

OPTICAL FEEDER LINKS FOR HIGH THROUGHPUT SATELLITES THE H2020 VERTIGO PROJECT

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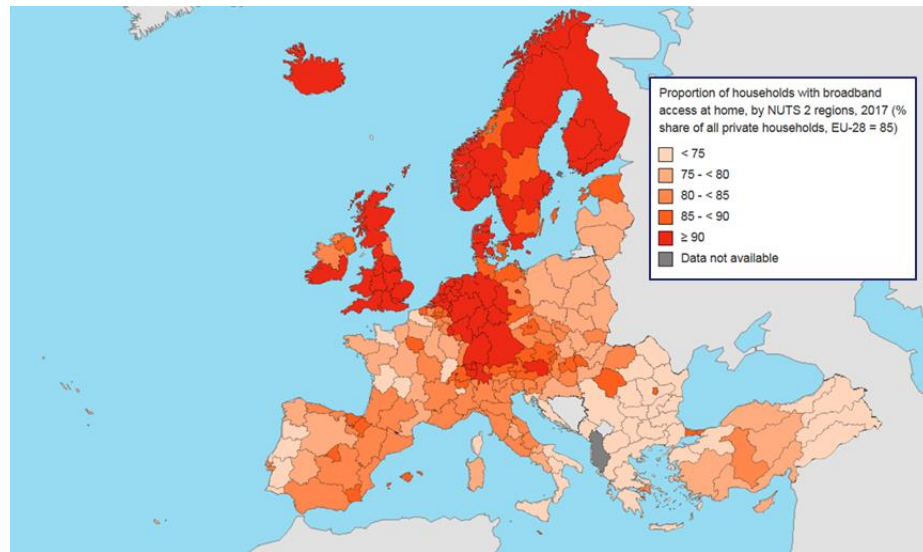
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OPTICAL FEEDER LINKS FOR V/HTS

///Context

- / Increasing demand for broadband services
- / Emergence of new capacity-hungry technologies / applications
 - 5G
 - Internet of Things (IoT)
 - Artificial Intelligence
 - Data Analytics & Big Data
 - M2M
 - Digital transformation of companies
 - ...
- / Reduction of digital divide in Europe (and in the world)



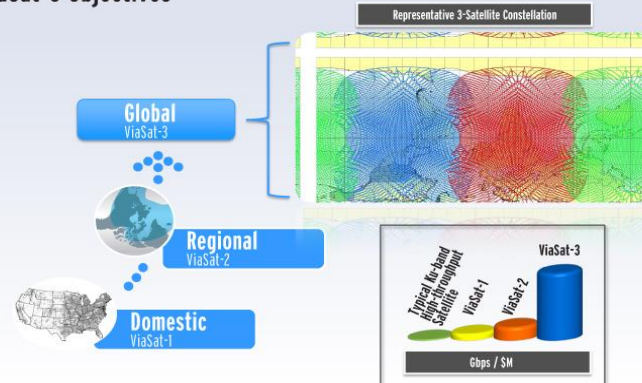
OPTICAL FEEDER LINKS FOR V/HTS

/// Context

- Satellite is the solution
 - To bridge the digital bringing connectivity to everyone everywhere
 - To complement terrestrial communication infrastructures
- A few examples of capacity growth from space
 - **Eutelsat**
 - Ka-Sat (2010): 90 Gbps capacity
 - KONNECT (2019): 75 Gbps of capacity, scheduled for launch in January
 - **KONNECT VHTS (2022): 500 Gbps capacity**
 - **EchoStar**
 - Jupiter 1 (2012): 120 Gbps
 - EchoStar 19-Jupiter2 (2016): 180 Gbps
 - **Jupiter3- Echostar 24 (2021): 500 Gbps**
 - **Intelsat**
 - Intelsat 33 (2016): 60 Gbps capacity
 - **ViaSat**
 - ViaSat-1 (2011): 140 Gbps capacity
 - **Viasat-2 (2017): 300 Gbps capacity → 45 Gateways**
 - **Viasat-3 (2020-2022): 1 Tbps capacity / satellite (3 satellites)**
→ **100's Gateways for the trio**



ViaSat-3 Objectives



→ Huge (and expensive) ground segment

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OPTICAL FEEDER LINKS FOR V/HTS

/// Context

The capacity needs are expected to continuously progress on ground and in space in coming years

RF spectrum is a limited resource for space

- Conflicts with terrestrial applications to grab RF spectrum resource
- Foreseeable Saturation of traditional RF bands (Ka, Q/V)
- Need to share spectral resource between users and feeders (unless not colocated)

higher RF frequency bands are considered for space applications (beyond Q/V)

- Low maturity
- Issues related to high microwave frequencies (attenuation)

