

Emerging Technologies and their Implications on Networks and Peering

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25+
Countries

50+
Metros

6
Continents

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A unique vantage point!

Digital Realty has a unique vantage point to observe and participate in early stages of projects that shape the future of the internet!

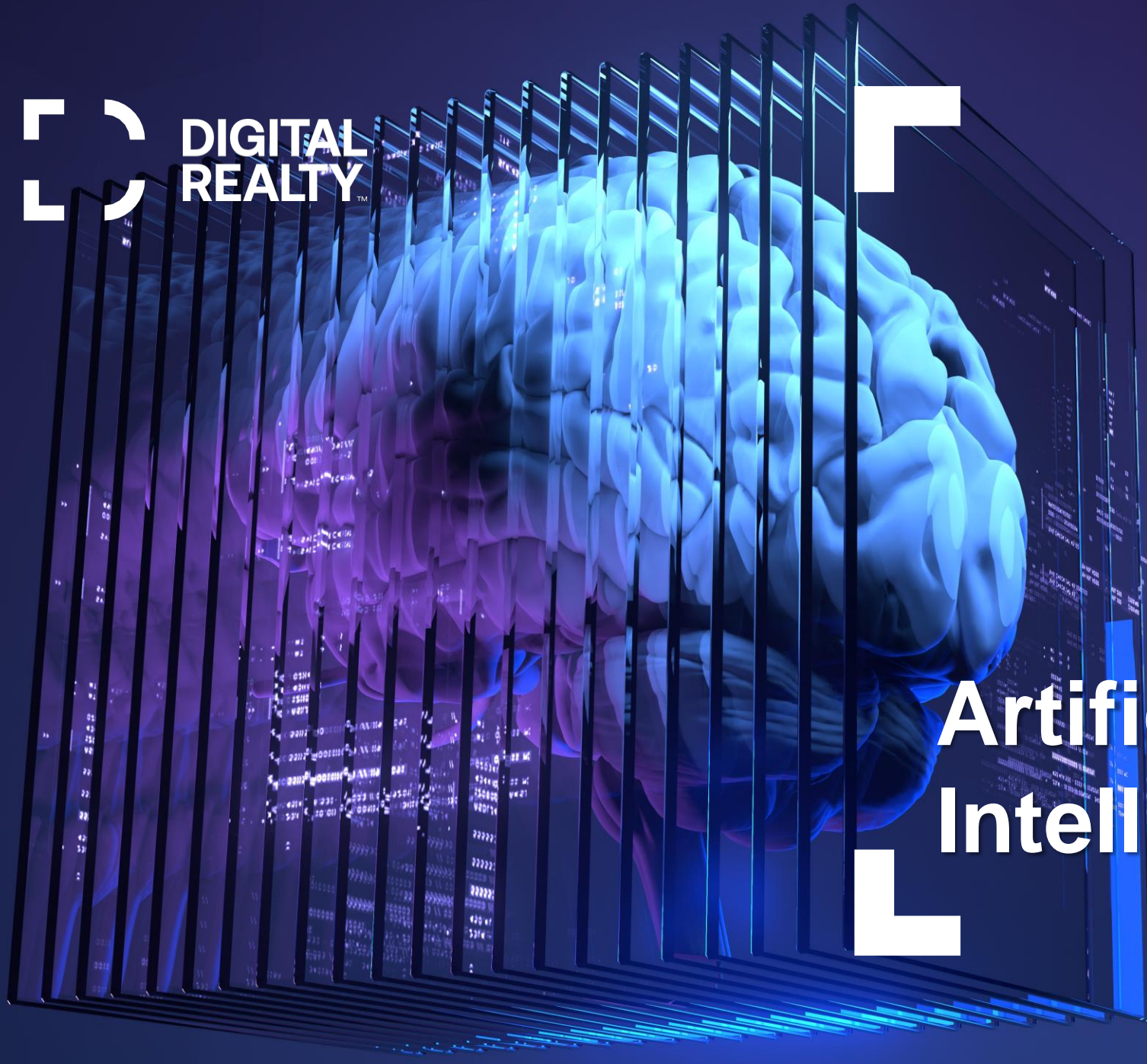
Some of the emerging technologies and developments that will affect connectivity and peering:

- Artificial Intelligence (AI)
- Cloud Computing
- Subsea Networks
- Satellite Networks
- Internet Exchanges
- Quantum Computing & Quantum Networking
- Edge Computing
- Fiber optics
- ...





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Artificial Intelligence



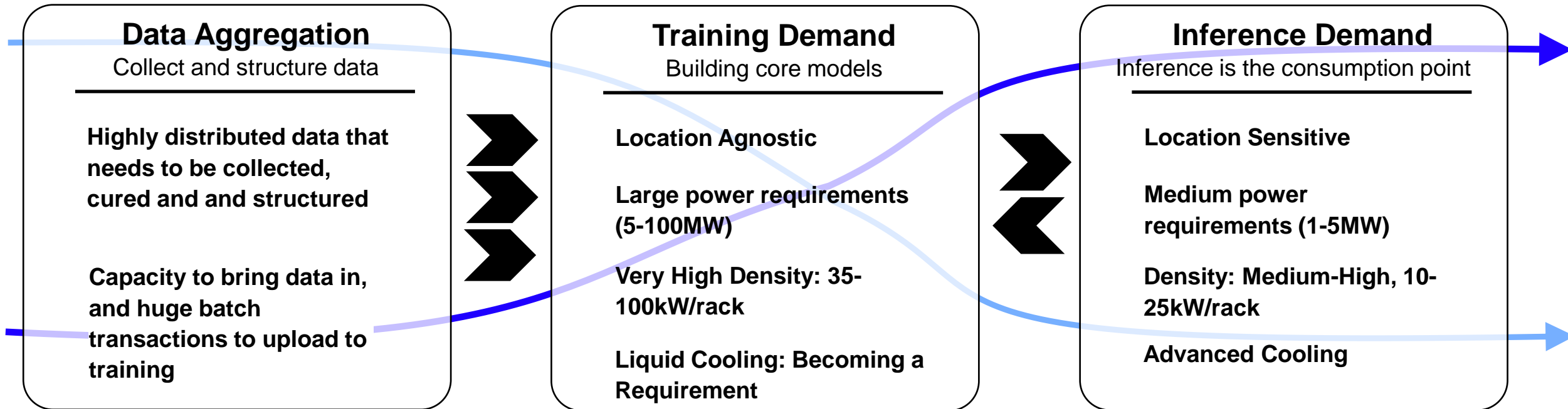
AI is continuing to accelerate and evolve

Data aggregation, training and inference workloads co-exist in Digital Realty data centers

0 Data Aggregation & Preparation

1 Training

2 Inference



AI & Interconnections/Peering

CAPACITY, CAPACITY, CAPACITY

- Huge capacity requirements (eg 400G/800G) for gathering distributed data and feeding training clusters

