SPECTRUM FOR THE INDUSTRIAL INTERNET OF THINGS – INDUSTRY NEEDS, BARRIERS AND RECOMMENDED NEW MODELS

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Research questions

What are the economic drivers behind Industrial Internet of Things (IIOT)?

How spectrum is currently allocated and how it addresses the IIOT needs?

What are the spectrum model options?

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Future economics - New value creation: The industrial opportunity

Technology, Content, Finance & Insurance, Professional & Technical Services

	Share of GDP	% of Private Workforce	Share of Private-Sector IT Investment	Annual Productivity Growth (15yr avg)
Digital Industries	30%	25%	70%	2.7%

Manufacturing, Construction, Mining, Utilities, Healthcare, Hotels, Restaurants, Transportation, Wholesale and retail trade

Physical Industries	70%	75%	30%	**0.7%**

M. Mandel. "Long-Term U.S. Productivity Growth and Mobile Broadband: The Road Ahead." Progressive Policy Institute, March 2016.

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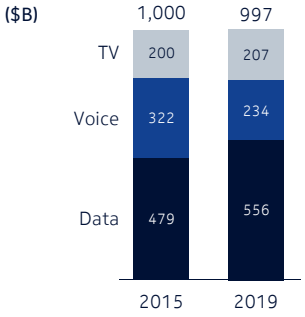
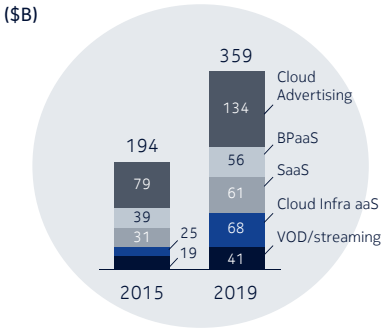
The quest for new economic value

The legacy problem!



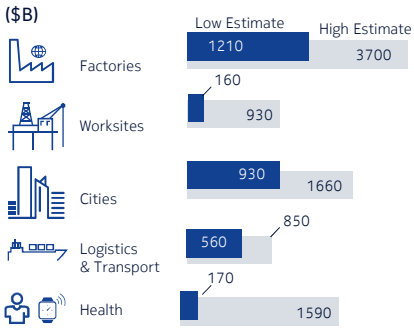
* Western Europe, Canada, USA, Japan, South Korea, Singapore, Australia, and NZ
Source: Gartner

Some growth, but not all for Telcos



Source: Gartner
BPaaS = Business Processes as a Service

New DSP markets offer growth



Estimated 2025 value creation potential of the IoT - *McKinsey Global Institute*

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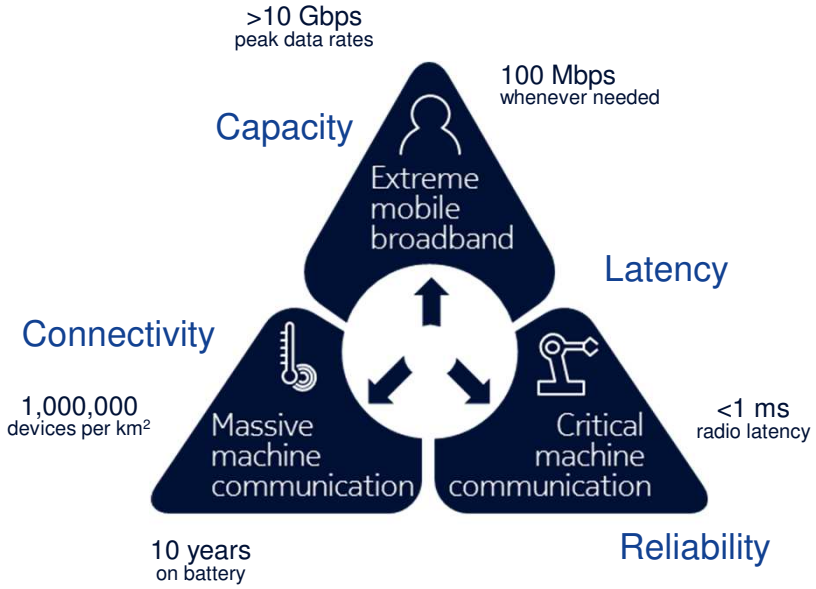
5G characteristics for all use cases



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Megatrends in wireless

Cloud, NFV and network slicing are transforming network infrastructure deployment

Shared spectrum is 'virtualizing' the spectrum asset ownership, altering valuation and utility

Localized edge services and ultra low latency, high reliability applications emerging with vertical needs