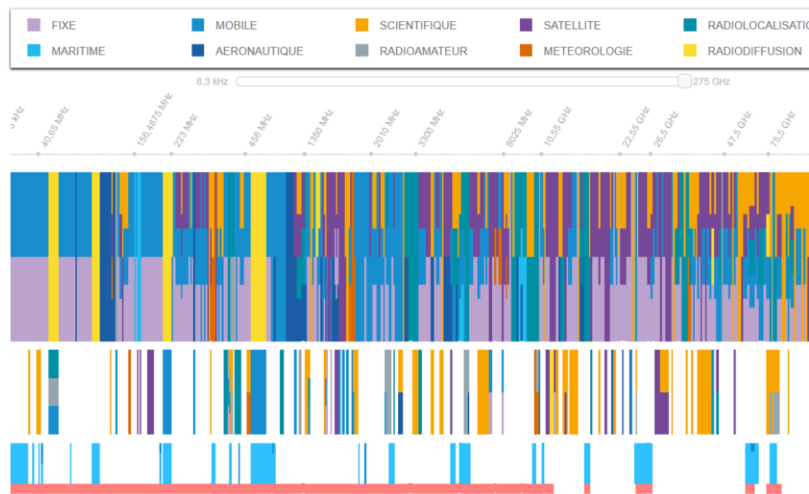
Optical technologies offer simultaneously several assets

- No regulation
- Large bandwidth available
- large availability of components from terrestrial telecom networks applications (@ 1.5 μm)
- Leveraging large R&D efforts and
- Possibly future integration with terrestrial optical networks

Reduction of ground segment + freeing RF bands for users

Increasing number of Gateways

(source: ANFR)



OPTICAL FEEDER LINKS FOR V/HTS

/// Towards Tbps capacity : How to convey these huge capacities ?

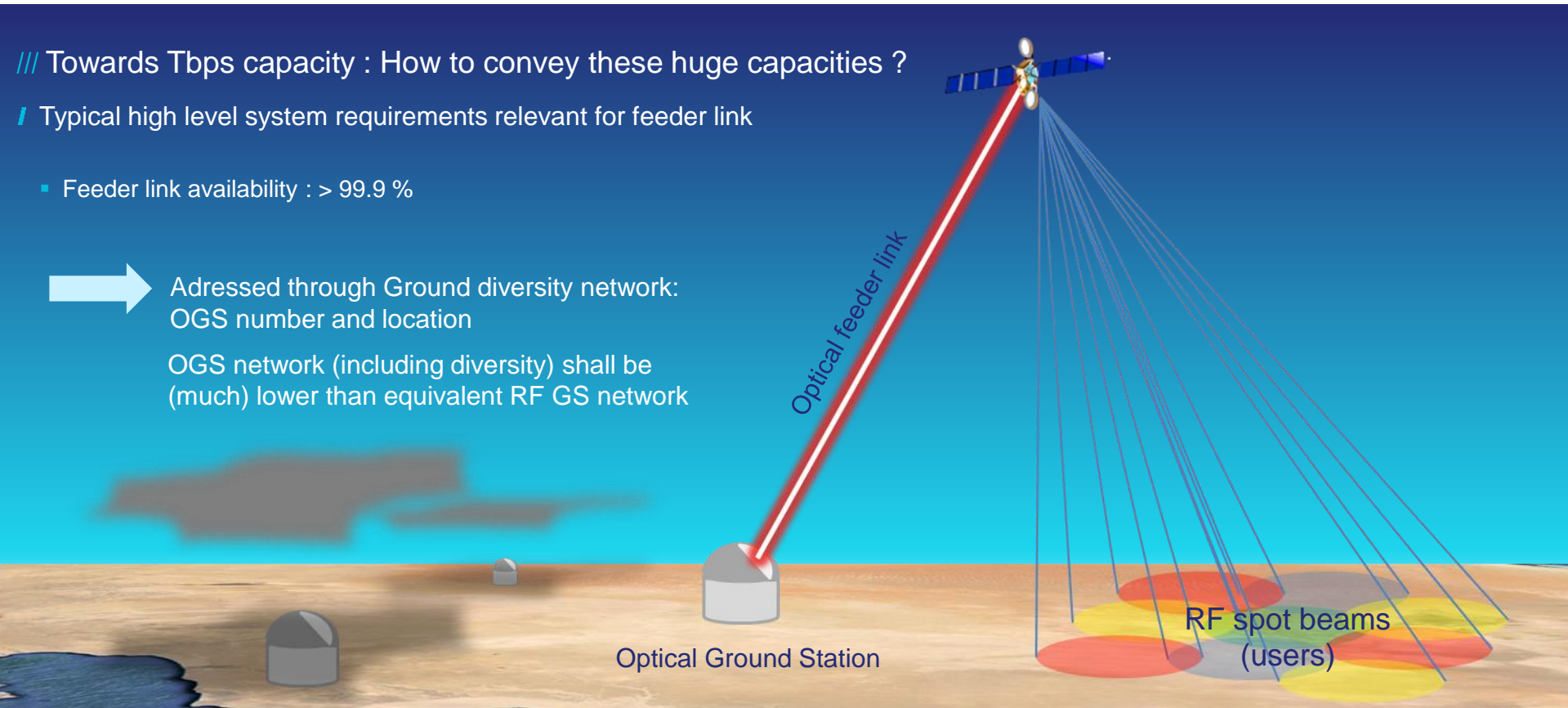
■ Typical high level system requirements relevant for feeder link