HYBRID AI

- Public Cloud AI infrastructure will absorb a significant portion of the demand
- Private AI for corporate-sensitive data and proprietary training
- Governance, Regularity & Sovereignty rules (eg on sectors like FS or Health) may lead to Sovereign AI
- Hybrid AI to connect different AI providers

▪ ORCHESTRATION

- AI and Data Exchanges, to provide access to hybrid AI and interconnect components from different providers
- Intelligent orchestration across data, AI models, and applications, delivered to users in real-time

INFERENCE, AI GATEWAYS & ON-RAMPS

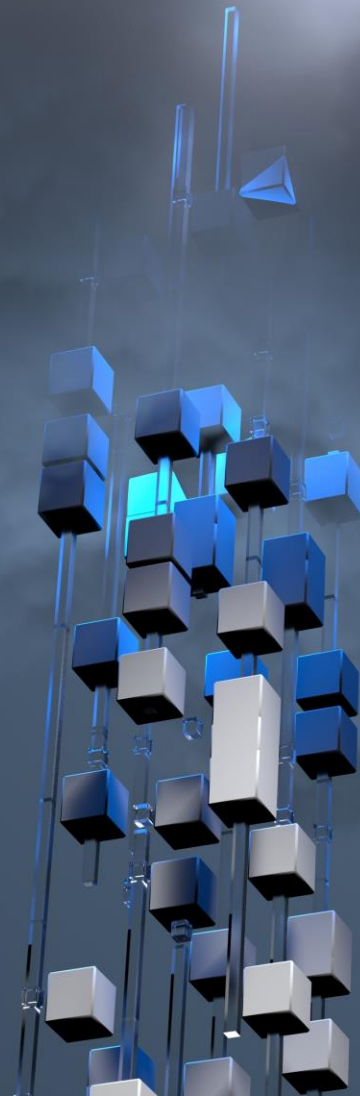
- Expect AI Inference to drive interconnection
- Cloud on-ramps may evolve to also host “AI Gateways/on-ramps”
- New specialized AI-related network/peering services?

TRAINING LOCATIONS

- Training will take place on selected core locations, within purpose-built datacenters that meet the huge capacity and rack density requirements
- Power availability/price will affect training locations
- Land availability/price may drive deployments to suburban campuses.
- Connectivity, although important, not a key factor in land selection. Infrastructure providers are expected to adapt their footprint to address the needs of AI
- Sovereign AI will also affect training locations



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Cloud Computing



Cloud Connectivity & Peering

TRENDS

- Compute datacenters: 100s of MW in US, 10s in Europe
- Sovereign clouds expanding – smaller players entering
 - E.g., 2x Oracle Sovereign Clouds (OSC) in EMEA, and separate on-ramps
- Today Clouds host a large part of the AI workloads; Cloud developments are highly affected by AI

ON RAMPS

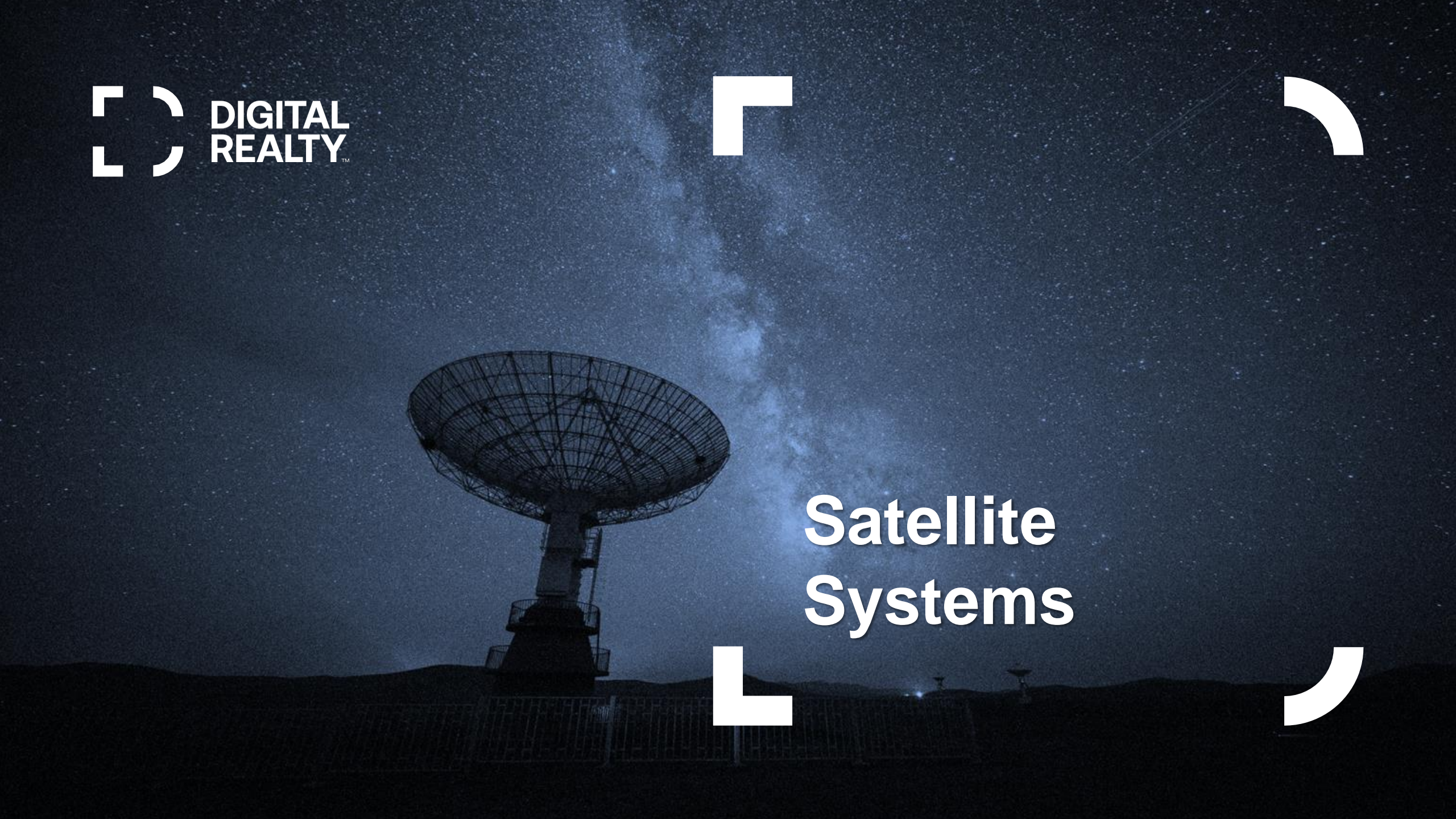
- The top 5 hyperscales have already deployed >500 on-ramps.
- Deacceleration seen during 2023/2024
- Still unclear how AI on ramps will evolve

PUBLIC PEERING

- Is there a shift towards private peering?

