Federal Communications Commission Technological Advisory Council Meeting

June 21, 2024

FCC Technological Advisory Council Agenda – June 21, 2024

10:00am – 10:15am	Opening Remarks
10:15am – 10:25am	Records Management Overview
10:25am – 11:05am	Advanced Spectrum Sharing WG Presentation
11:05am – 11:45am	AI/ML WG Presentation
11:45am – 12:25pm	6G WG Presentation
12:25pm – 12:30pm	Closing Remarks
12:30pm	Adjourned

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FCC TAC
Advanced Spectrum Sharing WG

Chairs: Andrew Clegg (Wireless Innovation Forum)
Monisha Ghosh (Wireless Institute, Univ. of Notre Dame)

Date: June 21, 2024

Advanced Spectrum Sharing Meetings & Call for Participants

- Meeting schedule is Tuesdays from 3-4 PM eastern (same as previous cycle)
- Please send an email to aclegg@google.com, mghosh3@nd.edu, and tac@fcc.gov to be added to the list of participants in the SS WG
  - Be sure to include all three email addresses on your request
  - We can only add those who have been vetted by the FCC for TAC membership

Advanced Spectrum Sharing WG Participants

Rob	Alderfer	Charter Communications, Inc.
Mark	Bayliss	Visual Link Internet
Donna	Bethea-Murphy	Viasat
Dean	Brenner	TAC Chair
Michael	Cataletto	Scientel Solutions, LLC
Ranveer	Chandra	Microsoft Corporation
Lynn	Claudy	NAB
Andrew	Clegg	Wireless Innovation Forum
Carlos	Cordeiro	Intel
Brian	Daly	AT&T
Aleksandar	Damnjanovic	Qualcomm Incorporated
Jay	Desai	Amazon
Skyler	Ditchfield	GeoLinks
Adam	Drobot	Stealth Software Technologies, Inc.
Monisha	Ghosh	Wireless Institute, Notre Dame
Iain	Gillott	Wireless Infrastructure Association
Manu	Gosain	Northeastern University
Lisa	Guess	Ericsson
David	Gurney	Motorola Solutions Inc.
Dale	Hatfield	University of Colorado at Boulder
Jason	Jackson	Kyndryl
David	Kaufman	Amazon (Alternate Member)
Humberto	La Roche	Cisco Systems, Inc.
Greg	Lapin	ARRL
Mike	Laskowsky	Rural Wireless Association
Dan	Mansergh	Apple Inc.
Brian	Markwalter	Consumer Technology Association

Lynn	Merrill	NTCA - The Rural Broadband Association
Amit	Mukhopadhyay	Nokia
Jack	Nasielski	Qualcomm Incorporated
Bridget	Neville	Sirius XM Radio Inc.
Roger	Nichols	Keysight Technologies, Inc.
Timothy	O'Shea	DeepSig Inc.
Jon	Peha	Metro 21, Smart Cities Institute
Tom	Sawanobori	CTIA
Henning	Schulzrinne	SGE (Columbia University)
Ardavan	Tehrani	Samsung
Rikin	Thakker	NCTA - The Internet & Television Association
Michelle	Thompson	Open Research Institute, Inc.
David	Young	ATIS
Robert	Acacio	FCC EMCD Observer
Chrys	Chrysanthou	FCC EMCD Liaison
Michael	Davis	FCC EMCD Observer
Martin	Doczkat	FCC DFO
Kamran	Etemad	FCC WTB Liaison
Navid	Golshahi	FCC PRD Liaison
Paul	Lafontaine	FCC OEA Liaison
Whitney	Lohmeyer	FCC SB Liaison
Rajat	Mathur	FCC EMCD Observer
Matthew	Miller	FCC PRD Observer
Robert	Pavlak	FCC EMCD Liaison
Barbara	Pavon	FCC EMCD Observer
Kambiz	Rahnavardy	FCC WTB Observer
LiChing	Sung	NTIA

Disclaimer

- The following slides contain information regarding initial discussions of each charter item by members of the Advanced Spectrum Sharing working group. In the coming months, the WG will continue its discussions, and may invite input from other subject matter experts. The WG's thoughts on each charter item will evolve from what is presented here.