- Feeder link availability : $> 99.9\%$



Adressed through Ground diversity network:
OGS number and location

OGS network (including diversity) shall be
(much) lower than equivalent RF GS network

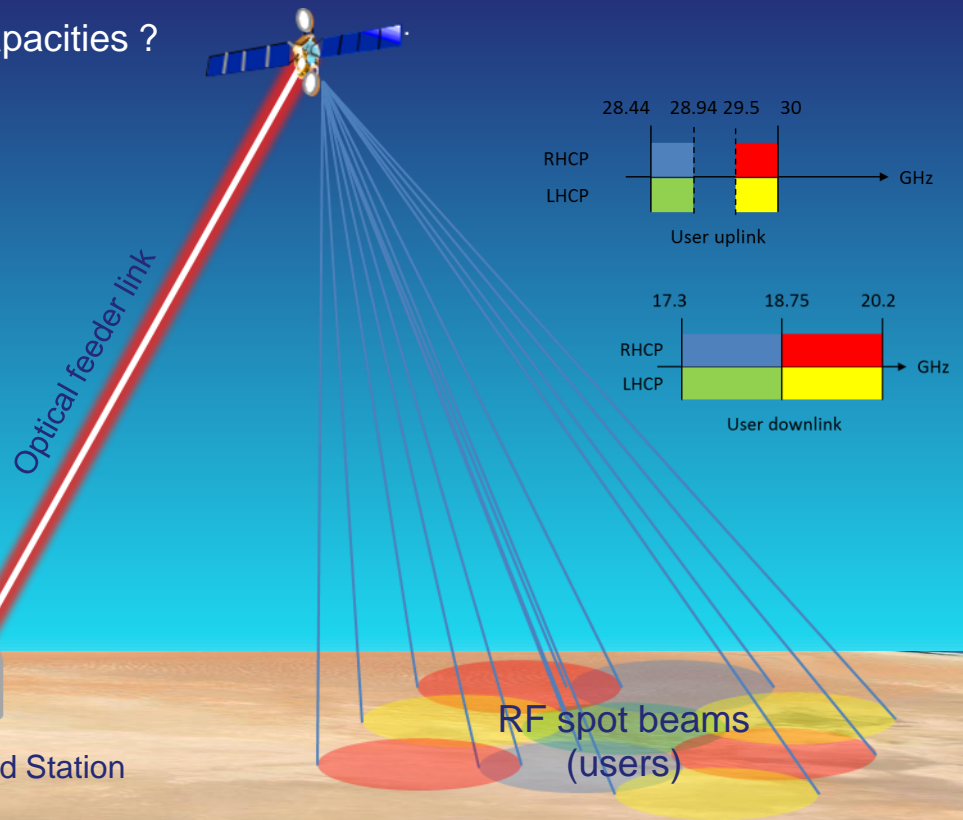


OPTICAL FEEDER LINKS FOR V/HTS

/// Towards Tbps capacity : How to convey these huge capacities ?

Typical high level system requirements relevant for feeder link

- Feeder link availability : > 99.9 %
- Forward user band : [17.3 – 20.2] GHz
- Return user band : [28.44 – 28.94] & [29.5 – 30] GHz
- RF band/beam
 - Forward : 1.45 GHz/beam
 - Return : 0.5 GHz/beam
- Physical layer :
 - Forward : DVB-S2X
 - Return : DVB-RCS2

