Shared Radio Access Network Architecture for Mission Critical Applications

Antonio Aranibar (Canadian National Railway)
Alek Goulet (Canadian National Railway)
Barmak Khosravi (Hydro-Québec)
Sylvain Riendeau (IREQ)

March 26th, 2019

Critical Infrastructure Operators/Industries (CIOs/CIIs) and Mission Critical Applications

- *Critical infrastructure refers to processes, systems, facilities, technologies, networks, assets and services* ***essential*** *to the* ***health***, ***safety***, ***security*** *or economic* ***well-being of Canadians*** *and the* ***effective functioning of government*** [1]

- *Critical infrastructure can be stand-alone or interconnected and interdependent within and across provinces, territories and national borders* [2]

- *Disruptions of critical infrastructure could result in catastrophic* ***loss of life***, ***adverse economic effects*** *and* ***significant harm to public confidence*** [3]

- **Rail and Electric Utilities are a centerpiece of the Critical Infrastructure landscape. Our Industries require robust and dependable Applications, running over highly Reliable and Available technologies, to accomplish our Mission Critical operations**

1,2 and 3*: Government of Canada: Public Safety Canada/National Security*

The Guiding and Overarching Principle of Mission Critical Operations

If we were to pick ONE WORD that embodies Mission Critical Operations …. unequivocally this word would be ……

RAMS: Reliability, Availability, Maintainability – the Pillars of Safety

Mission Critical Application examples: Train Control and beyond …

- Train Control Operations require **dependable Communications Systems** among …

Rail Traffic Control (Back-Office Systems)

On a nation-wide spanning Field Area Network

Train-Onboard Systems

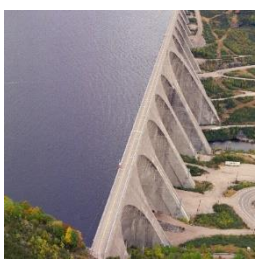
Wayside Equipment

Incrementally more Systems rely on dependable Wireless Communications:

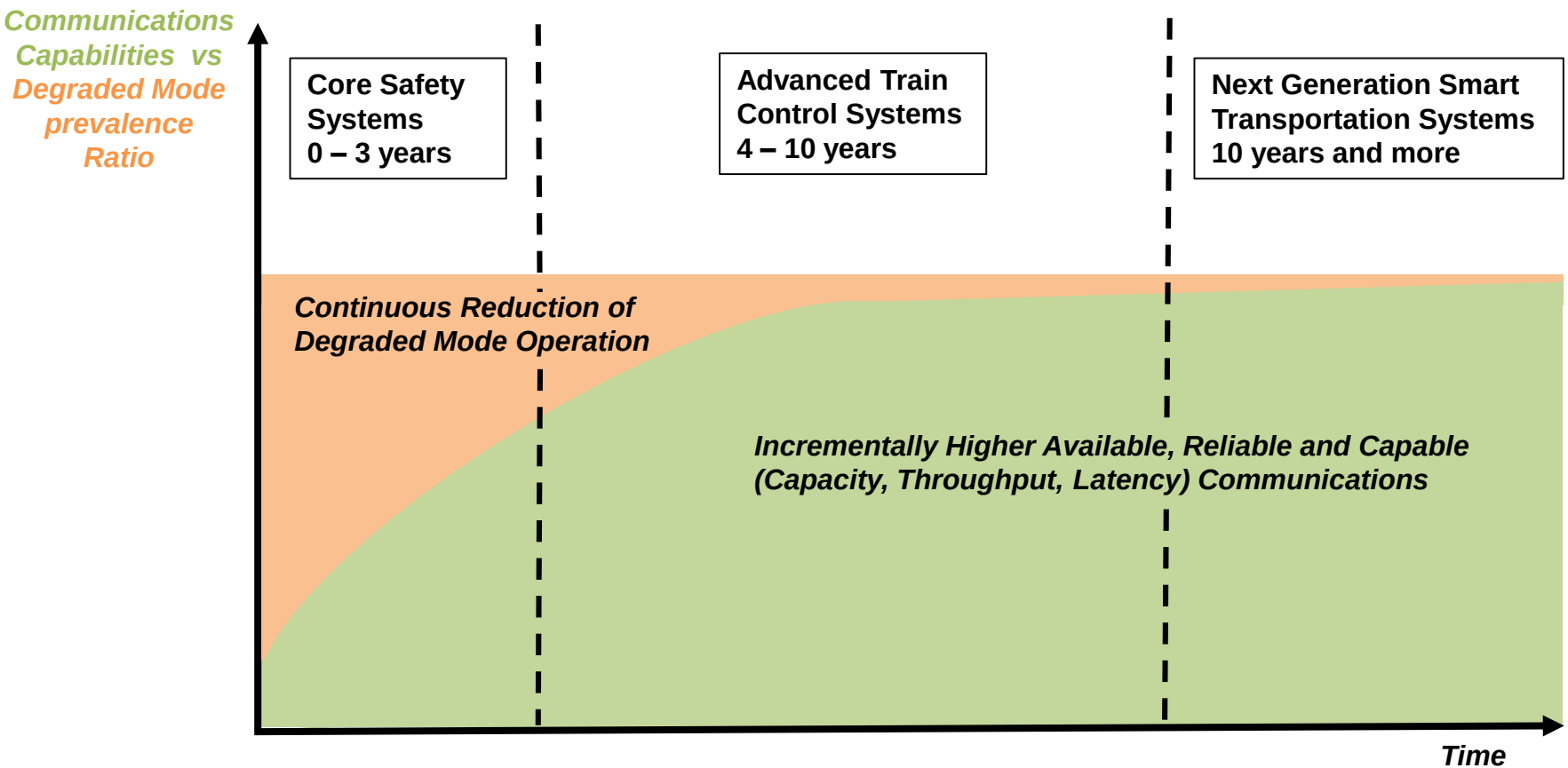
- ✓ **Preventive maintenance (e.g. Hot Box Detectors, "Machine Vision" Portals, WILD)**
- ✓ **Consist Verification (e.g. AEI tag readers)**
- ✓ **Track Verification (e.g. Autonomous Track Inspection and Geometry Systems)**