Advanced Spectrum Sharing Charter 1 (1 / 2)

- **What will advanced sharing frameworks and architectures look like in the future?**

Lead: Amit Mukhopadhyay, Nokia

Progress:

The following frameworks are emerging candidates in Europe

- Licensed-unlicensed
  - Indoor-outdoor
  - Urban-rural
  - Variable spectrum priority (in parts of shared spectrum)
- Local licensing

Potential additional frameworks for US

- Federal-federal, commercial-commercial, or federal-commercial sharing

Advanced Spectrum Sharing Charter 1 (2 / 2)

Emerging architectures/mechanisms in Europe (for licensed-unlicensed):

- Contention based
- Inter-system signaling
- Uplink-downlink split (for licensed)
- Broadcast signal based

Other possible architecture/mechanisms for US:

- Enhanced coordination system
- Interference reporting (threshold crossing)
- Transmitter identity
- Sensing
- Incumbent Informing Capability

Advanced Spectrum Sharing Charter 2 (1 / 2)

- **2.1 How will spectrum sharing models adapt and evolve to meet the growing demand for spectrum access among various services to support multiple purposes?**
- **2.2 How can the interplay between terrestrial and satellite services be complemented in sharing models to promote more efficient spectrum use?**

Lead: Amit Mukhopadhyay, Nokia

Progress:

- Spectrum sharing models emerging in Agenda Item 1.13 for WRC-27 is aligned with FCC's Supplemental Coverage from Space (SCS):
  - Ensure that terrestrial service is protected from any MSS allocation under WRC-27 AI1.13 and ensure that satellite service will complement terrestrial, not compete with it.
  - Ensure that terrestrial service is not negatively affected by spectrum allocated exclusively for satellite service (WRC-27 AI1.12, 1.14 and AI1.19).

Advanced Spectrum Sharing Charter 2 (2 / 2)

- Spectrum sharing in the uplink direction for satellite service is mostly “co-existence”
  - Studies in ITU are being split into WP 5D (terrestrial) and WP 4C (satellite).
- Dynamic spectrum access is yet to be considered at ITU
- Spectrum sharing between TN and NTN is still primarily geography based
  - NTN uses TN partner spectrum outside the coverage area of TN.
- Handset evolution is a key element of spectrum sharing
  - Device manufactures prefer common standard solution for both TN and NTN.
- Use cases may also play a role in sharing frameworks
  - IoT devices as well drones etc. may require different sharing frameworks

Advanced Spectrum Sharing Charter 3

- **3.1 To what extent can the FCC optimize its propagation models to reflect less conservative, more realistic assumptions and support more intensive sharing while still protecting against harmful interference?**
- **3.2 Are there specific bands where improved propagation models offer a pathway to liberalize performance capabilities beyond what the FCC permits today?**

Lead: David Gurney, Motorola Solutions

Progress:

- Clutter modeling is crucial for improved propagation modeling accuracy (among other items)…
- Significant progress is being made in existing shared spectrum bands (e.g., CBRS) to improve propagation modeling accuracy (e.g., use of P.2108 clutter models, median propagation modes, system loading factors, etc.)*
- The 6 GHz shared band already incorporates P.2108 and P.452 clutter models, etc.
- NTIA/ITS currently studying improved propagation and clutter models (e.g., 2024 ISART conference)
- Distributed sensing results may also be able to improve propagation model accuracy (e.g., Amateur radio database)
- AI may be able to be utilized to better classify propagation & clutter environments (*incl. update from AI/ML work group*)
- Strongly suggest that we continue to push these types of improvements…

* See https://www.ntia.gov/sites/default/files/2024-06/ntia_notice_to_fcc_re_reduced_cbrs_dpas_5-21-2024.pdf