INTER-CLOUD CONNECTIONS

- Multicloud integration eg
 - Azure ExpressRoute + Oracle FastConnect (14)
 - Google Interconnect + Oracle FastConnect (11)
- Virtual Routers provided by most Cloud connectivity platforms



Satellite Systems

Satellite Systems

DRIVERS/TRENDS

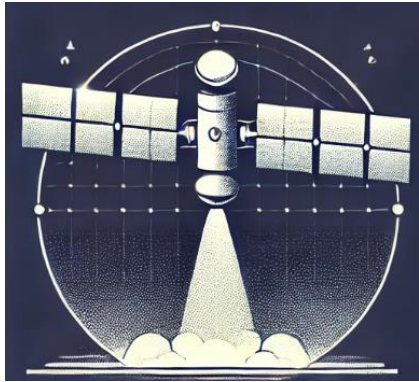
- Satellite price and size decreased; computing capabilities increased.
- Launch cost also reduced, new players (eg Space-X)
- Technology for optimized intra-constellation traffic relaying, for path optimization and resilience
- Mega LEO constellations are now financially and technically possible
- Increased coverage and performance with decreased costs
- A renewed appeal to provide internet services - new entrants

EVOLUTION OF SERVICES AND APPLICATIONS

- Cover hard to reach & under served geographies
- B2C (internet for all)
 - Broadband services
 - Remote households
 - Aviation, Maritime, Automotive
- B2B
 - Remote Enterprises (eg Mining)
 - 5G mobile backhaul.
 - IOT



Satellite components



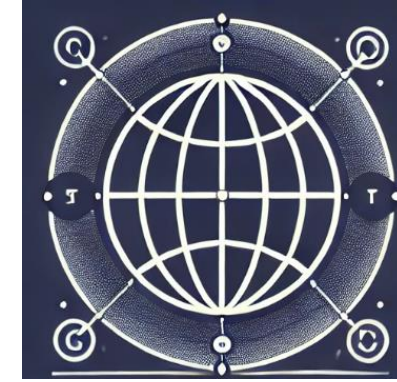
SATELLITES

- Usually at Low-Earth Orbit (LEO, <2000km).
- Move fast, 1 orbit per 90-120 min, switch-overs between Teleports
- Usually in constellations



TELEPORTS

- Serve multiple satellites.
- A clear line of sight to the sky is important!
- Uninterrupted power is required, but power requirements not too large.
- Diverse connectivity to network POP is important but proximity not so critical



NETWORK POP

- High connectivity requirements: transit & carriers, CDNs, clouds, IXPs
- **Connectivity and Peering with other networks takes place here**

Starlink AS14593

EXPORT

Organization	SpaceX
Also Known As	Space Exploration Technologies Corp
Long Name	
Company Website	http://www.spacex.com
ASN	14593
IRR as-set/route-set	AS14593:AS-SX-STARLINK
Route Server URL	
Looking Glass URL	
Network Types	Cable/DSL/ISP
IPv4 Prefixes	1000
IPv6 Prefixes	1000
Traffic Levels	Not Disclosed
Traffic Ratios	Mostly Inbound
Geographic Scope	Global
Protocols Supported	<input checked="" type="radio"/> Unicast IPv4 <input type="radio"/> Multicast <input checked="" type="radio"/> IPv6 <input type="radio"/> Never via route servers
Last Updated	2024-09-05T20:47:26Z
Public Peering Info Updated	2024-08-23T22:05:04Z
Peering Facility Info Updated	2024-09-05T20:47:22Z
Contact Info Updated	2021-11-11T17:04:55Z
Notes	Recommend prefix limit 1000 for IPv4 and 1000 for IPv6 Satellite based internet service provider For SpaceX corporate see AS27277
RIR Status	ok
RIR Status Updated	2024-06-26T04:47:55Z

Peering Policy Information	
Peering Policy	
General Policy	Open
Multiple Locations	Not Required
Ratio Requirement	No
Contract Requirement	Not Required
Health Check	

Contact Information		
Some of this network's contacts are hidden because they are only visible to authenticated users and you are currently not logged in.		
Role	Name	Phone E-Mail
Abuse	Abuse	starlink-abuse@spacex.com

Public Peering Exchange Points

Exchange	ASN	Speed	RS Peer	BFD Support
IPv4	IPv6			
AKL-IX (Auckland NZ)	14593	100G	<input checked="" type="checkbox"/>	<input type="checkbox"/>
43.243.21.120	2001:7fa:11:6:0:3901:0:1			
Any2Chicago	14593	100G	<input checked="" type="checkbox"/>	<input type="checkbox"/>
206.51.43.23	2001:504:13:4::23			
Any2Chicago	14593	100G	<input checked="" type="checkbox"/>	<input type="checkbox"/>
206.51.43.22	2001:504:13:4::22			
Any2Denver	14593	200G	<input checked="" type="checkbox"/>	<input type="checkbox"/>
206.51.46.125	2605:6c00:303:303::125			
Any2Denver	14593	200G	<input checked="" type="checkbox"/>	<input type="checkbox"/>
206.51.46.124	2605:6c00:303:303::124			
Any2West	14593	200G	<input checked="" type="checkbox"/>	<input type="checkbox"/>
206.72.211.84	2001:504:13::211:84			
Any2West	14593	200G	<input checked="" type="checkbox"/>	<input type="checkbox"/>
206.72.211.104	2001:504:13::211:104			
AR-IX Cabase	14593	100G	<input checked="" type="checkbox"/>	<input type="checkbox"/>
45.88.8.175	2001:13c7:6001::175			
AR-IX Cabase	14593	100G	<input checked="" type="checkbox"/>	<input type="checkbox"/>
45.88.8.182	2001:13c7:6001::182			
BIX BG	14593	200G	<input checked="" type="checkbox"/>	<input type="checkbox"/>
193.169.199.93	2001:7f8:58::3901:0:1			
ChIX	14593	100G	<input checked="" type="checkbox"/>	<input type="checkbox"/>
206.41.110.91	2001:504:41:110::91			
ChIX	14593	100G	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Interconnection Facilities

Facility	Country
ASN	City
Equinix MI1 - Miami, NOTA	United States of America
14593	Miami
Equinix SG1 - Singapore	Singapore
14593	Singapore
Equinix SP4 - São Paulo	Brazil
14593	Barueri
Equinix SV1/SV5/SV10 - Silicon Valley, San Jose	United States of America
14593	San Jose
Globenet Fortaleza CLS	Brazil
14593	Fortaleza
KIO Querétaro 1 (QRO1)	Mexico
14593	El Marques
MainOne MDX Lagos	Nigeria
14593	Lagos
NEXTDC P1	Australia
14593	Malaga
NEXTDC S1	Australia
14593	Sydney
NTT Jakarta 2 Data Center (JKT2)	Indonesia
14593	Jakarta
Telehouse - London (Docklands West)	United Kingdom
14593	London
Telehouse - TOKYO Otemachi (KDDI Otemachi)	Japan
14593	Tokyo
TELEPOINT Sofia Centre	Bulgaria
14593	Sofia

