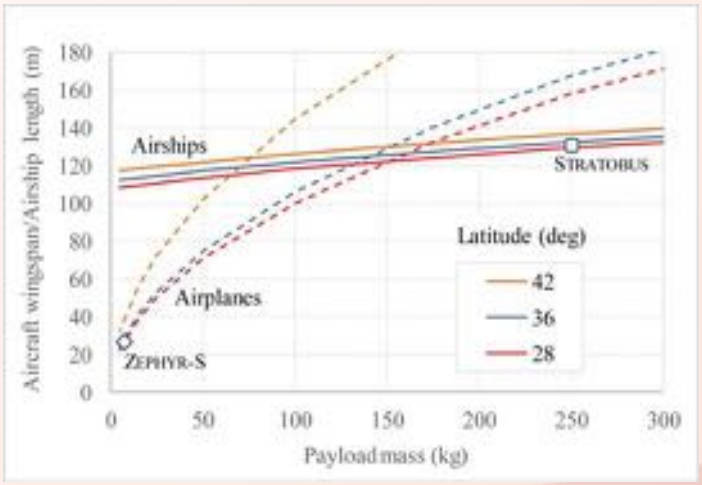
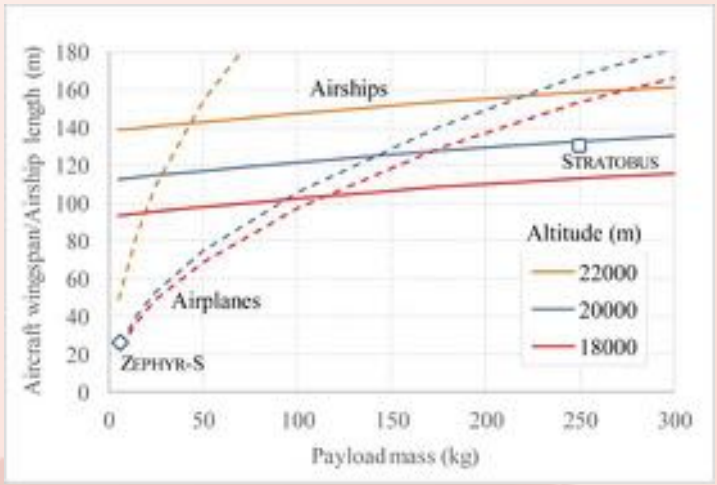
Narrow FOV design& performance

- Payload capability strongly depends on the selected HAPS platform and its size. **How big can you go**?





- Envisaged limits:
  - Aircraft: 50-60 m wingspan → ~35 kg payload
  - Airship: 120-130 m long → ~250 kg payload

Ref: [1] Gonzalo J., Dominguez D., et al., "On the capabilities and limitations of HAPS", Progress in Aerospace Sciences, 2018

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4. Payload concepts

Multiple camera arrangement

Main EO payload specifications

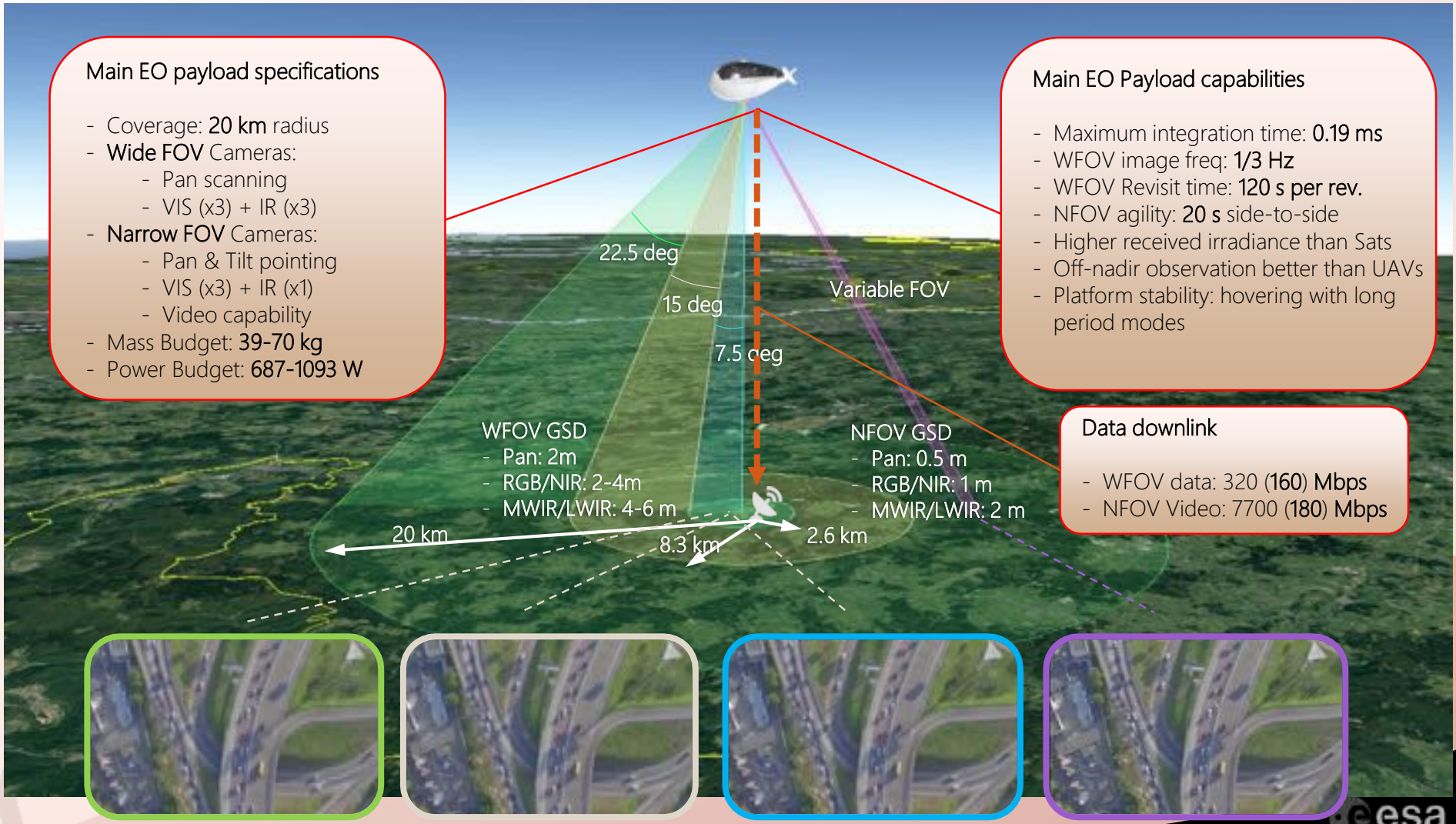
- Coverage: **20 km** radius
- **Wide FOV** Cameras:
  - Pan scanning
  - VIS (x3) + IR (x3)
- **Narrow FOV** Cameras:
  - Pan & Tilt pointing
  - VIS (x3) + IR (x1)
  - Video capability
- Mass Budget: **39-70 kg**
- Power Budget: **687-1093 W**