Advanced Spectrum Sharing Charter 4

- **4.1 What steps can be taken to better facilitate spectrum repurposing efforts?**
- **4.2 How can potential intra-band and inter-band issues be identified and addressed early in the process?**
- **4.3 How can incumbent services be better informed about the nature of adjacent or nearby spectrum environments and how can users be encouraged to take steps needed to accommodate new spectrum uses in those environments?**
- **4.4 What steps and processes should be used regarding adjacent band spectrum users' wide receiver bandwidths (i.e., the passband extends into adjacent bands)?**

Leads: Tom Sawanobori, CTIA (4.1), Roger Nichols, Keysight (4.2 – 4.4)

Progress:

- Developed draft recommendations for technical analysis/collaboration and financial incentives for spectrum repurposing using C band as a case study.
- Examining UK OFCOM study of 6 GHz 'hybrid sharing' and 'indoor/outdoor' between Wi-Fi and licensed mobile services.
- (Inter-mod issues to be considered?)

Advanced Spectrum Sharing Charter 5

- **5.1 What is the current state of the art in receiver technology?**
- **5.2 What state of the art active antenna array and filter technologies can be utilized to mitigate potential harmful interference?**
- **5.3 How can advanced antenna systems help reduce both inter-system and intra-system interference and enhance intra-system performance (e.g., beam vs. null steering)?**
- **5.4 What are the cost benefit tradeoffs on utilizing the current filter technologies or advanced antenna systems?**
- **5.5 Are there specific bands where improved receiver technologies offer significantly improved coexistence beyond what is permitted today?**

Leads: Monisha Ghosh, UND and Dale Hatfield, UC Boulder

Progress:

- Write-up being prepared, including common set of terminology

Advanced Spectrum Sharing Charter 6

- **6.1 What are the candidate bands or services that can co-exist with low-power, indoor-only operation such as factory automation?**
- **6.2 What are the sharing mechanisms to consider?**

Lead: Jason Jackson, Kyndryl

Progress:

- Hypothesis - many of the protocols and technologies deployed in these use cases already use de-conflicted unregulated spectrum (2.4Ghz) and will do so in the future. Allocating additional spectrum to these types of use cases is potentially unnecessary as radio technology in this space starts to use multi-point wavelength measurements, allowing for signal aggregation, aggressor management, and improved packet delivery reducing RF power needs and improving battery life.

- Strawman proposal created - needs broader review and consensus from the WG. Can bring example technology OEM to showcase AoTP for the WG.

Advanced Spectrum Sharing Charter 7

- **What are the sharing mechanisms to consider among various services above 95 GHz, including passive services?**

Lead: Jason Jackson, Kyndryl

Progress:

- Requested SME consultancy thru the committee regarding this topic - Action to WG chairperson to allocate resource and field an appropriate discussion. Nothing further on this topic has been progressed without the consultancy.

- Observation - Northeastern University is doing good work in this space that could also be considered https://wiot.northeastern.edu/news/open-6g-otic-general-availability-open-ran-testing-and-integration-solutions/

- Strawman proposal TBD - needs broader review and consensus from the WG.

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Advanced Spectrum Sharing Charter 8

- **What role should sensors play in informing spectrum use and in supplementing spectrum sharing databases?**

Leads Jason Jackson, Kyndryl

Progress:

- Hypothesis - additional requirements should be recommended for relevant standards/rules to create a 'Dynamic' SAS vs. the static registrations today for all shared spectrum solutions going forward. 'Cybersquatting' (Practice of allocating spectrum by finding a deconflicted channel then setting up a registration regardless of the utilization of the spectrum) is escalating. If this continues without appropriate remedies, there will be no amount of shared spectrum that would satisfy the demand. This should be addressed by implementing sensors in an existing range (propose CBRS) and use the findings to set the policy.