44 IXPs,
70x 100-500Gbps
ports

Network Gateways(?):
18 countries,
33 cities,
33 facilities

- Argentina
- Australia
- Australia
- Brazil
- Brazil
- Bulgaria
- Chile
- Colombia
- Germany
- Indonesia
- Japan
- Mexico
- New Zealand
- Nigeria
- Peru
- Philippines
- Singapore
- Spain
- United Kingdom
- United States of America
- United States of America
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- Buenos Aires
- Malaga
- Sydney
- Barueri
- Fortaleza
- Sofia
- Santiago
- Bogota
- Frankfurt
- Jakarta
- Tokyo
- El Marques
- Auckland
- Lagos
- Santiago de Surco
- Makati City
- Singapore
- Madrid
- London
- San Jose
- Ashburn
- Atlanta
- Bluffdale
- Chicago
- Dallas
- Denver
- Los Angeles
- Miami
- Minneapolis
- New York
- Salt Lake City
- Seattle
- Tempe

Satellites – effects on connectivity & peering

TRAFIC & DENSITY

- Significant levels of traffic
- Denser gateways

PEERING CHALLENGES

- Traffic may not be local
 - Situation improves as gateways become denser
- Peering with the same AS at multiple locations
 - But mechanisms are in place
- Some BGP tweaking might be necessary
- GEO-IP seems to work

EVOLUTION OF TRAFFIC PROFILES

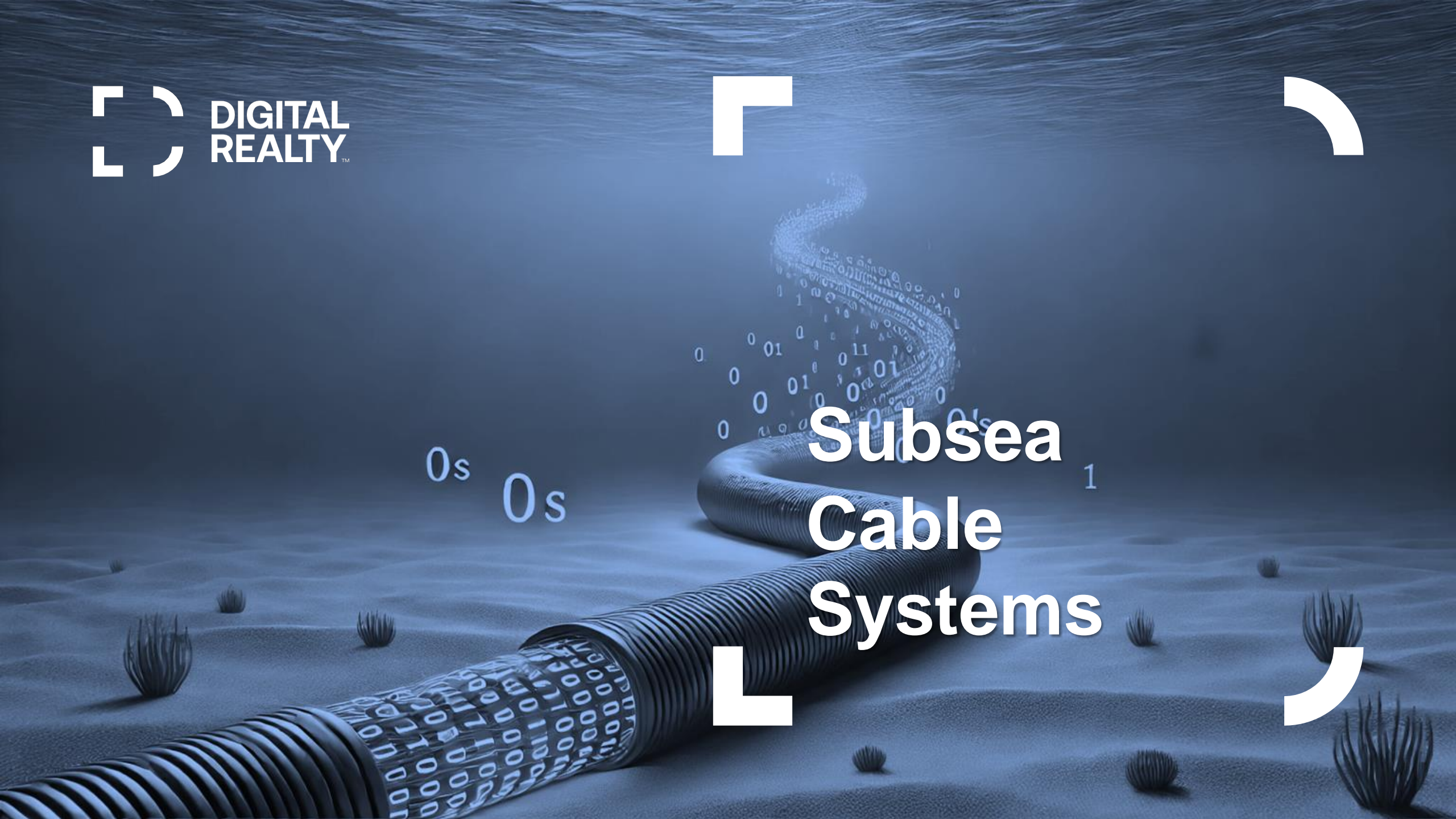
- In the past, satellite networks were mostly eyeball networks, with heavily unbalanced traffic profiles (inbound traffic)
- Enterprises, B2B applications and backhauling affect traffic profiles and criticality
- No significant content served through satellite (today or in the foreseeable future)

Note: Different companies have different target groups (eg rural connectivity, maritime, emergency services, B2B etc)