Utilities critical safety related field applications

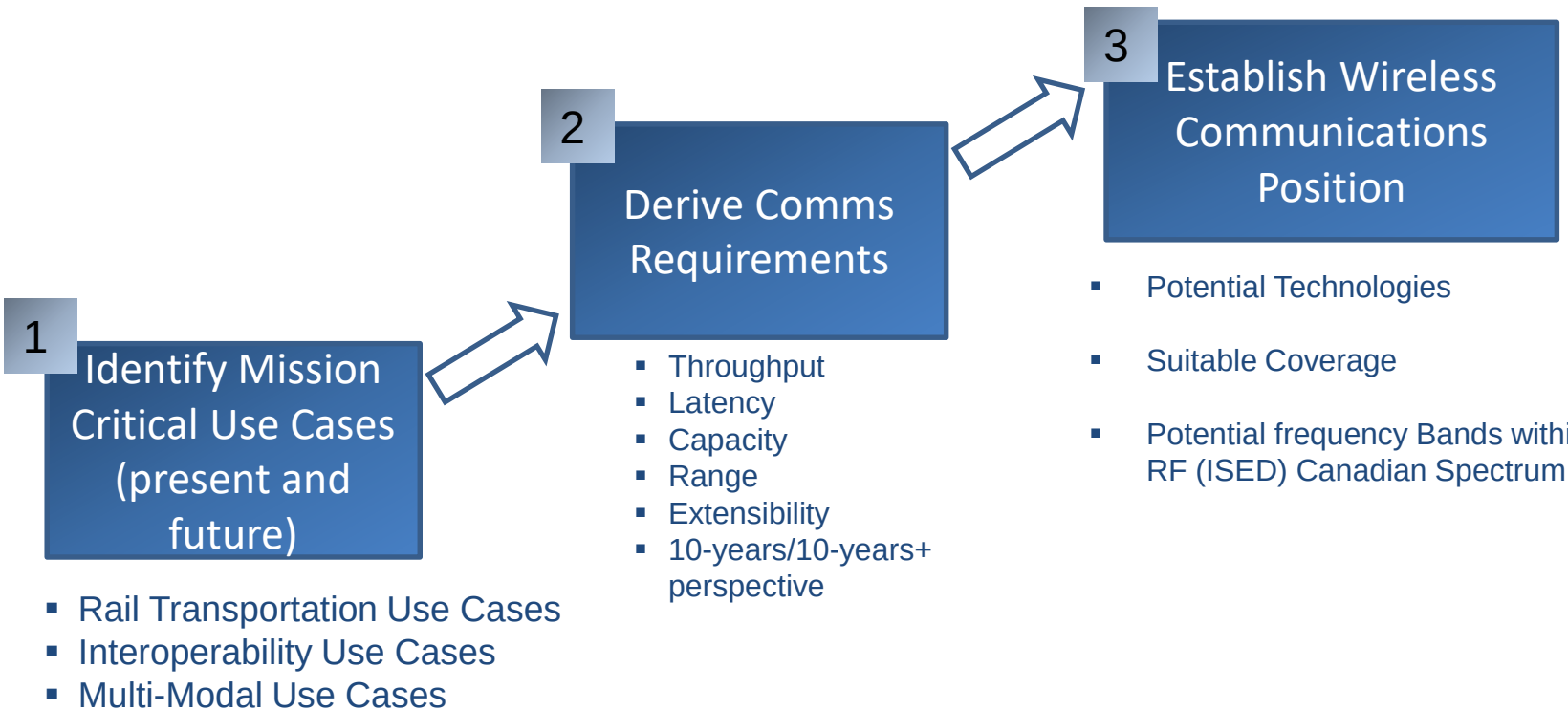
- LMR – Land Mobile Radio
  - Field crew lifeline (MAY-DAY)
  - Highest reliability / coverage requirements
- DA - Distribution Automation
  - Switches / re-closers
  - Grid resilience, Outage management
  - ePadlock (worker safety)
- Dam Safety
  - Seismic Monitoring, Control, …
  - Sensors (accelerometer, seismographs, .
  - Cameras and Public alerting systems