- Proposal - create strawman of a new 'Dynamic' Spectrum Access Service that combines these metrics with registration data. Identify the appropriate sensors to deploy. Employ AI to make analyze the utilization sensor data and police stewardship of shared spectrum. Sensorize aggressor metrics, data quality metrics, and utilization metrics on deployed networks going forward, with direct tie-back to SAS data. This will build confidence in the sharing of other unlicensed bands over time.

- Strawman proposal TBD - focus will be to use an existing band (CBRS?) to model a proposal, test, then inform results. identify sensors and metrics that can be used for this specific endeavor. Needs broader review and consensus from the WG.
- Focus on 'Proposal" - "Hypothesis" may be controversial

Advanced Spectrum Sharing Charter 9

- **What are the trade-offs between efficient spectrum use and environmental considerations, including sustainability and energy efficiency?**

Lead: Rob Alderfer, Charter

Progress:

- SME, Professor Dinesh Bharadia scheduled to present on energy efficiency of small cells.

Advanced Spectrum Sharing Charter 10

- **10.1 What methods can support the Commission in identifying spectrum bands that have the most potential and flexibility for sharing and repurposing?**
- **10.2 What are the candidate bands and which bands should be prioritized?**
- **10.3 How should those bands be combined or separated for federal and/or non-federal uses?**
- **10.4 What are the optimal coordination processes between stakeholders to better support implementation and consideration of these methods?**

Leads: Andy Clegg, Google (10.1, 10.3), Michael Cataletto, Scientel (10.2, 10.4),

Progress/discussion points:

- Emphasis on bands adjacent to existing shared bands
- Consider non-traditional shared services, not just mobile broadband
- Who determines whether spectrum is being “used”?
- Role of multi-stakeholder groups (similar to CBRS, 6 GHz)
- Should coordination/coexistence requirements be fully specified by FCC?
- Impacts of TDD vs FDD
- Work product: TBD

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What Has Transpired Recently wrt Spectrum Sharing?

- National Spectrum Strategy and Implementation Plan
- WRC-23 concludes, WRC-27 planning begins
- 6 GHz sharing (VLP & AFC)
- FCC Public Notice on access to unassigned spectrum inventory
- Rules for Supplemental Coverage from Space (draft)
- AI/ML continues exponential adoption and technical refinements.
- Ofcom vision for hybrid sharing in 6 GHz, May 21, 2024, Ofcom hybrid sharing
- CBRS 2.0

Thank You

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FCC TAC

Artificial Intelligence, Machine Learning Working Group - AIWG

AIWG WG Chairs: Lisa Guess, Cradlepoint/Ericsson
Adam Drobot, Stealth Software Technologies, Inc.

AIWG SWG Chairs: Ardavan Tehrani, Samsung
(Softwarization) Richard Kessler, Marvell

FCC Liaisons: Bahaman Badipour**,** Chrysanthos Chrysanthou, Rajat Mathur, Patrick Sun, Martin Doczkat – DFO, and Sean Yun – Alternate DFO

FCC Observers: Robert Acacio, Damian Ariza, Etemad, Kamran, Jonathan Lu, Mathew Miller,, Joseph Prebble, and Aniqa Tahsin

Date: June 21, 2024

Working Group - Membership, FCC Liaisons, and Observers, Meetings

Agenda June 21, 2024

- Working Group - Membership, FCC Liaisons, and Observers, Meetings
- Review of the AIWG Charter for 2024/2025
- Background and Context – 7 Dimensions of AI/ML Adoption
- Identification of Main Major Use Cases and Priorities (Work to Date)
- Infrastructure and other Considerations for AI/ML
- Deliverables
- Scheduled and Prospective Speakers