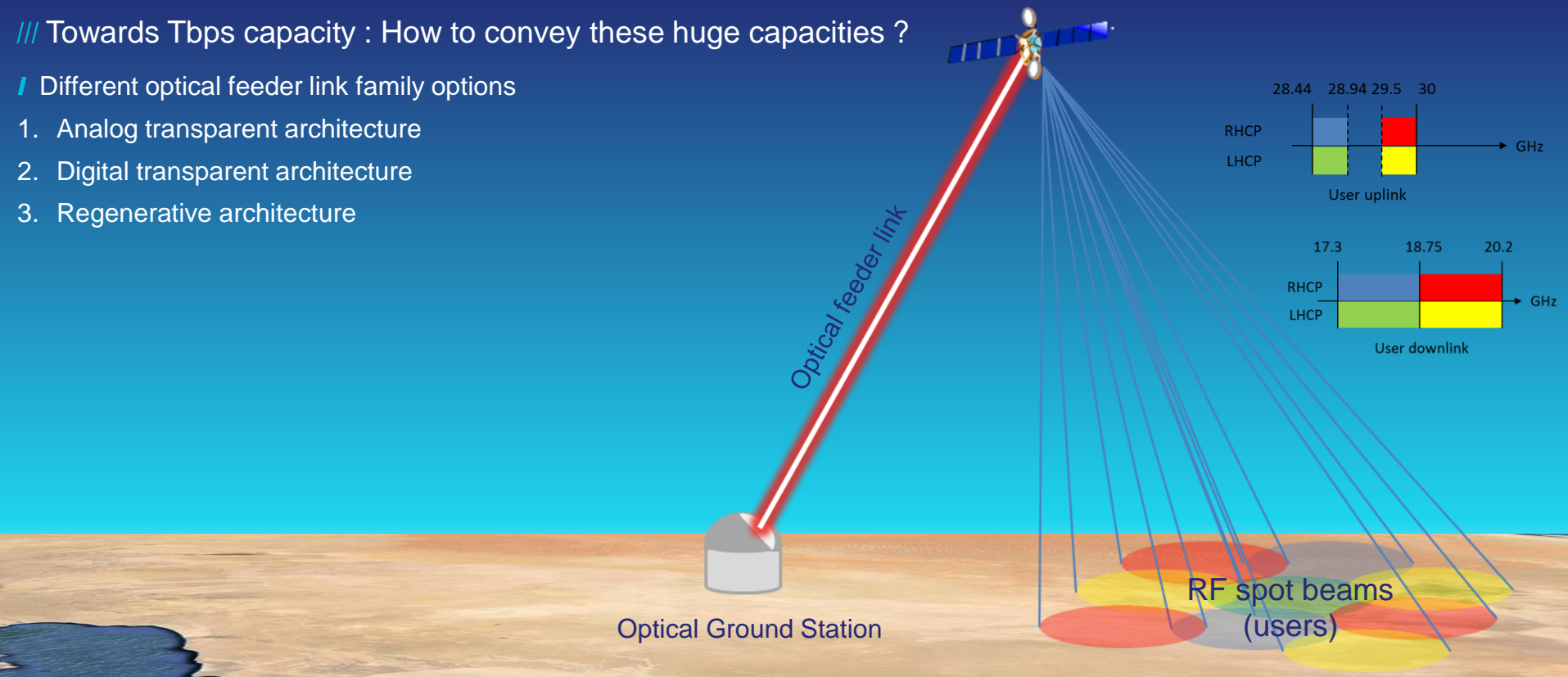


OPTICAL FEEDER LINKS FOR V/HTS

/// Towards Tbps capacity : How to convey these huge capacities ?

/// Different optical feeder link family options

1. Analog transparent architecture
2. Digital transparent architecture
3. Regenerative architecture



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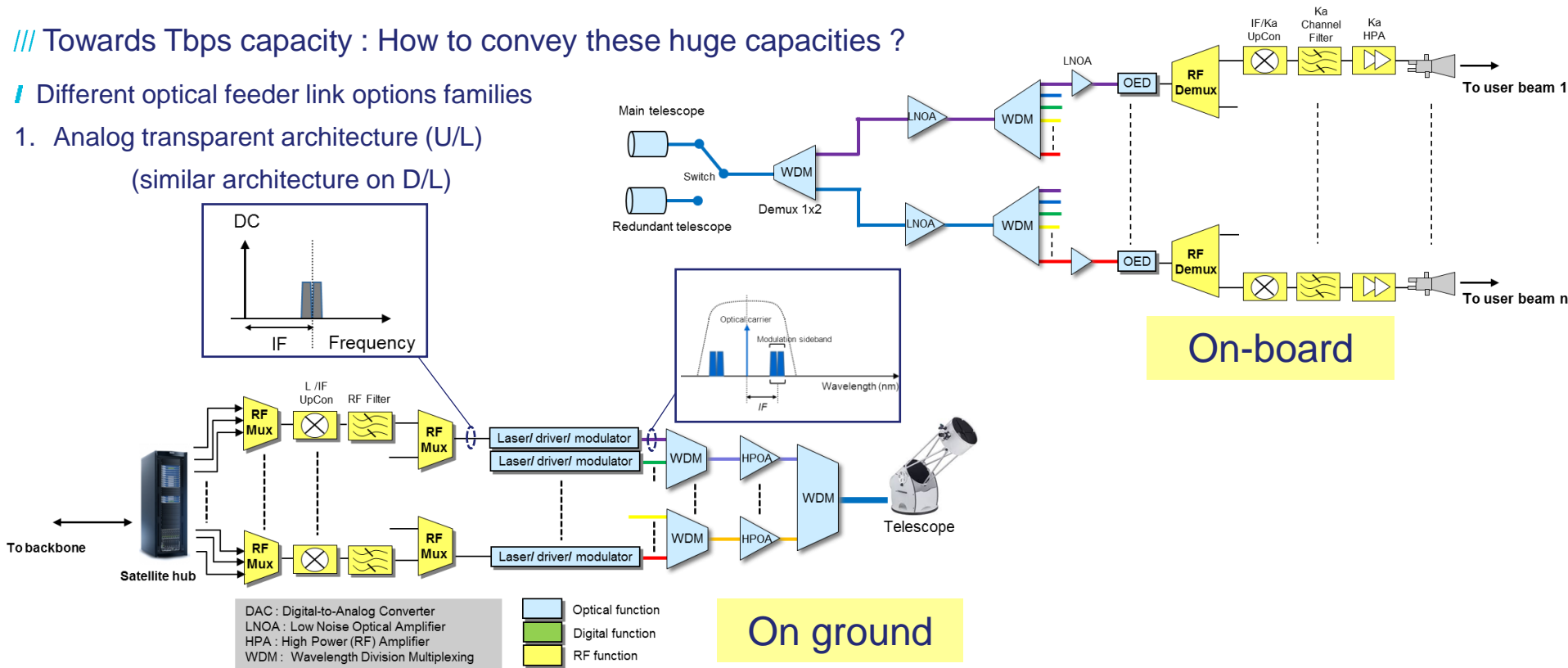
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OPTICAL FEEDER LINKS FOR V/HTS