→ See <https://radar.cloudflare.com/traffic/as14593>

LONG TERM

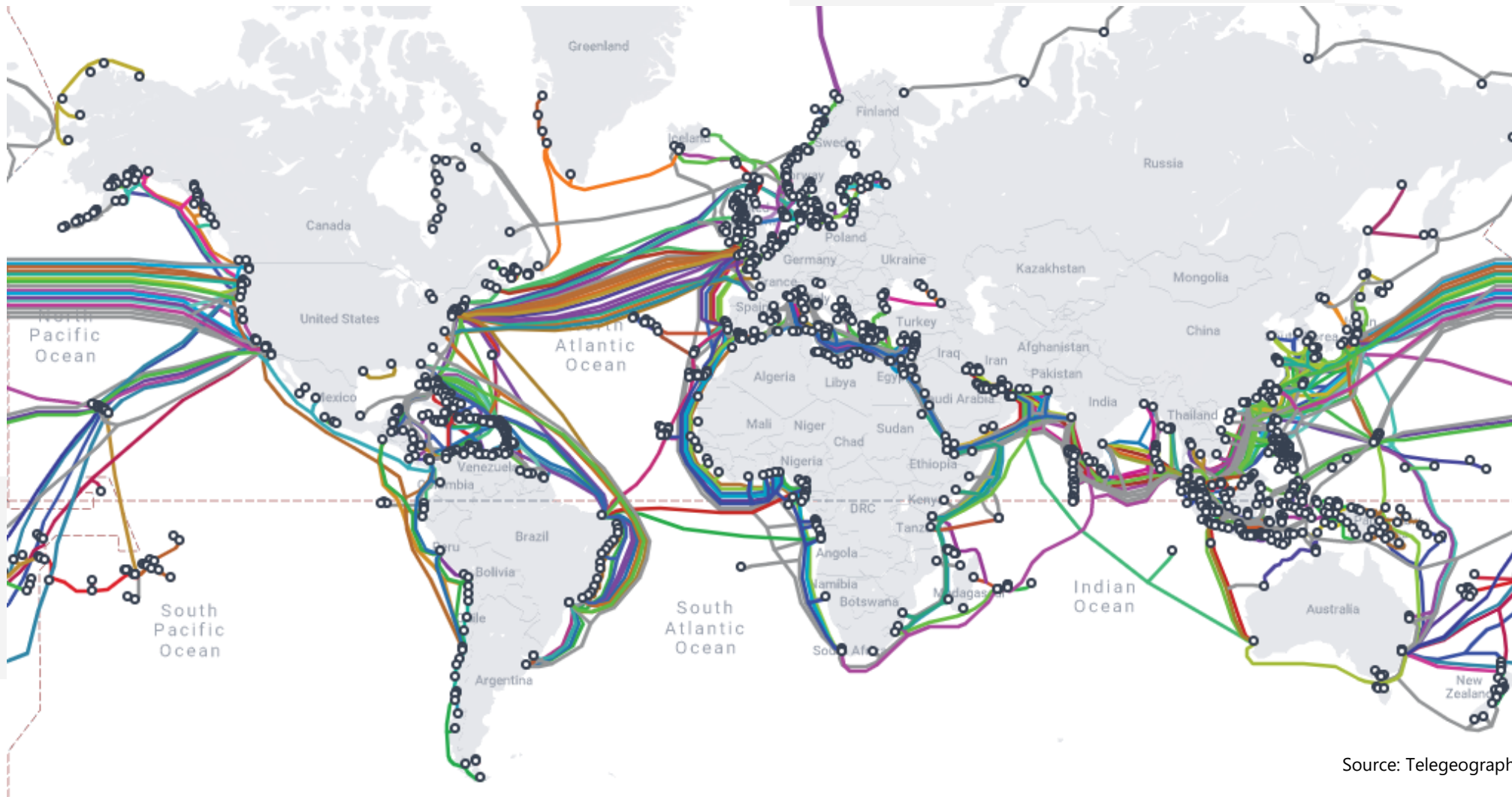
- Inter-constellation traffic exchange?