AIWG Members

Name	Organization	Name	Organization
Bayliss, Mark	Visual Link Internet	Lapin, Gregory	ARRL
Brenner, Dean (1)	SGE	Markwalter, Brian	Consumer Technology Association (CTA)
Clegg, Andrew (2)	Wireless Innovation Forum	Merrill, Lynn	NTCA
Daly, Brian K. (3)	AT&T	Mukhopadhyay, Amit	Nokia
Drobot, Adam T.	Stealth Software Technologies	Nasielski, Jack	Qualcomm
Ghosh, Monisha (2)	University of Notre Dame	O'Shea, Tim	Deepsig.Ai
Gosain, Abhimanyu (3)	Northeastern University	Pankajakshan, Bejoy	Mavenir
Guess, Lisa	Ericsson	Peha, Jon M.	Carnegie Mellon University
Gupta, Sachin	NRECA	Raghothaman, Balaji	Keysight
Hatfield, Dale H.	University of Colorado	Sirbu, Marvin	SGE
Jog, Suraj	Microsoft Research	Sung, LiChing	NTIA Office of Spectrum Management
Kessler, Richard	Marvell	Tehrani, Ardavan M.	Samsung
Lan, Tian	SGE		

(1) TAC Chair, (2) SSWG Chairs (3) 6GWG Chairs

AIWG FCC Liaisons and Observers

Name	Organization	Name	Organization
Acacio, Robert	EMCD - Observer	Miller, Matthew	PRD - Observer
Ariza, Damian	PRD - Observer	Prebble, Joseph	PRD - Observer
Badipour, Bahman	PRD - Liaison	Sun, Patrick	OEA - Liaison
Chrysanthou, Chrys	EMCD - Liaison	Tahsin, Aniqa	PRD - Observer
Etemad, Kamran	WTB – Observer		
Lu, Jonathan	EMCD - Observer		
Mathur, Rajat	EMCD - Liaison		
Doczkat, Martin	FCC EMCD – FCC DFO		
Yun, Sean	FCC EMCD – FCC ADFO		

Weekly Meetings

AIWG (Spectrum Sharing and Functionality – Buckets 1 and 2)
Co-Chairs Lisa Guess (Ericsson)
Adam Drobot (Stealth Software Technologies)
Meeting Time: Wednesdays 3pm - 4pm ET

AIWG SWG (Testing and Softwarization - Buckets 3 and 4)
Co-Chairs Ardavan Tehrani (Samsung)
Richard Kessler (Marvell)
Meeting Time: Thursdays 3pm - 4pm ET

Review of AIWG Charter and "Bucket Summary"

AIWG Charter

For 2024 there are ten items in the Artificial Intelligence, Machine Learning, Working Group (AIWG) Charter.

Bucket 1: AI and ML for Spectrum Sharing and Management

1.1 Explore the use of AI/ML methods to improve the utilization and administration of spectrum (licensed, unlicensed, and shared) based on the fundamental characteristics of propagation, interference, signal processing, and protocols. How could the scalability aspect of AI/ML algorithms support such methods by use of techniques such as parallelization, dimensionality reduction, sampling, and approximation?

1.2 How can AI/ML be leveraged to help better understand real-time spectrum usage, either at the front end (e.g., improved sensing) or the back end (e.g., improved analytics)?

AIWG Charter

For 2024 there are ten items in the Artificial Intelligence, Machine Learning, Working Group (AIWG) Charter (continued)

Bucket 2: Network Safety, Security, Assurance, and Performance

2.1 Evaluate the use of AI/ML methods and techniques applied to assuring the safety, security, and performance of network equipment, network control, and network operations in a network environment that increasingly relies on automation, is seeing a rapid growth of new network connections, and is increasingly digitized and softwareized.

2.2 Explore and evaluate AI-enabled networks in optimizing long convergence time, memory complexity, and complex behavior of machine learning algorithms under uncertainty as well as how the highly dynamic channel, traffic, and mobility conditions of the network contribute to the challenges of AI networks.

2.3 How can AI/ML techniques be used to address the challenges of data quality, availability, privacy, and security in wired and wireless networks, such as data cleansing, data fusion, data anonymization, and data protection?

AIWG Charter

For 2024 there are ten items in the Artificial Intelligence, Machine Learning, Working Group (AIWG) Charter (continued)

Bucket 3: Testing Regimes for AI/ML in Telecommunications

3.1 What approaches should be taken, if any, on testing and certification of AI/ML softwarization of network components, capabilities, and equipment?