/// Towards Tbps capacity : How to convey these huge capacities ?

/// Different optical feeder link options families

1. Analog transparent architecture (U/L)
(similar architecture on D/L)

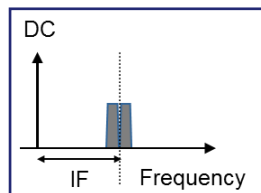
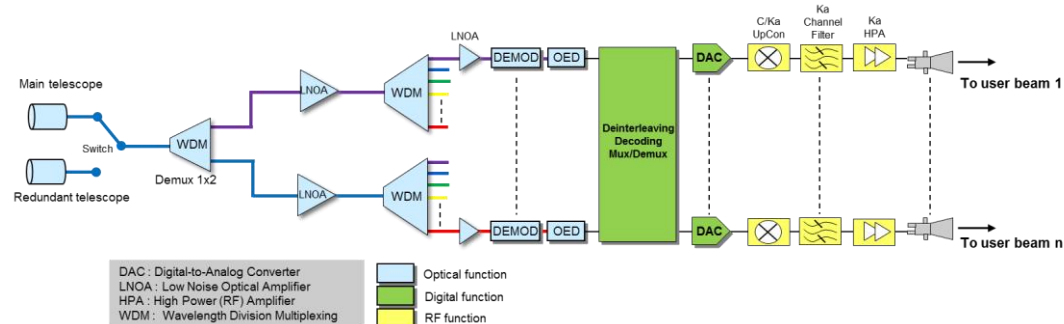


OPTICAL FEEDER LINKS FOR V/HTS

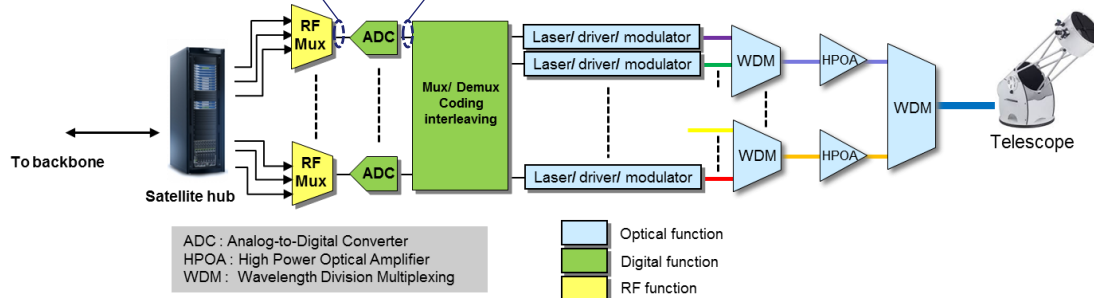
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~ bit rate: RF Bw x 10
to 16 bits (typ.)