Business model innovation boosting as-a-Service models

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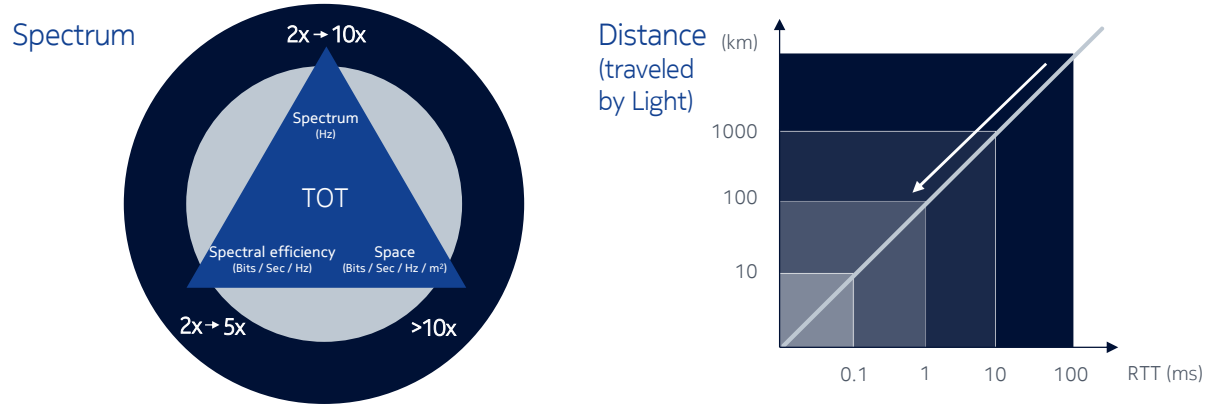
The future architecture – Defined by physical limits of spectrum and distance



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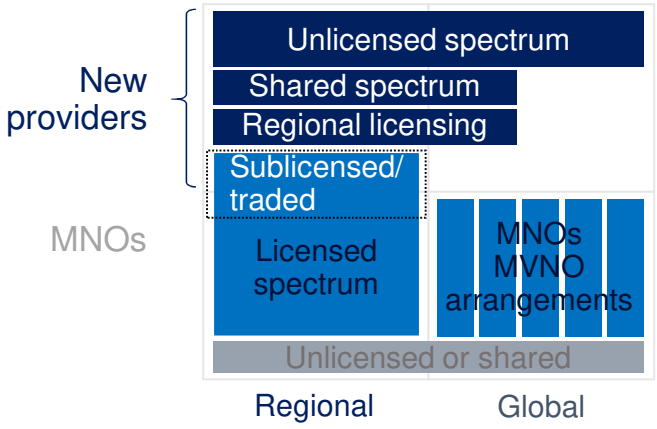
Critical value - Spectrum determines the solution and the opportunity



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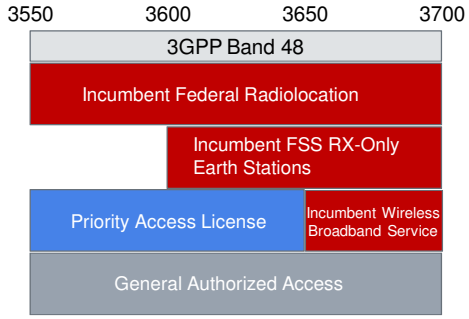
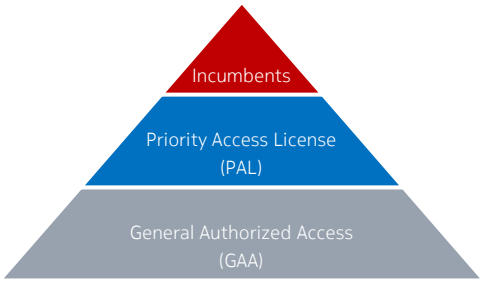
CBRS Spectrum Sharing





- US designated 150 MHz of mid-band spectrum for incumbents to share with CBRS broadband users
- Incumbents include: US Navy, Fixed Satellite Stations, and Incumbent Wireless Broadband
  - Incumbent broadband licenses to expire starting in 2020, then must comply with CBRS rules
- New CBRS broadband users authorized by SAS, to ensure they do not interfere with incumbents
- Two categories of new CBRS users: PAL (SAS to assure "clean" spectrum) and GAA

FCC, "Part 96 - Citizens Broadband Radio Service,"