Main EO Payload capabilities

- Maximum integration time: **0.19 ms**
- WFOV image freq: **1/3 Hz**
- WFOV Revisit time: **120 s per rev.**
- NFOV agility: **20 s** side-to-side
- Higher received irradiance than Sats
- Off-nadir observation better than UAVs
- Platform stability: hovering with long period modes

Data downlink

- WFOV data: 320 (**160**) **Mbps**
- NFOV Video: 7700 (**180**) **Mbps**



4. Payload concepts
Narrow & Wide FOV sensors

NFOV

COTS

MOSP3000 HD
Mass: ~33kg
Power: <200 W
Visible: 1920x1080
IR: 1280x1024, 3-5 μm (MWIR)

ULTRAFORCE 350-HD
Mass: ~28kg
Power: <150 W
Visible: 1280×720
IR: 640x512, 3-5 μm (MWIR)

MX-15
Mass: < 45kg
Power: ~ 280 W
Visible: 1920x1080
IR: 1280x1024, 3-5 μm (MWIR)

minor modifications?

WFOV

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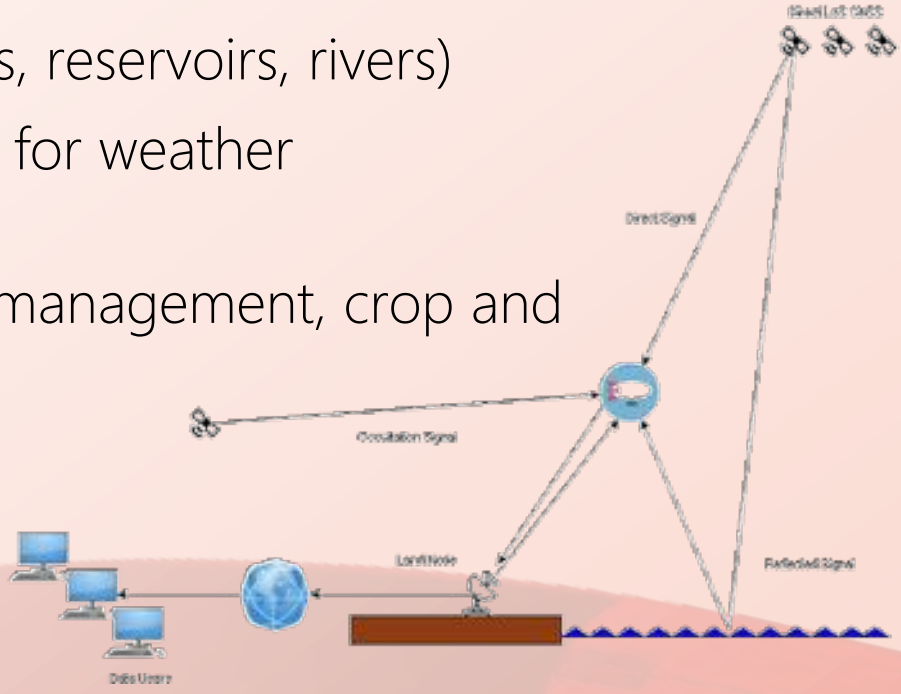
GNSS-based EO services

- GNSS-R data
  - Water level monitoring (sea, lakes, reservoirs, rivers)
  - Wind and current measurements for weather forecasting and maritime studies
  - Biomass measurements for land management, crop and forest monitoring
  - Ice monitoring
- GNSS-RO data
  - Troposphere studies
  - Weather forecasting using GNSS data
- Calibration and testing platform for GNSS-RO and GNSS-R receivers



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5. Conclusions
HAPS-based Earth Observation

- After market analyses target services are identified
  - Security, maritime (coasts), emergencies, local planning (urban)
  - High value/risk areas, rapid changing scenarios
  - HAPS cover both existing and new niches
- Payload concept simple and scalable
  - WFOV persistent surveillance
  - NFOV high resolution steerable
  - Many COTS components
  - GNSS-based sensors are good options to complement EO services
  - Attractive **concepts from 25 to 100 kg** depending on complexity
  - Possibly, business case also for very light payload (~5 kg)

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Thank you very much!

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