Satellite trends

Technical and business technology

and regulatory challenges

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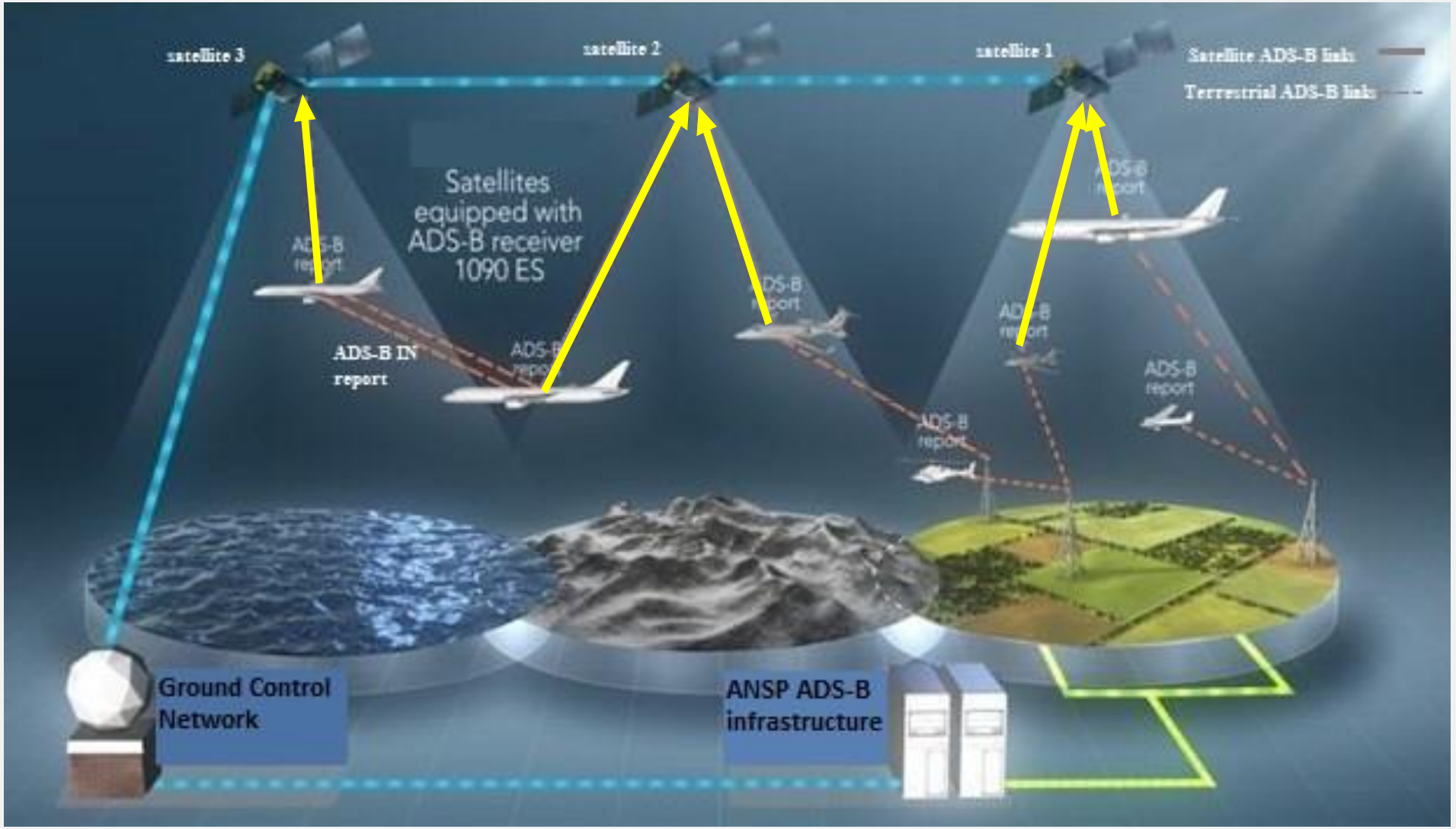
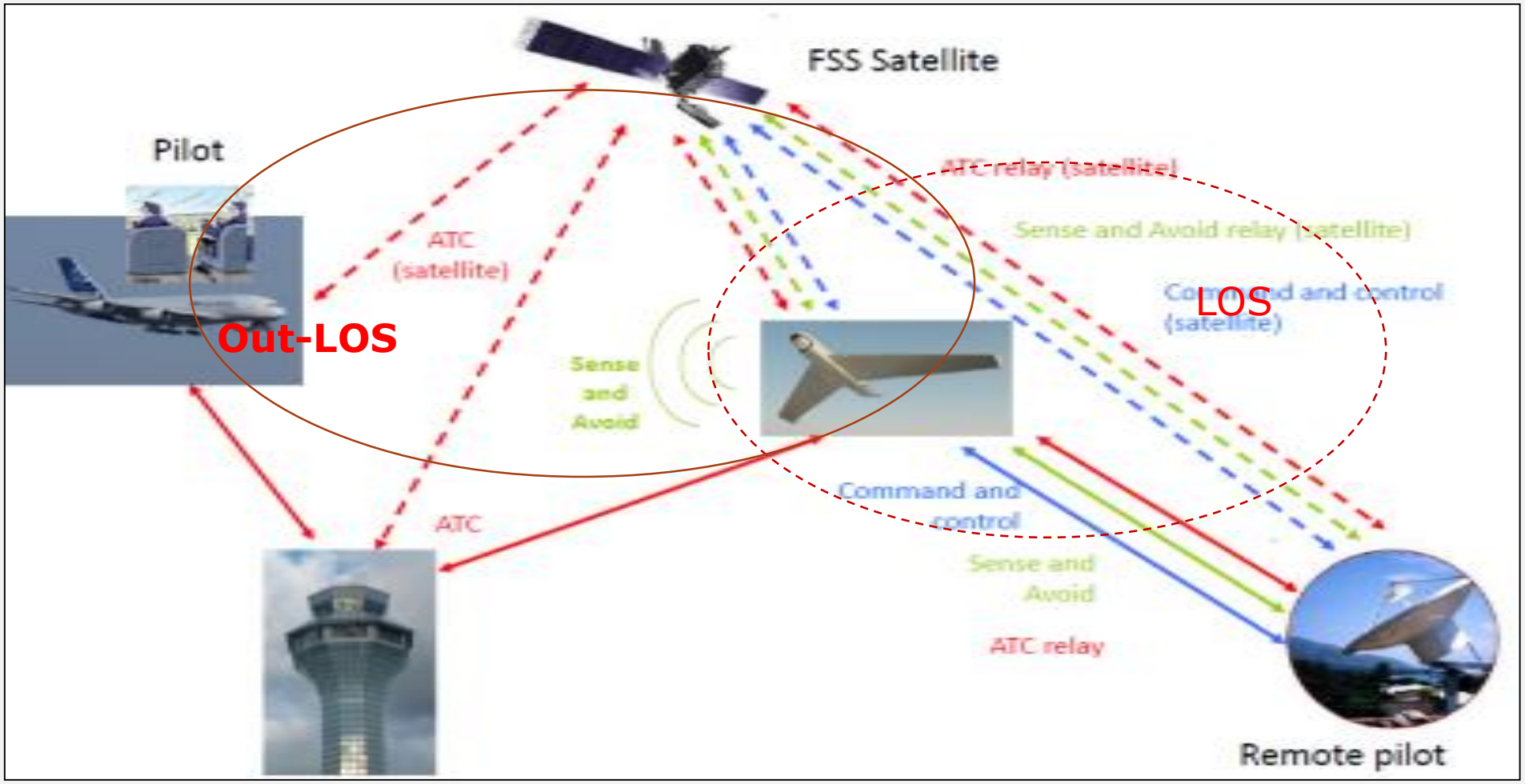
WRC-15 GFT Decision