AIWG Charter

For 2024 there are ten items in the Artificial Intelligence, Machine Learning, Working Group (AIWG) Charter (continued)

Bucket 4: Softwarization of Telecommunications

4.1 Are there opportunities, for the Commission, to use AI/ML to improve its analysis of data presently collected and housed in databases like ULS?

4.2 What are the implications and complications of using AI/ML in optimizing wireless and wired networks performance by analyzing network traffic patterns, network failures, proactive corrective actions, network routing, and predicting network congestion?

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AIWG Charter

For 2024 there are ten items in the Artificial Intelligence, Machine Learning, Working Group (AIWG) Charter (continued)

Bucket 4: Softwarization of Telecommunications

4.3 How can AI/ML techniques be used to support the integration and interoperability of wired and wireless networks, such as heterogeneous access networks, multi-domain networks, and adaptive network slicing?

4.4 How can AI/ML techniques be used to design and implement novel network architectures and protocols for wired and wireless networks, such as software-defined networking (SDN), network function virtualization (NFV), and information-centric networking (ICN)?

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AIWG Charter - Organization for 2024

The AIWG has taken the ten items in the Charter and organized them as four Buckets.

Subject	Area Covered	Responsibility
Bucket 1	**AI and ML for Spectrum Sharing and Management** 1.1 – 1.2	AI/ML Working Group **Functionality and Performance**
Bucket 2	**Network Safety, Security, Assurance, and Performance** 2.1 – 2.3	AI/ML Working Group **Functionality and Performance**
Bucket 3	**Testing Regimes for AI/ML in Telecommunications** 3.1	AI/ML Sub-Working Group **Softwarization**
Bucket 4	**Softwarization of Telecommunications** 4.1 – 4.4	AI/ML Sub-Working Group **Softwarization**

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Background and Context

7 Dimensions of AI/ML Adoption

Seven Dimensions of AI/ML Digital Transformation

1. Commitment and Mindset
2. Strategic Business Cases
3. Organizational Structure and Capabilities
4. Allocation of Resources
5. Access to Technology (and Technology Maturity)
6. Customers, Partners, Vendors, and Suppliers
7. Investment and Participation in Ecosystem

Significant Investments in AI/ML. - Momentum and Growth

- Global Investments in AI Technologies and Deployments

Over the last 5 Years the Amount invested in AI/ML by country in Millions

	Country	$ Millions	$ / $1000 GDP	Population 2023
1.	United States	328,548	12.90	339,996,563
2.	China	132,665	7.39	1,425,671,352
3.	United Kingdom	25,541	8.32	67,736,802
4.	India	16,147	4.77	1,428,627,663
5.	Canada	12,457	5.82	38,781,291
6.	South Korea	10,348	6.21	51,784,059
7	Sweden	8,281	14.13	10,612,086
8	Singapore	7,005	15.01	6,014,723

Source: https://edgedelta.com/company/blog/ai-investment-statistics#:~:text=The%20AI%20sector%20grew%20in,Microsoft%2C%20NVIDIA%2C%20and%20Salesforce