Train Control Roadmap and Wireless Communications needs



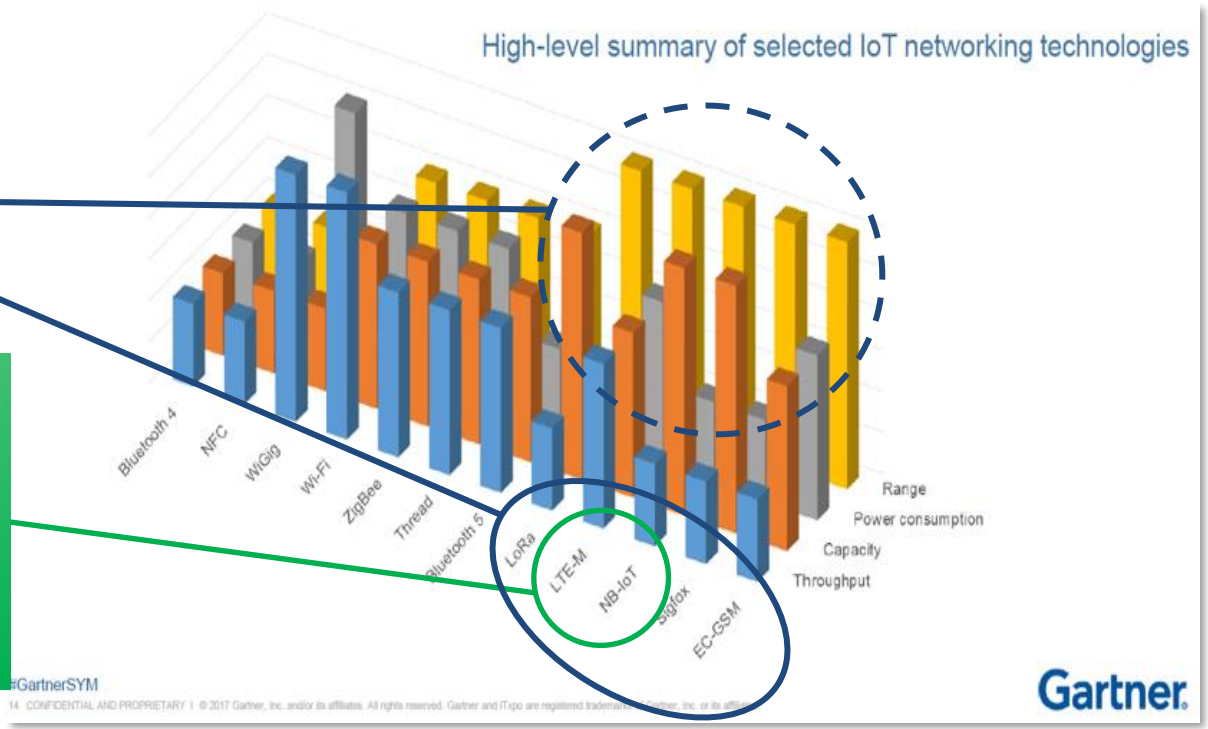
Choosing the right technology ….