Seamless satellite based ADS-B – GFT - world wide coverage



WRC-15 – UAS Decision

Unmanned Aircraft Systems (**UAS**) – Use of FSS bands for control and non-payload communications (**CNPC**) of UAS in *non-segregated* airspaces



Non-GSO satellites

Advantages

- Less booster power required
- Less delay in transmission path
- Suitability for providing service at higher latitude
- Lower cost per satellite to build and launch satellites

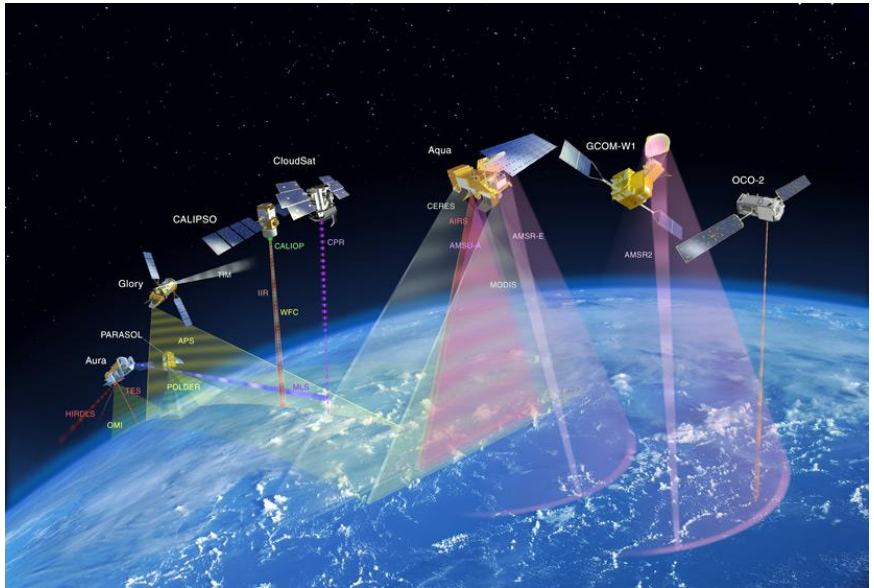
Disadvantages

- Satellite system and ground segment are expensive
- Less expected life of satellites due to ionizing radiation effects, requires frequent replacement
- Requirements for deorbiting

Non-GSO satellite projects

Nowadays

- Space science missions, navigation (GPS, Galileo, Glonass, Compas) and mobile-satellite systems (Iridium, Globalstar)
- First non-GSO broadband from O3B



Satellite technology

- Era of microsats, nanosats
- Mass production brings down the cost
- Technological advancements
  - Satellites terminals are smaller and cheaper
  - Ka-band applications
  - New technologies – optical links, electronic propulsion

How it is non-GSO different?

	1990s	2016
Cost per kg to LEO (USD)	>10 000 (Dnepr-1)	[1 600] – 4 000 (FH projected)

	Teledesic	OneWeb
Cost per sat. (USD)	20mil/35mil	[0.5mil]
Project cost (USD)	9bn	1.5-2bn

How is the satellite communication different?

Investments

More IT/TECH - companies ready to invest (Google, Facebook)