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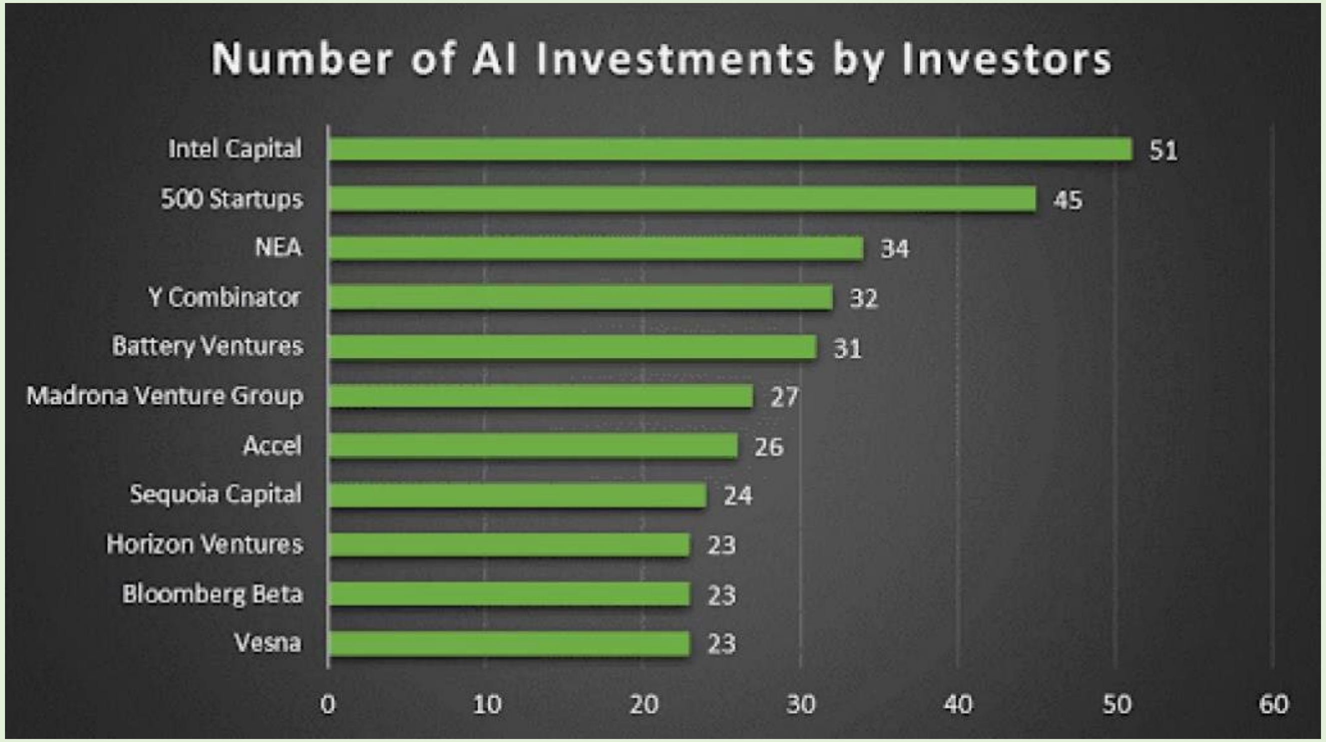
Significant Investments in AI/ML. - Momentum and Growth

➢ Investments in AI



In 2023, tech giants secured two-thirds of the $27 billion raised by emerging AI companies. The AI sector grew in 2021, but the industry needed capital and resources from established tech companies to develop products and services.