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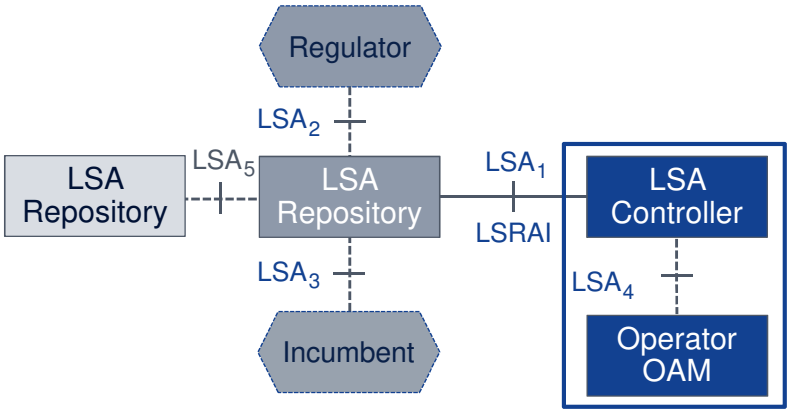
LSA architecture reference model



ETSI, System Architecture and High-Level Procedures for operation of Licensed Shared Access (LSA) in the 2300 MHz-2400 MHz band. TS 103 235, 2015.

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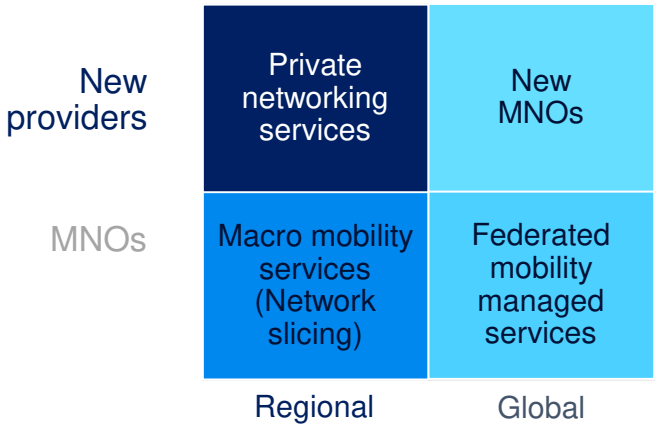
Critical value - Spectrum determines the solution and the opportunity



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IIOT application characterization

Security / resilience	Security, privacy, reliability Key driver for use of LTE/5G Unlike all of the other categories this is a commercial requirement
QoS	Availability, reliability, latency, congestion Key driver for use of a private network (High QoS vs. Best effort)
Indoor / outdoor	Locality of devices, requirement for mobility Driver for use of LTE (Reach/mobility required vs Low mobility/local area)
Bandwidth	Speed and capacity requirement (Broadband vs. Narrowband)
Transmission asymmetry	Symmetric / asymmetric, uplink / downlink bias (Symmetric vs. Asymmetric)

T. Lavender et al., "Use cases, spectrum requirements and valuation of spectrum for private LTE," PLUM Consulting, April 2018.

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The diversity challenge

Industries:
Manufacturing
Seaports
Mining
Agriculture
Utilities
Smart Cities

Use-Case		Delivered by Network Slice					
Application Category	Examples	Throughput (bps)		Latency (RTT)		Reliability	Cost Sensitivity
		UL	DL	E2E Appl.	Network		
Critical automation	▪ Collaborative robots/drones ▪ Electrical grid tele-protection	1-10M	1M	5-50 ms	1-5 ms	High/Very High	Low
Tele-operation	▪ Video-based remote control ▪ Video w/haptic remote cntrl	1-10M	1M	50-150 ms	1-25 ms	High/Very High	Medium
Highly interactive AR	▪ Co-present Mixed Reality ▪ 360° volumetric video AR/MR	1-100M	5-100M	50-100 ms	1-10 ms	Medium	Medium
Mass sensor arrays	▪ Agricultural field sensors ▪ Smart city sensors & meters	1k - 1M	1k - 1M	1-2 s	200-500 ms	Medium-Low	Very High

(4 Slices Types x 5 Slice Specifics) per industry x 1000 industries = 20000 simultaneous optimizations

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Spectrum sharing enables access to long tail of non served IIOT users.

- The future wireless architecture is defined by physical limits of spectrum and distance.
- New IIOT markets offer significant multi Billion business opportunity.
- Current spectrum regulation forces vertical business to a large extent to rely on the MNOs.
- Verticals IIOT use case specific applications differ from mobile broadband use case.
- Governments and regulators should expand their view of the use of mobile systems to include provision of private network services.
  - Allow and incentify spectrum transfer through trading and leasing.
  - Authorize spectrum sharing concepts that deliver guaranteed QoS.

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Thank you
Questions/discussion?

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