Launch Costs

Launch costs are down, new entrants in the market

SpaceX, Virgin Galactic, Orbital ATK etc

Market

Internet is very different

There are millions without access

Big Data requires more users to mine data

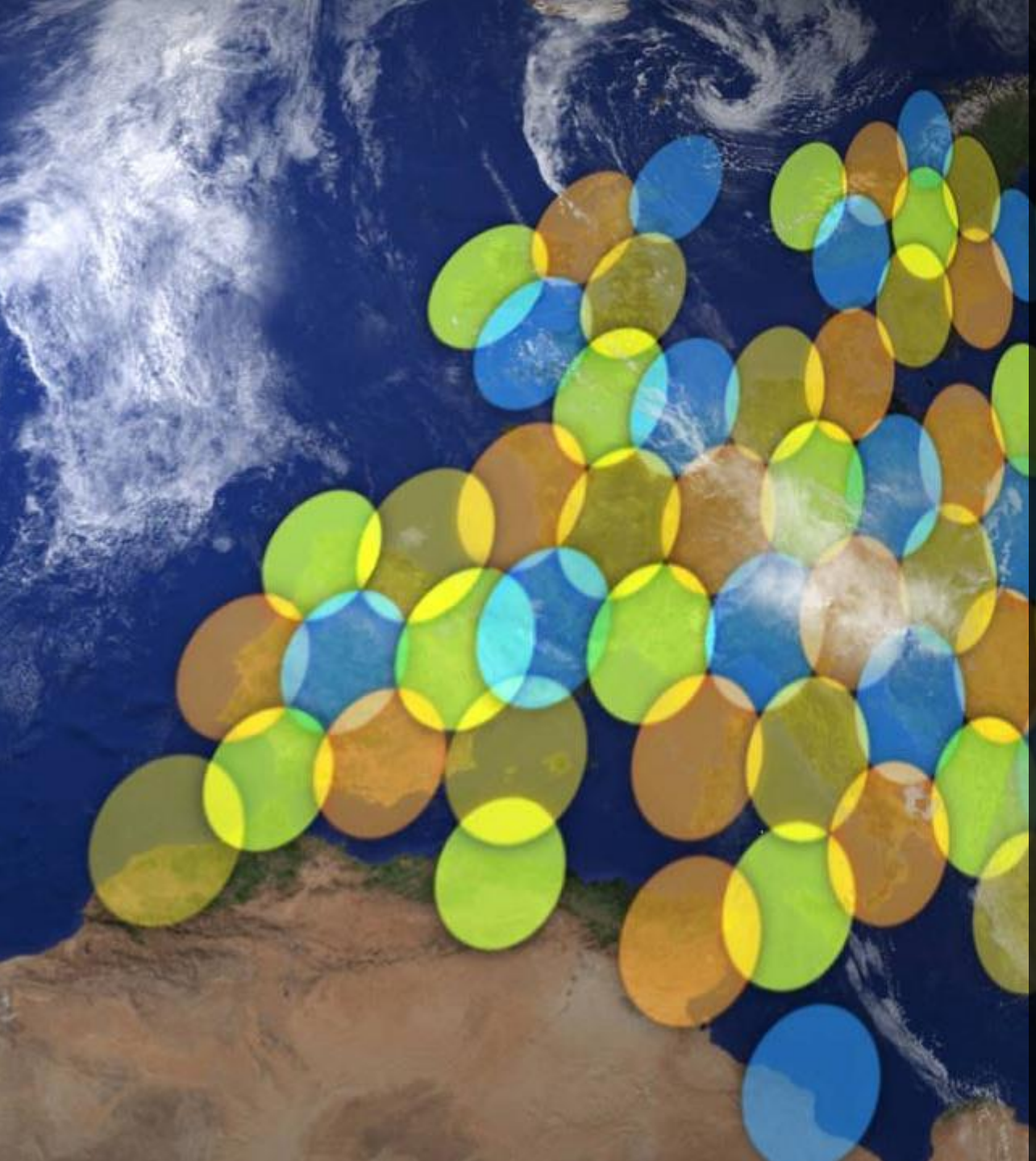
Mobile is the next market to win

New applications – ADS-B, UAS, IoT, ESiM

Competition

More players

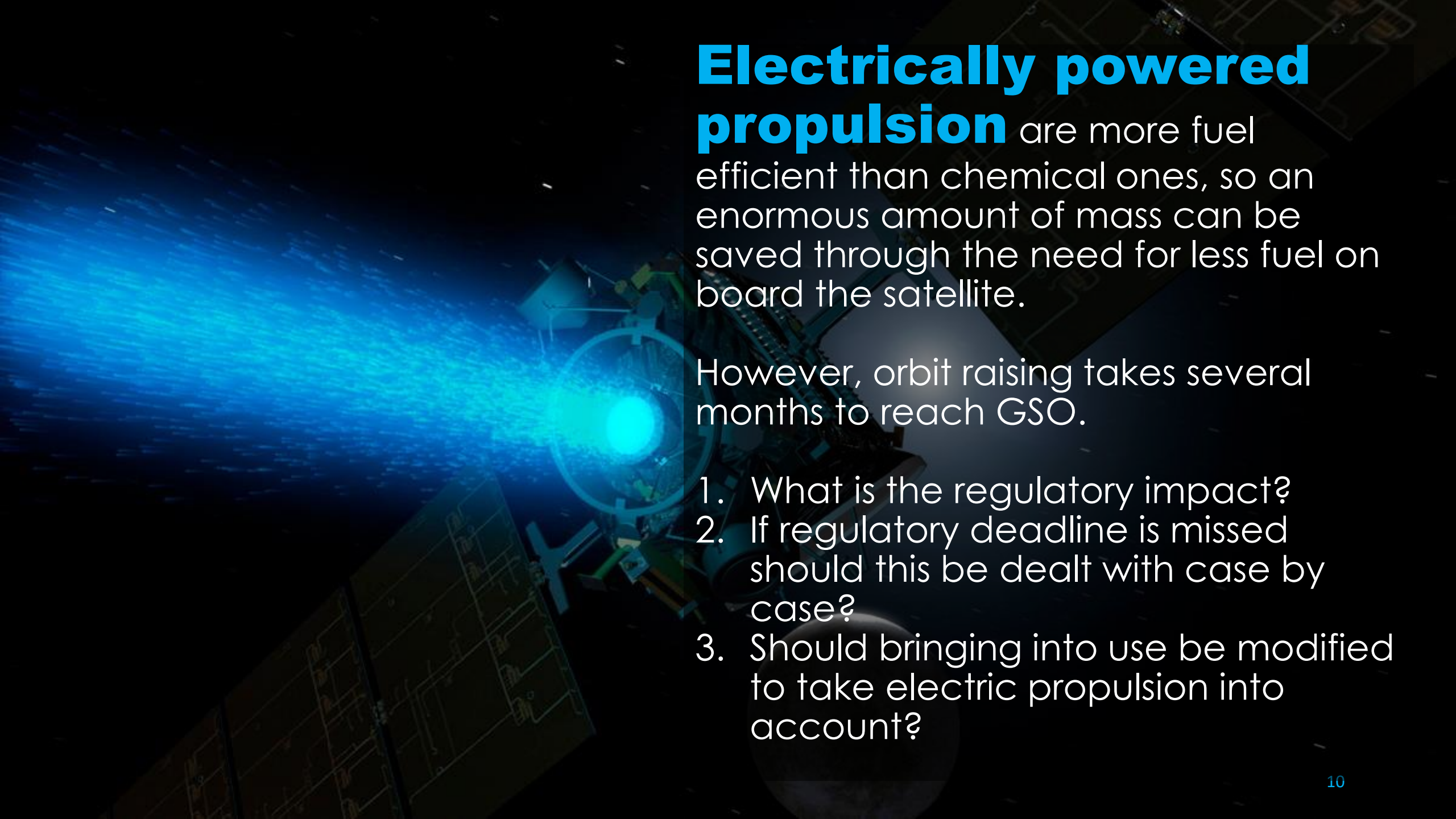
Support from satellite operators



High Throughput Satellite (HTS)

Improved capacity, higher throughput rates, lower space segment cost per MB through frequency reuse and multiple spot beams

1. Is the future towards a fully HTS?
2. Will traditional FSS satellites cease to exist?
3. Does the current Radio Regulations fit to the concept of HTS with its operational flexibility?



Electrically powered propulsion are more fuel efficient than chemical ones, so an enormous amount of mass can be saved through the need for less fuel on board the satellite.

However, orbit raising takes several months to reach GSO.

1. What is the regulatory impact?
2. If regulatory deadline is missed should this be dealt with case by case?
3. Should bringing into use be modified to take electric propulsion into account?

On Orbit Servicing

Providing satellite operators with life-extension (beyond-end-of-fuel continuous service) and other in-orbit services (relocation, orbit correction, inclination correction, bring-into-use (BIU) and deorbiting) using small satellites.

1. What could be the frequency / service used by small satellites for in-orbit service and TT&C?
2. Can the current Radio Regulations procedures –API / Coordination / Notification support such services?
3. Is there a demand for such services in view of 15-20 years lifetime of a satellite?

Small satellites

A “standard 1U" CubeSat has a volume of one liter - 10 cm cube and a mass of 1 kg, orbiting at 300-600 km circular orbit, 1W transmitter on 145 or 435 MHz amateur-satellite service band.

Source: Rasmus G. Sæderup/AAU Student Space (University of Aalborg, Denmark)

Why Small Satellites ?

"Faster, Cheaper, Better, Smaller"

- **Faster** to build/launch **(<1 year)**
- **Cheaper** to build/launch **(10's of k$)**
- **Easy** modular & standardised **(CubeSats)**
- **Smaller** latest technology **(lighter and efficient)**

Also promotes:

Technology transfer, Collaboration, Education, Earth Science, Testing innovative technologies, ...