Subsea
Cable
Systems

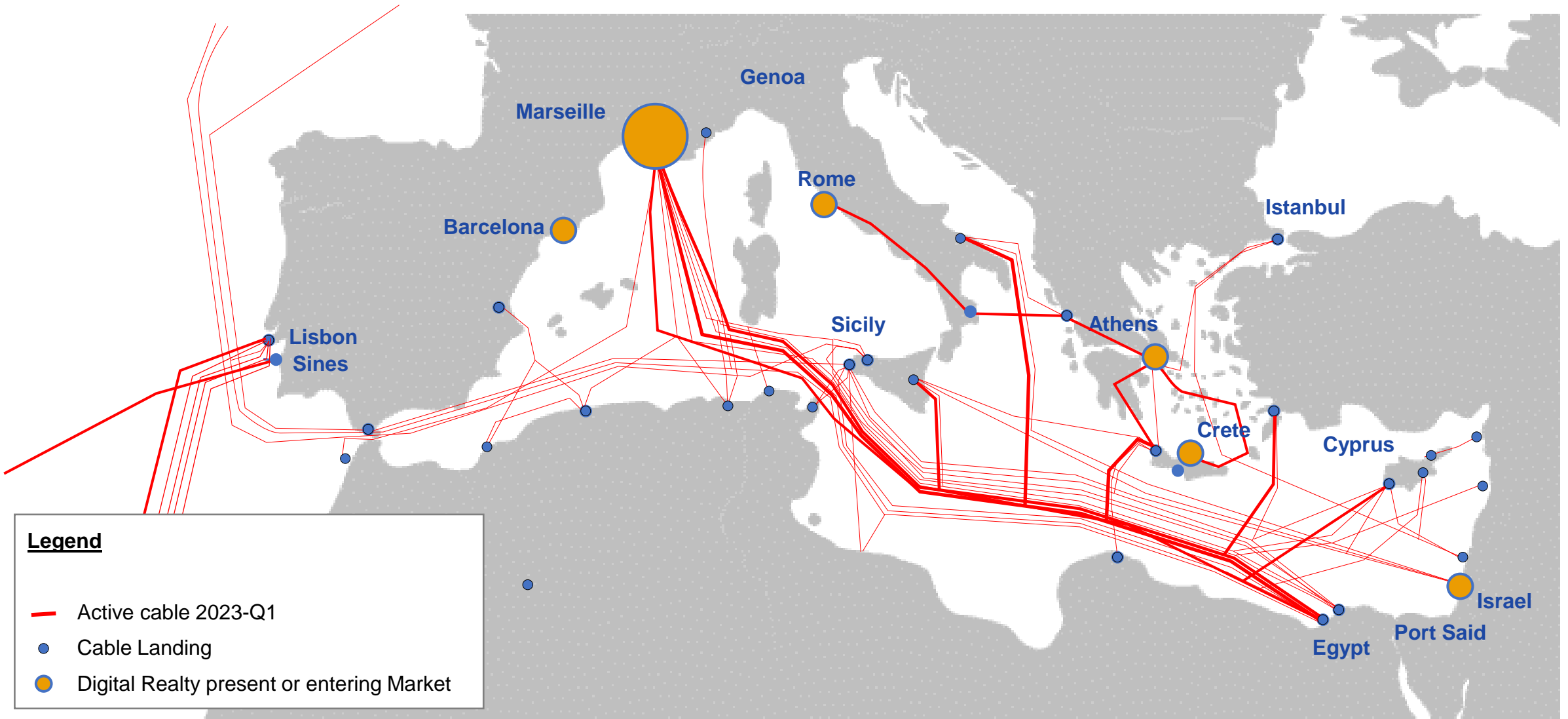
Subsea Cable Systems

99% of intercontinental internet traffic flows via subsea cable systems

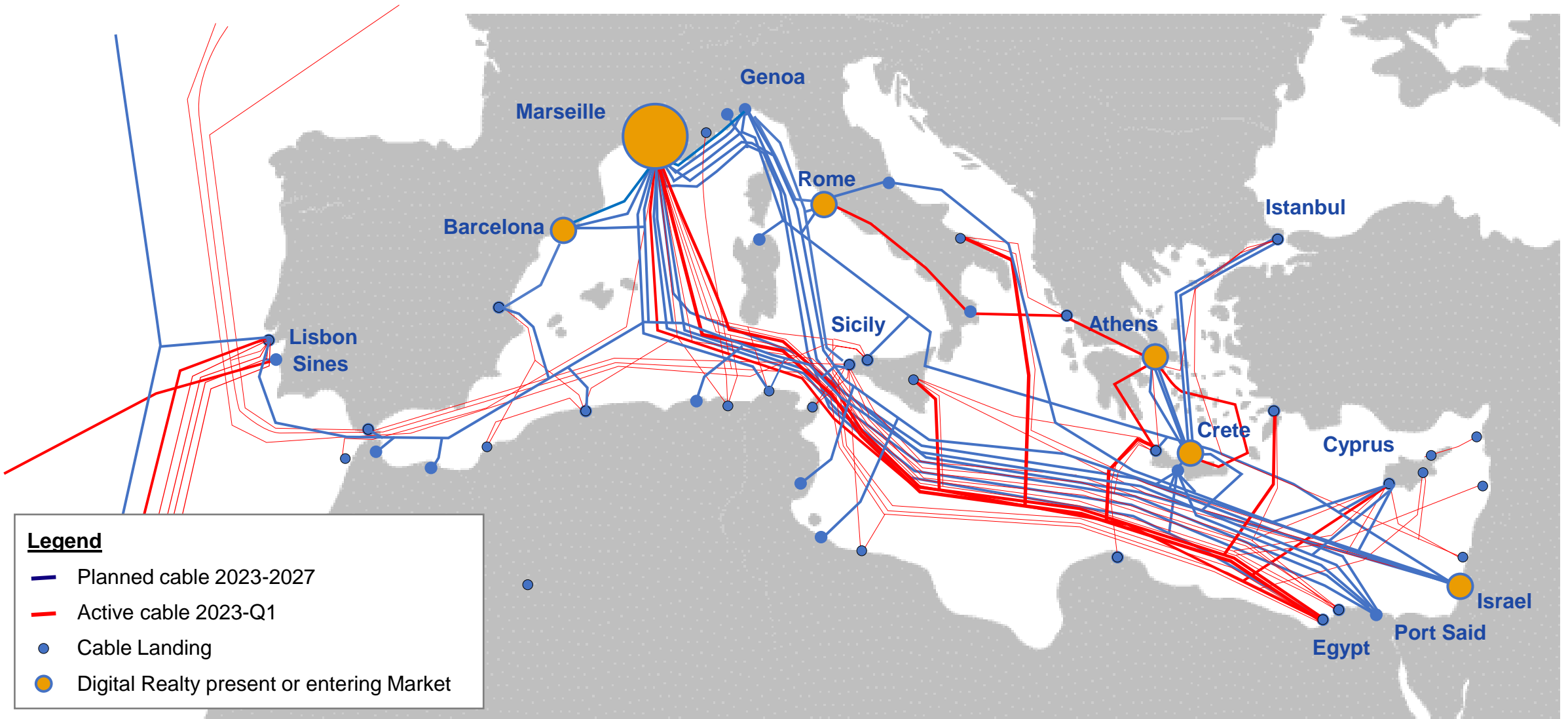


Source: Telegeography

Subsea cables at Mediterranean, **active**



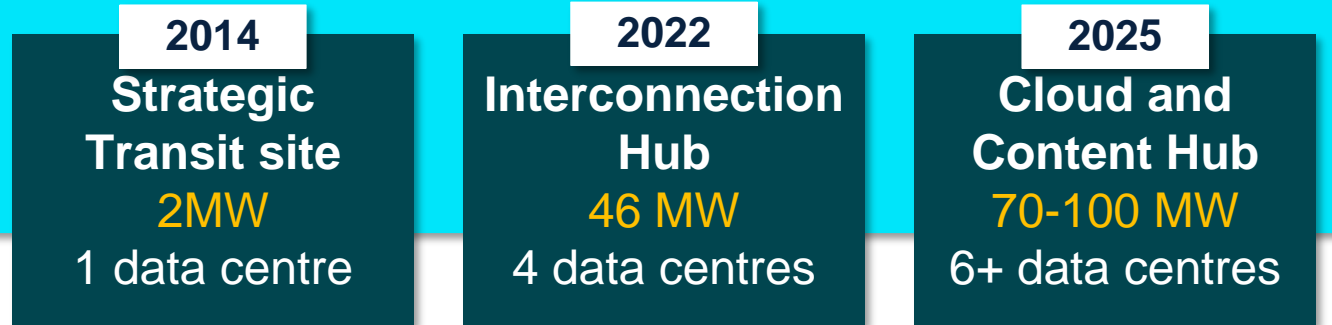
Subsea cables at Mediterranean, **active** and **planned**



Marseille Success Story:

The chronicle of the evolution from a transit location to a cloud and content hub

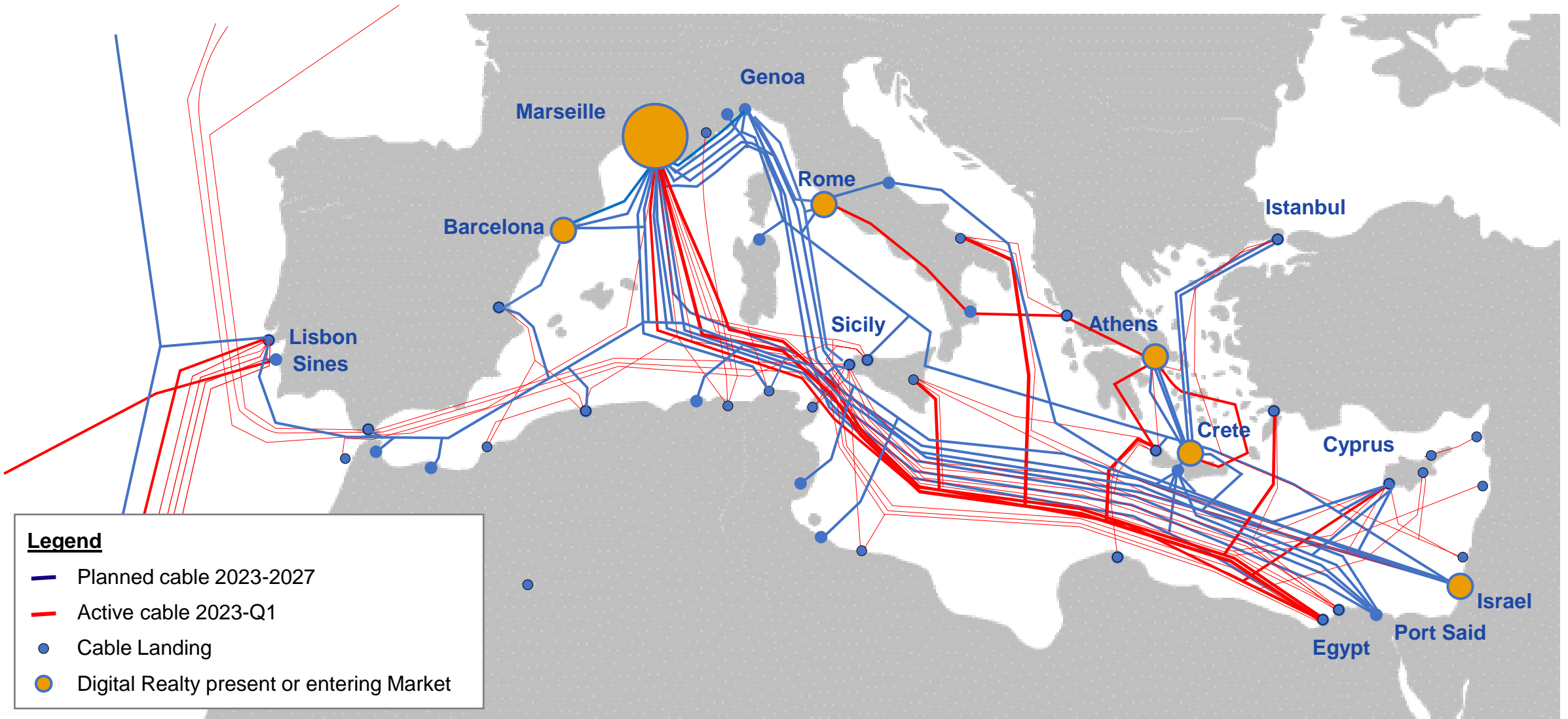
Marseille Data Centre growth Driven by Subsea Cable Evolution