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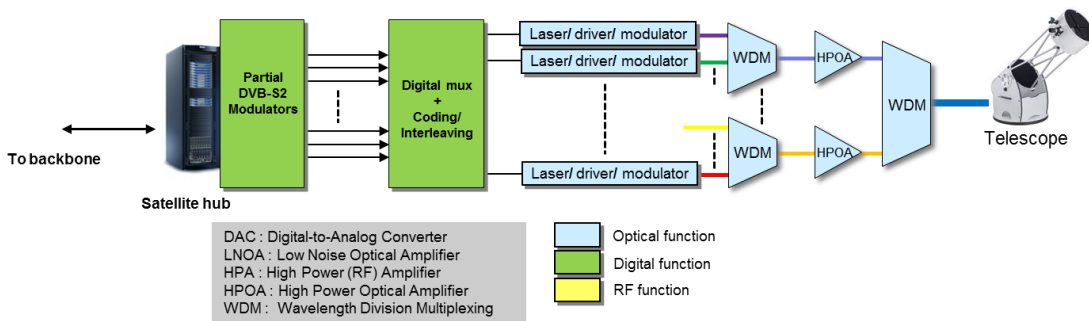
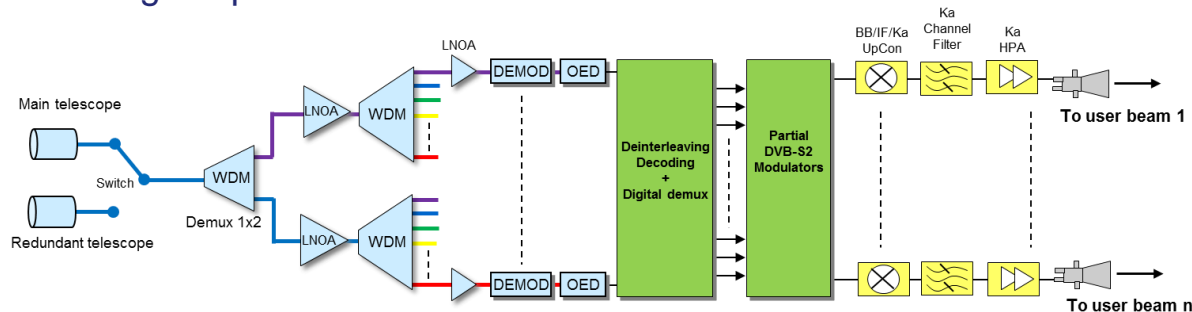
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OPTICAL FEEDER LINKS FOR V/HTS

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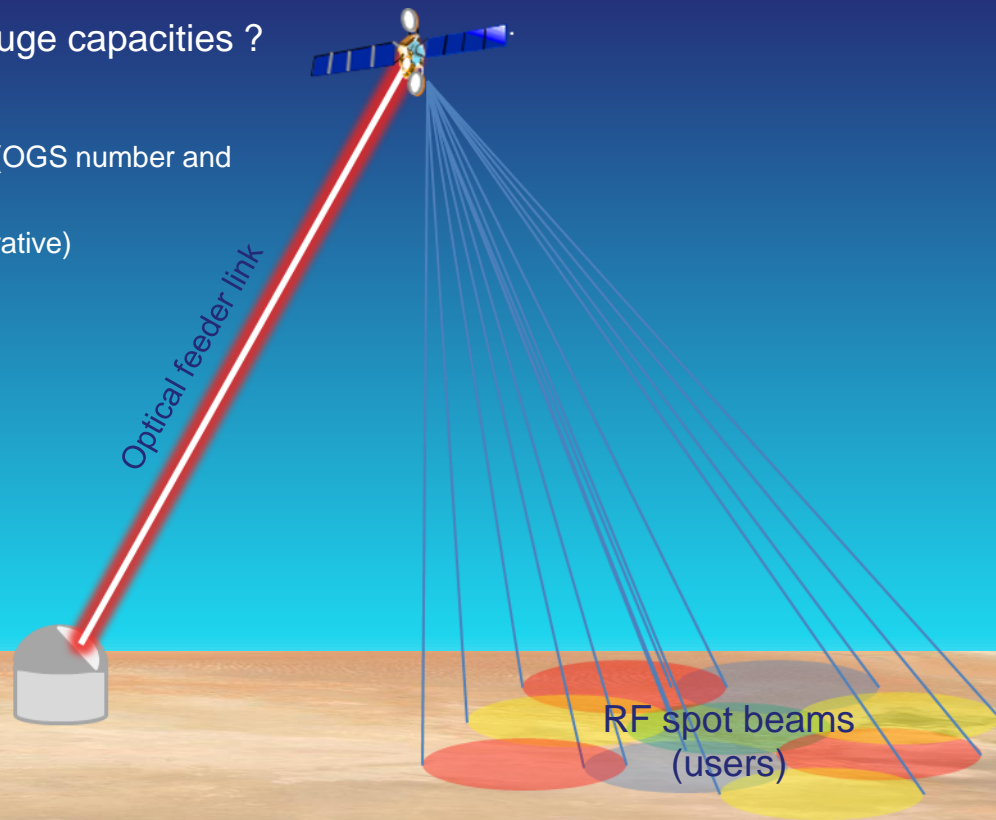
	Digital transparent	Analog transparent	Regenerative
Assets	<ul style="list-style-type: none">• Agnostic to signals to be transmitted• Robustness to atmospheric impairments thanks to coding/interleaving	<ul style="list-style-type: none">• Agnostic to signals to be transmitted• Low complexity• Low optical bandwidth requirements	<ul style="list-style-type: none">• Reasonable bitrate to be transmitted (w.r.t digital transparent)• Robustness to atmospheric impairments thanks to coding/interleaving
Weaknesses	<ul style="list-style-type: none">• Large increase of total bit rate due to digitization of RF signals• Large optical bandwidth requirements• Feasibility challenging at very high throughput	<ul style="list-style-type: none">• Robustness to propagation impairments questionable• May induce large power margin	<ul style="list-style-type: none">• Architecture not transparent, need for RF modems on-board

OPTICAL FEEDER LINKS FOR V/HTS

/// Towards Tbps capacity : How to convey these huge capacities ?