But this comes with drawbacks

Drawbacks!

no regulatory definition *for small satellites*
in the ITU RR (only geostationary (GSO) and non-GSO satellites)

- **Limited Launching opportunities**
  > mission delays
- **No/Little Orbit Control**
  > higher collision risks
- **Small/Unreliable Power Source**
  > large & costly ground stations
- **Limited Lifetime**
  > low reliability of electronics
- **Limited Mission Types**
  > commercially unsustainable
- **Limited Regulatory Certainty**
  > Lengthy time for Space Activity License
  > Lengthy ITU frequency/coordination

Small satellite characteristics?
ITU-R Question 254/7

Characteristics and spectrum requirements of satellite systems using nano and pico satellites

- The ITU-R WP7B finished study Question 254/7

- Report ITU-R **SA.2312** Characteristics, definitions and spectrum requirements of nanosatellites and picosatellites, as well as systems composed of such satellites

- Report ITU-R **SA.2348** Current practice and procedures for notifying space networks currently applicable to nanosatellites and picosatellites

For more info see **ITU-R WP7B** studies:

http://www.itu.int/en/ITU-R/study-groups/

Small satellite Launches

Depending on specific mission objectives, small satellite missions

- May or may not have particular orbital requirements
- May have a number of potential launch opportunities available, and may thus *not have knowledge of specific orbital characteristics until a launch vehicle is selected*
- Have been launched mostly *as secondary payloads*, meaning that the primary mission for the launch vehicle involves the launch of one or more larger satellites
  - *Because of the interest in small satellites, launch/mission developers are now considering whether dedicated small satellite launches and/or launch vehicles would be useful*

Small satellite TT&C and ground segment

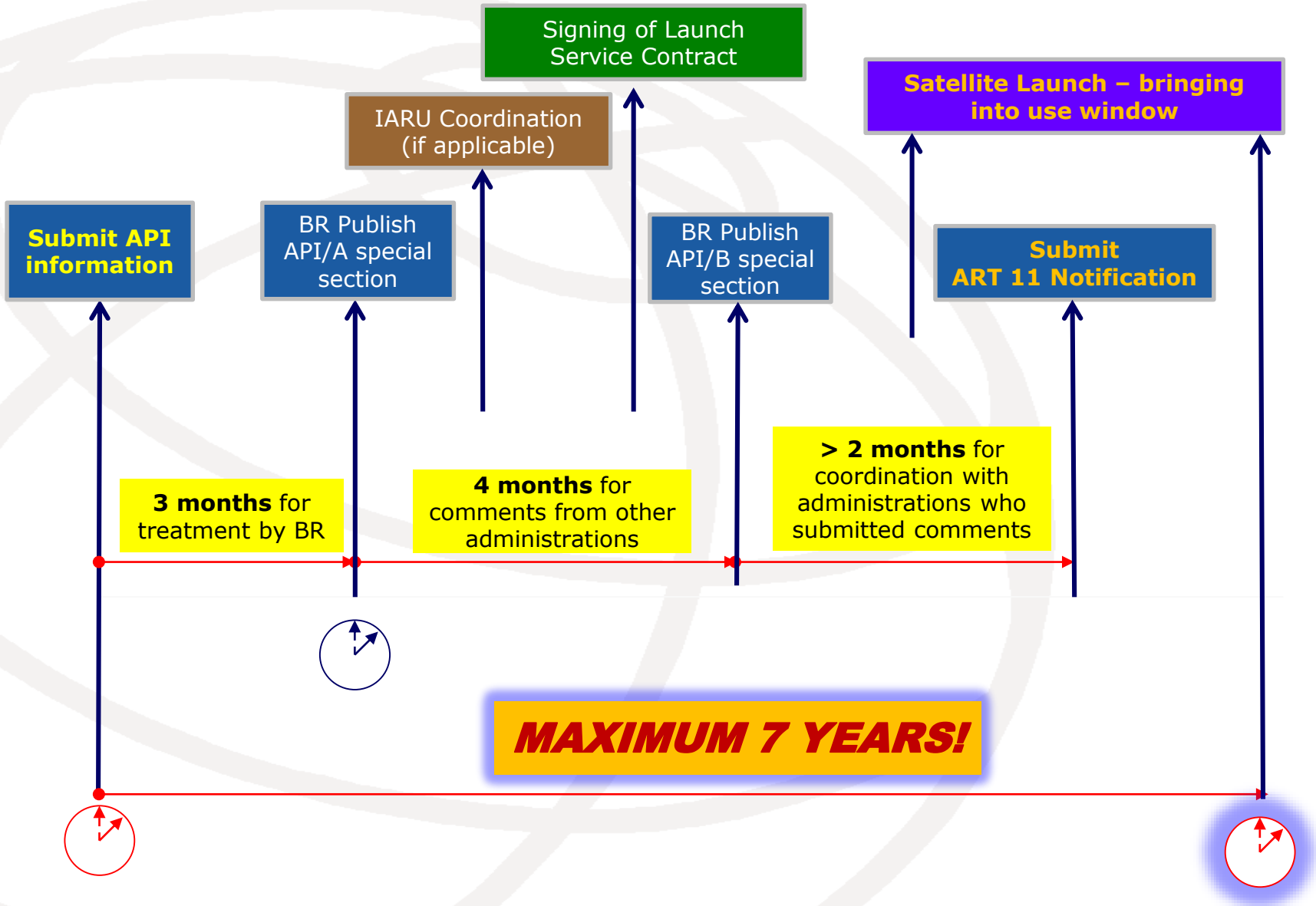
- Under No. **22.1** of the RR, *space stations shall be fitted with devices to ensure immediate cessation of their radio emissions by telecommand*