Optimal Communications Technology - Range, Capacity and Open Standards

First cut: *Most fit for purpose technologies meeting mission critical application requirements, providing the right* ***capacity****,* ***coverage range*** *and* ***throughput*** *to individual devices*

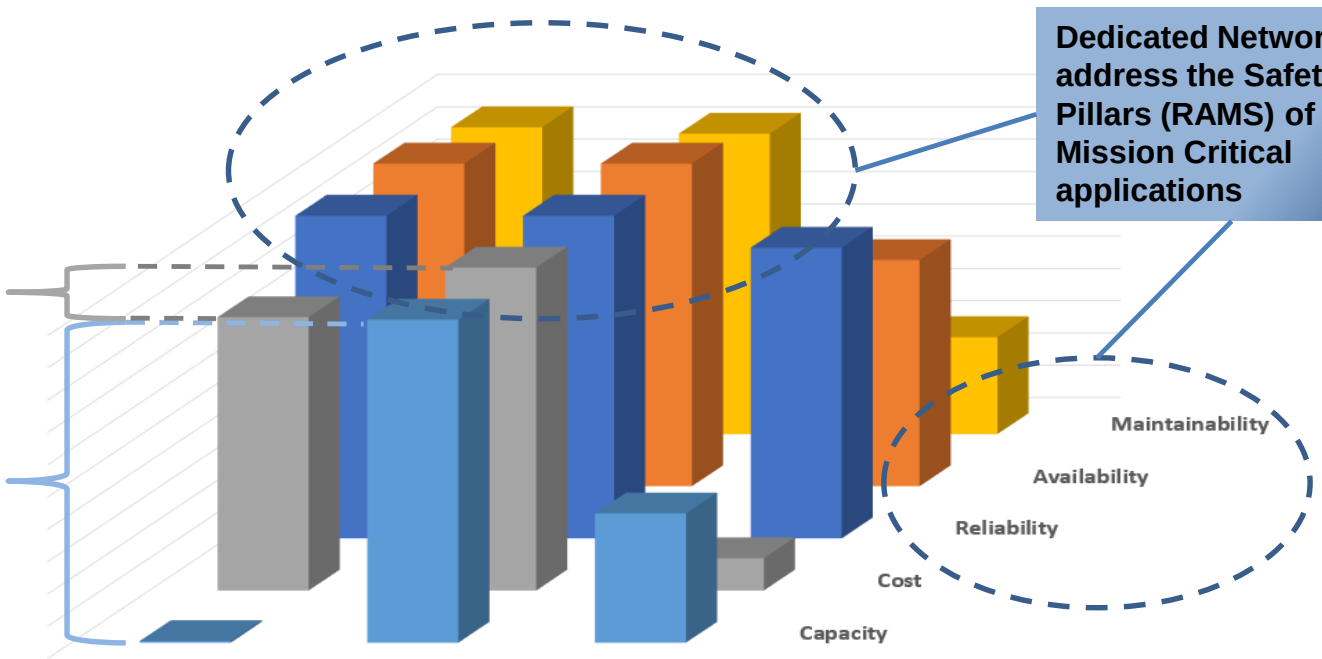
Final cut*: Technology supported by open standards and commercial ecosystems, driven by strong standardization bodies, while supporting a large* ***capacity*** *for growth*