! Several challenges to implement optical feeder links

- Ground diversity network dimensioning for high availability (OGS number and locations)
- Feeder link architecture (analog, digital transparent/regenerative)
- Optical transmission waveform
- High speed processing
- High optical power generation and management
- Atmospheric turbulence perturbation mitigation



OPTICAL FEEDER LINKS FOR V/HTS

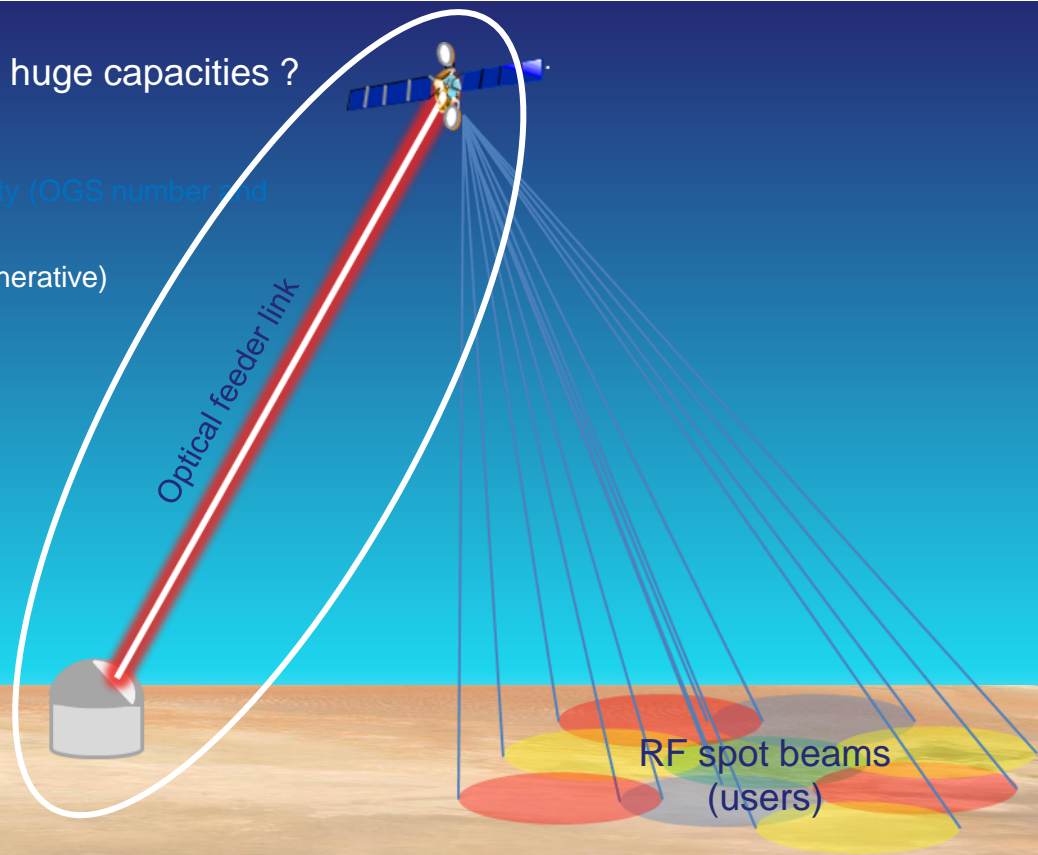
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H2020 VERTIGO project



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H2020 VERTIGO OVERVIEW



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 822030

/// VERy high Throughput Satellite-Ground Optical Link (VERTIGO)

/ VERTIGO ambition

- to establish the required breakthrough by developing the on-board and ground concepts and technologies enabling for a drastic increase of the link throughput towards and beyond 1 Tbps

/ VERTIGO objectives

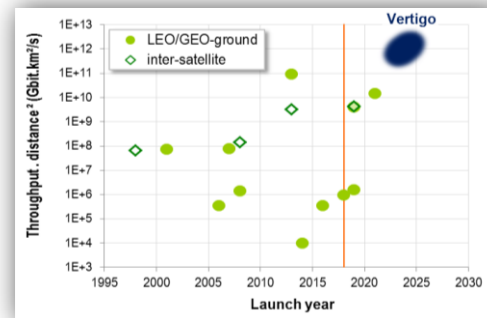
- Objective 1** : Higher capacity through advanced modulation format implementation
 - Direct Detection / Coherent / Analog modulation schemes
- Objective 2** : High optical power generation for free space optical coms
 - High power amplifier / high power beams combination
- Objective 3** : High availability optical links through atmosphere
 - Adaptive optics / multi-aperture / channel coding
- Overall objective** : To demonstrate the feasibility of very high throughput optical links in particular for GEO optical feeder links by an unprecedented combination of these concepts and technologies