➢ In order to comply with requirements to control and have the ability to cease transmissions, small satellites have implemented a *passively-safe system* - satellite is active **ONLY** *when in view of an associated earth station*

- Most small satellite missions are utilizing a *single small earth station*

➢ Recent developments in *networks of cooperative earth stations* have enabled to ***receive*** telemetry throughout large proportions of the orbit. *In this case the satellite service area shall be declared global*

Small satellite regulatory time limits



WRC-15 Decision - 1

- **SUP RES-757(WRC-12)** Consider *whether modifications to the regulatory procedures for notifying satellite networks are needed to facilitate the deployment and operation* of small (nano- and pico) satellites…
- **WRC-15 – decision**

➢ **NO need for any special regulatory procedures** *to facilitate the deployment and operation of nano- and pico satellites*

WRC-15 Decision - 2

Resolution 659 (WRC-15)

Studies to accommodate requirements in the space operation service for non-geostationary satellites with short duration missions

- *resolves to invite* ***WRC-19*** **(AI 1.7)**
  - to consider the results of ITU-R studies and *take necessary action*, as appropriate, provided that the results of the studies referred to in *invites ITU-R* below are complete and agreed by ITU-R study groups,
  - *invites ITU-R*
  - 1 to study the spectrum requirements for telemetry, tracking and command in the space operation service for the growing number of non-GSO satellites with short duration missions, taking into account RR No. **1.23** (space operation service);
  - 2 to assess the suitability of existing allocations to the space operation service in the frequency range below 1 GHz, taking into account *recognizing a)* and current use;
  - 3 if studies of the current allocations to the space operations service indicate that requirements cannot be met under *invites ITU-R* 1 and 2, to conduct sharing and compatibility studies, and study mitigation techniques to protect the incumbent services, both in-band as well as in adjacent bands, in order to consider *possible new allocations or an upgrade of the existing allocations to the space operation service within the frequency ranges 150.05-174 MHz and 400.15-420 MHz*

Small satellite operation *Issues…*

- *Operation in the "free ISM bands" – ISM band* is NOT allocated to ANY *space service* !…ISM *equipment or appliances to generate and use locally radio frequency energy for domestic or similar purposes*, ***excluding applications in the field of telecommunications***

- Operation without a licence in the "*free ham frequency band*"

- *Utilisation of Globalstar or Iridium earth terminal on board of small satellite for data collection*

- Commercial use of amateur-satellite bands – RR ART **25** and No. **1.56** apply ***(no commercial use !!)***

Thank you for your attention!

Questions?

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