- *A* ***Broadband Wireless LTE network is the foundation proposed*** *to provide these 3GPP LTE-derivative-services to a large number of IoT devices*
- *A* ***Broadband Wireless LTE network is also well suited for throughput-intensive*** *mission-critical applications*

1*: Organizational Portal under www.3gpp.org*

Choosing the right architecture …



Dedicated Networks address the Safety Pillars (RAMS) of Mission Critical applications

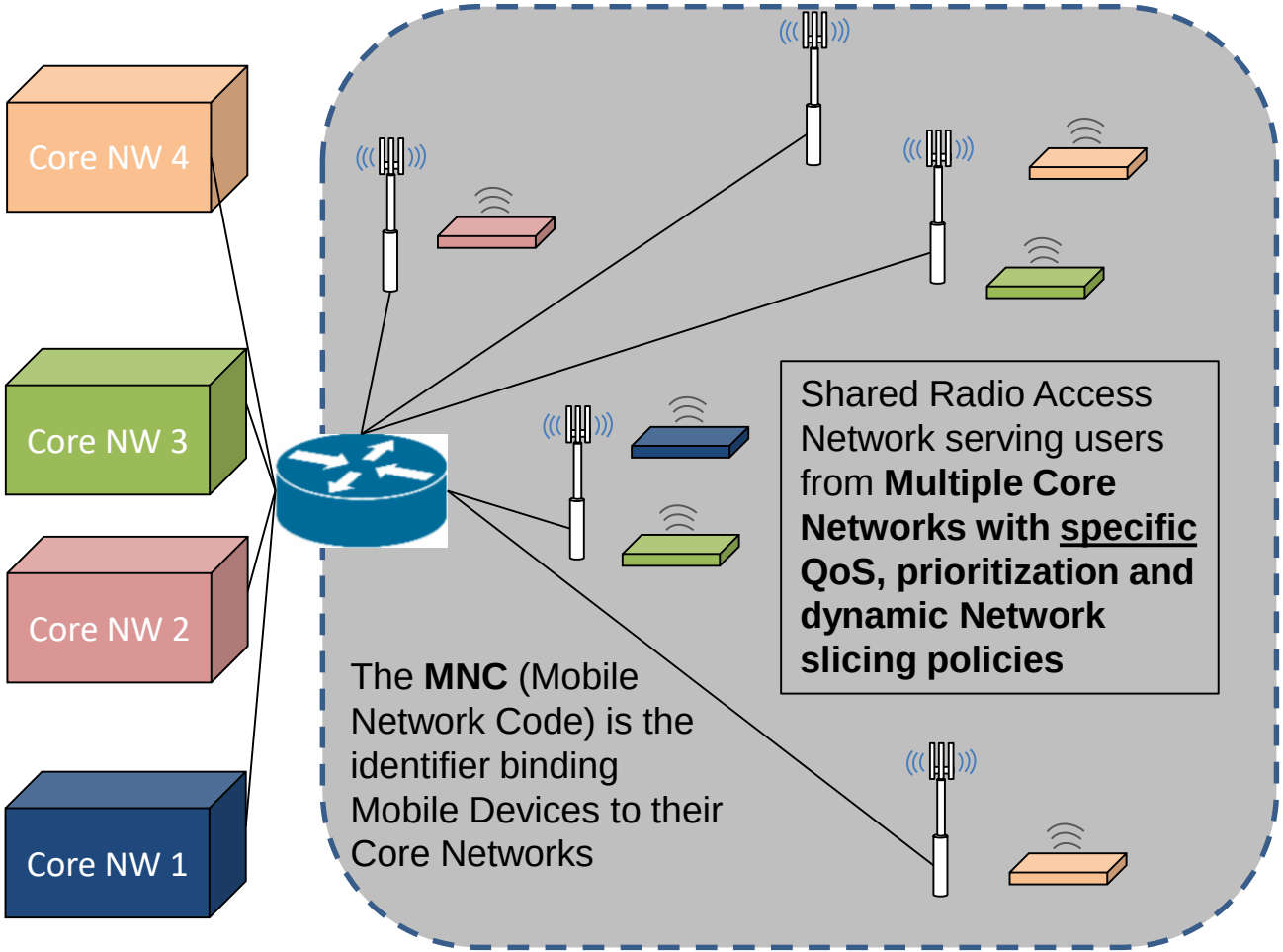
Same Order-of-Magnitude Technological Investment

Hundreds-of-times (x100s) capacity; Paving the road to the future

Preferred Option !