	2014	2022	2025
No of Subsea Cables	11	15	22
Design Capacity (Tbps)	90	350	2,000
Networks	40	190	240
Internet Exchanges	0	6	6
Cloud and Content Network & Caching Nodes	0	15	30
Cloud and Content Platforms	0	2	10
Cross Connects	1,300	10,000	15,000

Barcelona, Crete, Rome, Israel ?

Subsea cables at Mediterranean, **active** and **planned**



Recent large subsea outages in the EMEA region

Large outages are possible! Prepare!

Oct '22

Sabotage incident at multiple cables overnight in the area of Marseille, affecting **Marseille-Lyon, Marseille-Milan and Marseille-Barcelona.**

Feb '24

3 subsea cable systems in Red Sea cut as result of Houthis attacks in on ships on the waterway:
Asia-Africa-Europe 1, the Europe India Gateway, Seacom and TGN-Gulf

5+ months to repair!

May '24

SEACOM and EASSy subsea cables damaged off the coast of Kwazulu-Natal, **South Africa** due to dragging ship anchor

3 weeks to repair

<https://www.internetsociety.org/resources/doc/2024/2024-east-africa-submarine-cable-outage-report/>

Are you ready for large-scale outages?

Does your disaster recovery plan take into account

- Dependencies on neighboring subsea cables
- Blackouts of extended geographical regions?
- Large loss/rerouting/overflow of traffic?

Also relevant: power infrastructure

Sept '22

Nord Stream sabotage (Russian-Ukraine war?)



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Internet Exchanges



C.80
C.07 C.84
C.07 C.80
C.05
C.03
C.71

IXP-related developments

THE MOVING EDGE

- Need for denser IXP coverage, including smaller countries or secondary cities

RESILIENCE & DIVERSITY

- IXPs are critical infrastructure. Officially identified as such by NIS/NIS2!
- Increased SLA requirements
- One per country / market may no longer be enough

COMPETITION

- Competition is growing, even in markets with well established players

COOPERATION

- to address increased peering needs
- to defend against competition

STRETCHED PEERING LANS & REMOTE PEERING

- Disconnected, connected or stretched peering LANS? The paradigm is shifting.
- Remote peering is here to stay

NEW SERVICES, BROADER AUDIENCE

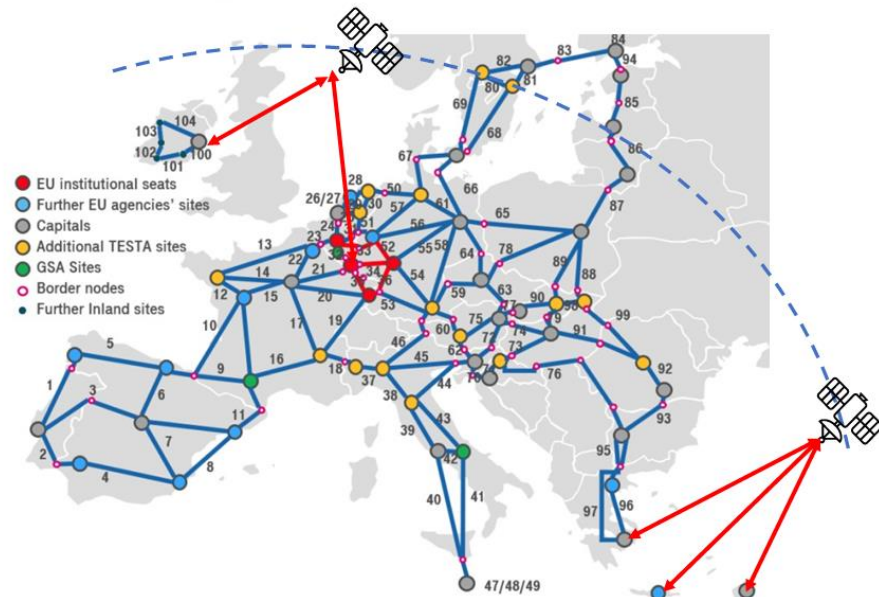
- Cloud is affecting IXPs: Cloud connectivity & MAPS
- Direct or indirect turn to enterprises
- Ideas for new services



Quantum Computing & • Quantum Networking

Quantum Networking

- Today's encryption over the internet (eg SSH/SSL) is based on Public Key Infrastructure encryption
- Brute force attacks are practically impossible with legacy computing
- Encryption no longer safe due to quantum computing advances
- **QKD (quantum key distribution) to answer**
 - QKD range is 80-100km today, but progress is being made
 - Challenges to deploy on longer legs (eg subsea)
 - Dedicated fibers needed – sharing DWDM spectrum is work in progress
- **EU's quantum computing manifesto** acknowledges the need to move forward with regard to quantum communications. Initial horizon 2015-2035, now accelerated due to developments.
- Quantum Flagship – 1 billion Euro project
- EuroQCI project: 27 EU countries, European Commission & ESA, to develop a European secure telecoms infrastructure based on quantum physics
 - 1 satellite also participating (to be launched 2026)
 - RFS 2027



Jean-François Buggenhout "EU Quantum Technologies Flagship and the quantum internet"
ENISA TELECOM SECURITY FORUM, 29 June 2022



The role of Data Centers – The Digital Realty approach

Epilogue: The role of Data Centers

Neutral, open datacenters are crucial to the development of the internet

- Data Centers: The meeting point
 - Infrastructure: subsea ↔ terrestrial ↔ satellite
 - Service Provides ↔ Enterprises ↔ Cloud & AI
 - Content ↔ Eyeballs
 - Data ↔ Applications
 - Hybrid cloud, hybrid AI etc
- While technology keeps evolving and modes of connectivity and transport keep changing, Data Centers will remain the home of the future ecosystems

Where We Continue to Evolve and Invest to Support Our Customers in Bold New Ways

We've invested **\$23 billion**⁽¹⁾ to build our global platform, PlatformDIGITAL[®], located in convenient metro and edge markets¹