/ VERTIGO means

- Consortium :



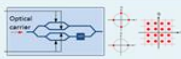

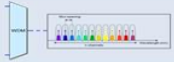










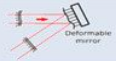





- Laboratory and outdoor demonstrations





H2020 VERTIGO OVERVIEW

/// VERTIGO concept and approach

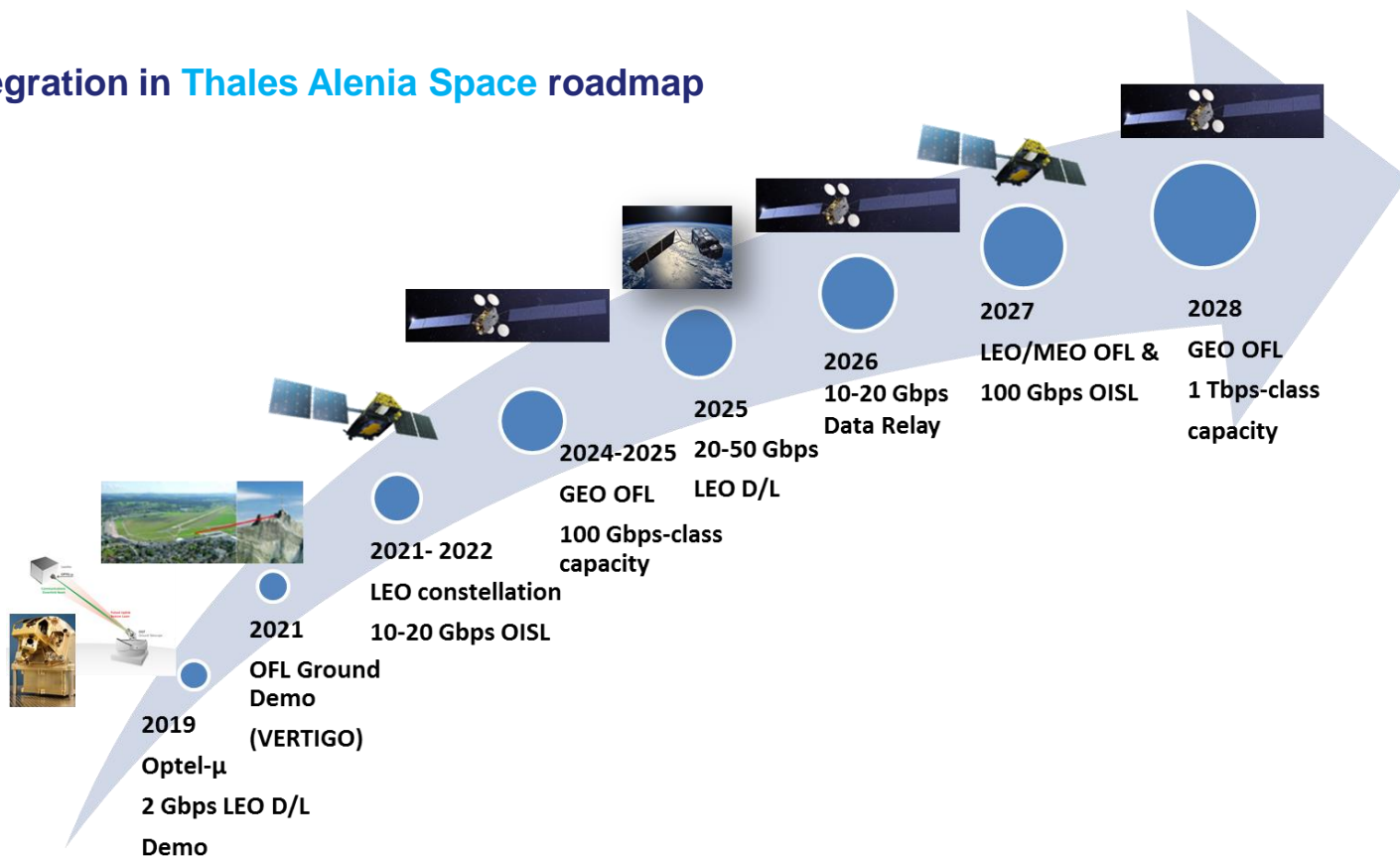
- How VERTIGO technologies serve VERTIGO objectives

		Throughput increase	Power & power efficiency increase	Atmospheric effects mitigation
	Advanced modulation formats			
	WDM (incoherent) Combining			
	Very-high-power optical amplifier			
	Coherent power combining			
	Aperture diversity			
	Adaptive optics			
	Error correction coding/interleaving			

 : for ground application
  : for on-board application

OPTICAL FEEDER LINKS FOR V/HTS

/// Full integration in Thales Alenia Space roadmap



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Questions ?

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