Standard (3GPP) LTE Shared Radio Access Network Architecture

Multiple Operator Core Networks share the Radio Access Network



Sharing Scenario Example 1: Public Safety, CIOs, Rural Broadband Access (by MNO/MVNOs)

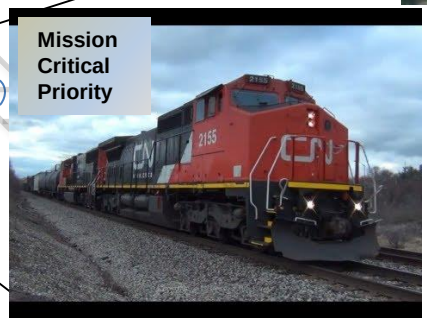
PSC Core NW

CIOs Core NW

MNO-A/ MVNOs

MNO-B/ MVNOs

700 MHz Public Safety B14



- ✓ *PSC obtains an extended reach to remote communities*
- ✓ *CIOs leverage their Operational footprint to build a Mission Critical capable Radio Network, while enabling also their partners*
- ✓ *Rural communities may benefit of Broad-band Internet Access if excess capacity-leasing to MNOs were to be leveraged*

Sharing Scenario Example 2: CIOs and Rural Broadband Access (by MNO/MVNOs)

CIOs
Core NW

Shared Broadband Spectrum TBD

MNO-A/
MVNOs

MNO-B/
MVNOs

- ✓ *CIOs leverage their Operational footprint to build a Mission Critical capable Radio Network, while enabling also their partners*
- ✓ *MNOs/MVNOs can provide rural communities with Broadband Internet in currently underserved remote areas*

In a nutshell, it's a Win-Win outcome for all parties involved (1/2)

The benefits of leveraging widely adopted open technologies, such as LTE, are many:

- ✓ De-facto interoperability
- ✓ Rich device and equipment vendor eco-system
- ✓ Coherent technology/vendor roadmaps ensuring continuity and scalability
- ✓ Moreover, shared Radio Access Network is a 3GPP standard-sanctioned architecture which will transcend 4G LTE

Win-Win outcome for all parties involved (2/2)

- Building a shared RAN, leveraging CIOs' Operational footprint, is a solid win-win scenario to all parties involved:
  - ✓ Public Safety and Mission Critical partners (CIOs) gain the ability to configure dynamic Quality-of-Service and "right-prioritization" of every sharing partner
  - ✓ Radio Base sites provide coverage to both, CIOs' and partners' coverage areas of interest (e.g. remote communities, trackside, etc.)
  - ✓ Communities benefit of potential access to multiple Broadband Internet access providers (MNOs/MVNOs)
  - ✓ The latter gain access to a new extended rural customer base, through a cost-sharing model, leveraging their existing commercial Core Networks

- **CIOs are looking forward to partner with the Canadian Government in creating a wireless infrastructure enabling Canada to be a world-leader in intelligent critical infrastructures in the domains of Transportation, Utilities and beyond**

Thank you so much …

Appendix slides

Context: Rail Safety Act Review 2018

❑ **Keynotes from the review:**

- *"**Dedicated radio spectrum is vital** for putting an effective train control strategy in place across the national rail network. Spectrum, however, is in high demand, and individual railway companies cannot ensure sufficient bandwidth is available to meet their identified communication needs for **high-speed mobile data** and radio spectrum."*

- *"A **shared broadband network** to support multi-modal transportation safety solutions requires a national approach, and engagement with multiple federal departments (e.g., Innovation, Science and Economic Development Canada or ISED, and Public Safety Canada). **Transport Canada has recognized this and has established a Memorandum of Understanding with ISED in an effort to identify and secure additional spectrum before technologies are rolled out"***