Coverage

Deploy where you need

Capacity

Host what you need,
how you need

Connectivity

Connect how you need
to whom you need

Control

Implement and operate
the way you need



Building a Sustainable Future

- Digital Realty is the largest buyer of renewable energy among data center providers
- We cover 100% of our North American colocation business and European portfolios with renewable energy
- Digital Realty has certified more green buildings than any other data center provider.
- Digital Realty has more Energy Star-certified data centers than any other data center provider
- Digital Realty has allocated \$6.4 billion towards green projects funded by green bond issuances

68%

Global carbon reduction target

1.4GW

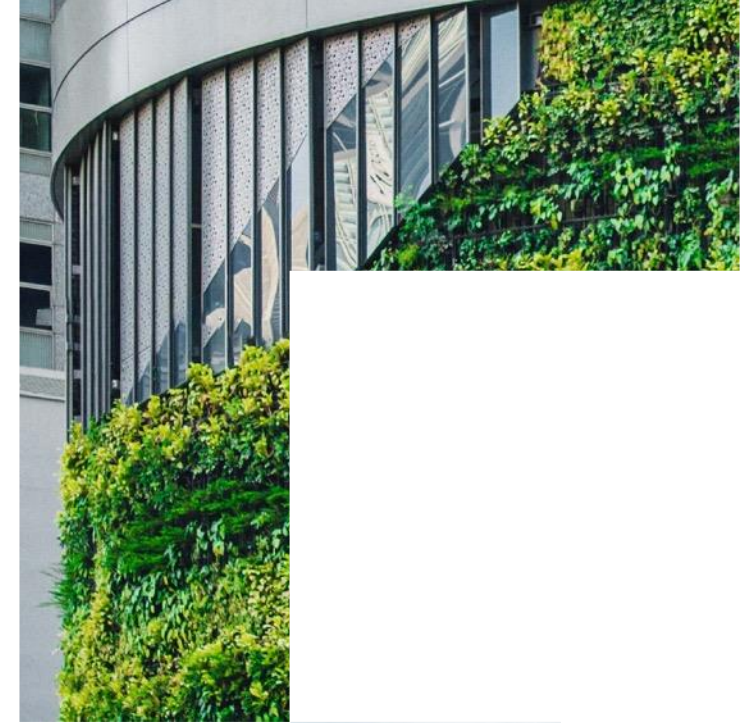
Renewable capacity

152

Data centers matched with 100% renewable energy

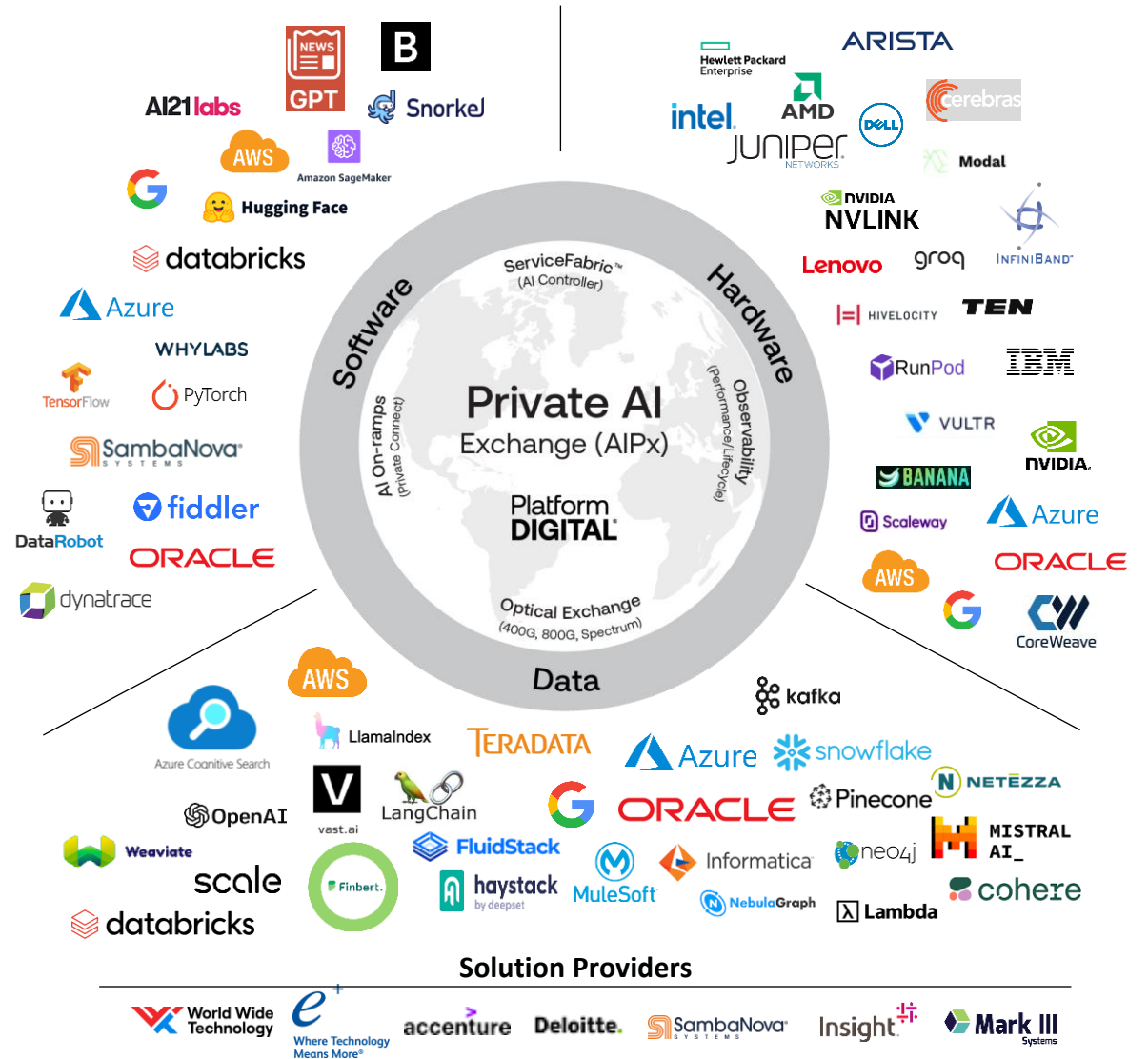
13M

Square feet green building certifications



ServiceFabric™ and AIPx

Private AI Exchange (AIPx) leverages ServiceFabric,™ enabling partners to extend their AI Infrastructure and Services over a single port (private, dedicated, AI On-ramp). The Service Directory, Service Key and Click to Connect features simplify and accelerate service distribution, consumption, and time to revenue to participating Enterprise and Service Provider customers and partners:



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Meet our team at EPF 2024



Viktor
Kyuzov

Director,
Market Development



Dimitri
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Dorian
Stefan

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Development
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Jon
Waldron

International
Accounts Director,
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Yolandi
Cloete

Platform Specialist



Andrew
Owens

Technical Lead -
Peering and
Interconnection





Questions?





Thank you!

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