❑ ***The review is making the point loud and clear to come together in a decisive Industry/Government collaborative action for the greater good of our Communities, future of Rail and multi-modal Transportation Safety***

1: *The Review is available under: "Enhancing Rail Safety in Canada: Working Together For Safer Communities The 2018 Rail Safety Act Review"*

3GPP: The largest Telecommunications Standardization body

- *3GPP stands for 3rd Generation Partnership Project [1]*
  - *The name was maintained for historical reasons, although 3GPP develops its work across 2G (GSM), 3G (UMTS), 4G (LTE, NB-IoT) and it is currently driving 5G*

- *It includes 7 major Organizational Partners who are Standards Developing Organizations, namely:*
  - ✓ *ARIB (Association of Radio Industries and Businesses, Japan)*
  - ✓ *ATIS (Alliance for Telecommunications Industry Solutions, USA)*
  - ✓ *CCSA (China Communications Standards Association)*
  - ✓ *ETSI (European Telecommunications Standards Institute)*
  - ✓ *TSDSI (Telecommunications Standards Development society, India)*
  - ✓ *TTA (Telecommunications Technology Association, Korea)*
  - ✓ *TTC (Telecommunication Technology Committee, Japan)*

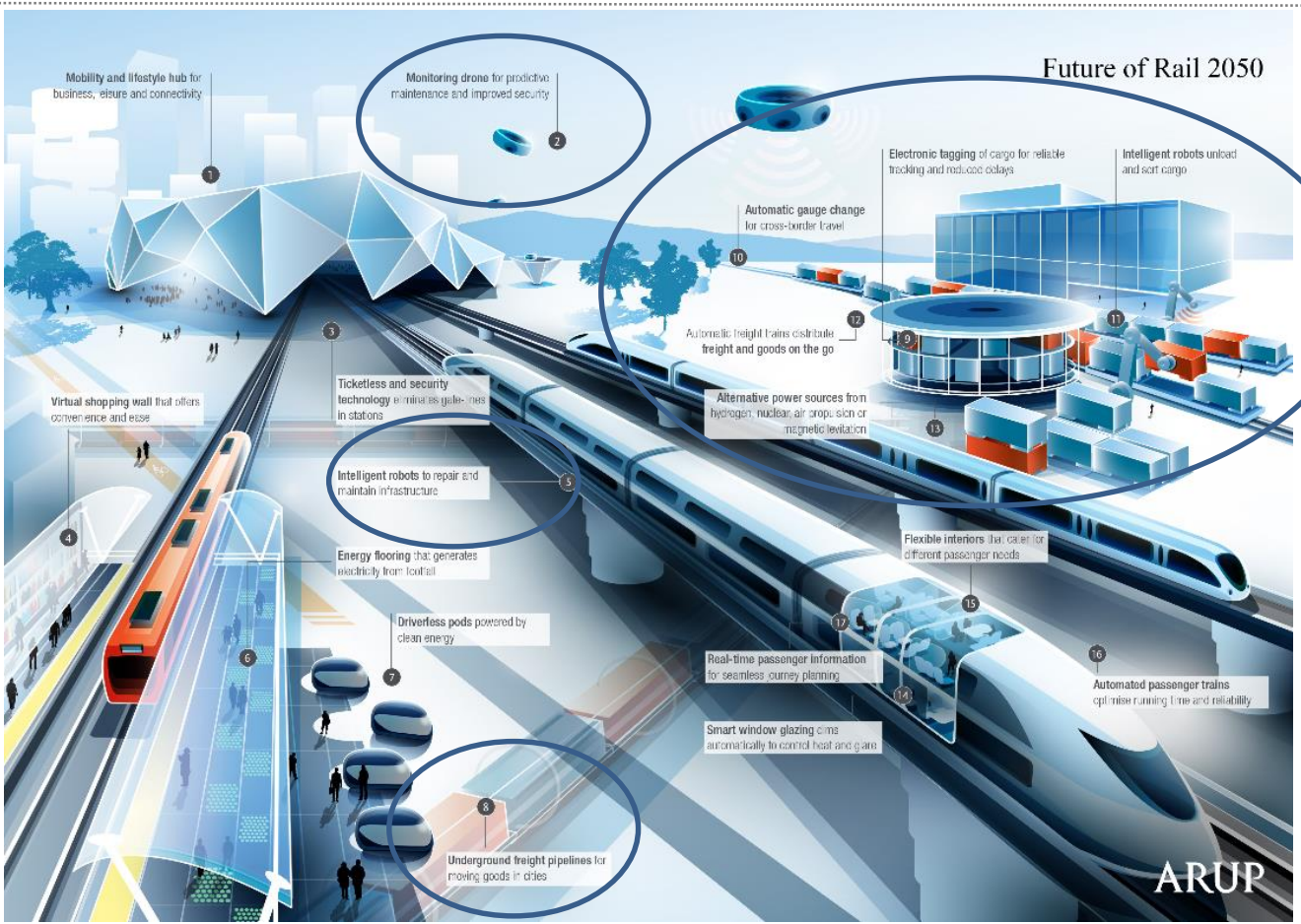
- *20 Market Representation Partners providing market perspective and advice (IPv6 forum, GSMA, CTIA, 5G Americas, 5G Automotive Association, etc.)*

***1**: Organizational Portal under www.3gpp.org*

Wireless Communications Requirements for modern Rail transportation systems

Requirement	Within next 10-years	Beyond next 10-years horizon
Throughput	• The sheer aggregated volume of data from multiple onboard Applications feeding OTDS (Big Data) Data Lakes, e.g. Interoperability and Supervisory Systems data from Locomotive and/or Wayside Interface Units, will continue to grow warranting the need of **Broadband transfer speeds**.	• **Even Higher Speed Communications** will be required to enable a wide variety of M2M communications requiring real-time processing. • High throughput-demanding applications, such as Real-time Video from Locomotive Front, Inwards and Rear-facing cameras; and even from Crossings' wireless Surveillance, will be streamed to the Back Office for Real-Time Video analytics.
Latency	• Sensors embedded in a wide variety of network elements is anticipated for automation and real-time analysis and monitoring, hence driving a requirement for **continuous latency reduction**	• Distributed Control Systems requiring even faster order-of-magnitude in feedback loops will drive the demand for **Latency Critical Mobile Communications**
Capacity	• Train density will increase in busy hubs and busy multiple-track lines, requiring Wireless Communications systems to handle **larger concentration of devices simultaneously**. The need will also be driven by the advent of "quasi-moving" and "moving block" train separations that will enhance the number of trains per track-mile.	• **Capacity (larger device concentration) needs will further increase** as new Interoperability Multi-Modal Use Cases arise, e.g. Crossings with self-driving trucks and ATO • An ever growing number of Mobile devices can be expected from additional train movement capacity enhancements, as well as from track-mounted and track-side Operations & Maintenance equipment.
	Time independent requirements	
Reliability / Availability	• Safety Critical applications (example: ETC/PTC technologies) will always demand **significant Reliability and Availability requirements, in the order of 99.999% or more**	
Coverage	• Considering the nature of Railway Operations, most Mobile (onboard) and/or Wayside Operational Use Cases will require Field-Area-Network (FAN) grade Communications, i.e. a **Coverage requirement in the miles order-of-magnitude**	
Interoperability	• A multiplicity of Transportation participants, both, from Rail and Multimodal environments, will require an Interoperable Communications system, i.e. a system **allowing communication between elements belonging to different entities**, whether Transportation companies or Association's controlled Network elements. This implies that the Communications System should be governed by **standardization enabling a rich technology vendor environment**	
Extensibility	• The ever evolving nature of Transportation Operations will trickle down into a sustainable approach to Communications. Systems should be scalable (short cycles) and be supported by a solid roadmap and technology lifecycle (long cycles), guaranteeing continuous incremental steps and migration to newer generation technologies, as requirements continuously become more stringent	

Future of Rail 2050 Research Paper



Freight Train Relevant Items surrounded in Blue contour (UK-based ARUP is one of the foremost Transportation Consulting Firms in the world (Awarded with the Design and Technical Requirement specification contract for the new Champlain Bridge by Transport Canada)