Source: https://edgedelta.com/company/blog/ai-investment-statistics

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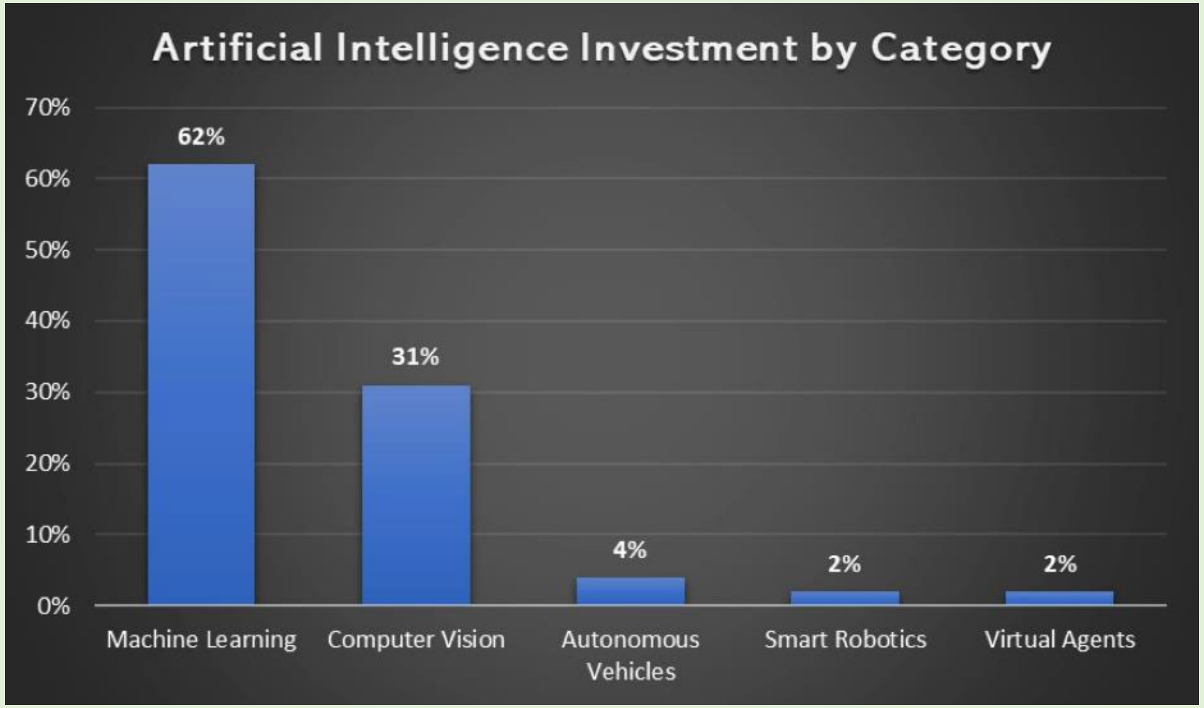
Significant Investments in AI/ML. - Momentum and Growth

- Investments in AI



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Significant Investments in AI/ML. - Momentum and Growth

Examples of Government Initiatives in AI - Projected US Govt. Spending in 2024 > $4B

Agency	Directive	Agency	Directive
Department of Agriculture (USDA)	Issue guidance on automated systems for public benefits programs	Department of State	Expand international partnerships in AI
Department of Commerce	Develop guidance for authenticating AI-generated content	Department of Transportation (DOT)	Examine the safe use of AI in transportation
Department of Defense	Establish a pilot program to identify vulnerabilities in critical systems	Department of the Treasury	Review antitrust guidance and enforcement policies related to AI
Department of Education	Develop guidance on responsible AI use in education	Department of Veterans Affairs (VA)	Host AI Tech Sprint competitions
Department of Health and Human Services (HHS)	Prioritize responsible AI development and create an HHS AI Task Force	Federal Trade Commission (FTC)	Protect consumers and enforce competition in the sector
Department of Housing and Urban Development (HUD)	Issue guidance on fair lending and housing laws to prevent discrimination by AI	Federal Communications Commission (FCC)	Examine how AI can aid in the fight against unwanted robocalls and robotexts
Department of Energy	Coordinate responsible AI governance across the government	General Services Administration (GSA)	Prioritize funding for AI projects for at least one year
Department of Homeland Security	Ensure that AI development aligns with U.S. values	National Science Foundation (NSF)	Fund and launch at least one NSF Regional Innovation Engine
Department of Justice (DOJ)	Identify best practices for recruiting and hiring law enforcement professionals with AI skills	Office of Personnel Management	Coordinate a pooled hiring action to recruit AI talent and develop guidelines on using generative AI by the federal workforce
Department of Labor	Analyze agency abilities to support workers displaced by AI	Patent Office	Publish guidance on how to address the use of AI in patents

Source: https://ai.gov/ai-use-cases/

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Significant Investments in AI/ML. – Impact Across Verticals

Six AI industry trends – Diginomica

By 2040, the adoption of AI is projected to reach 34.8%, with over 1.3 million businesses utilizing it to drive innovation. McKinsey's Global Survey on Artificial Intelligence has highlighted the adoption of AI has more than doubled since 2017. PWC affirms that AI is already having a widespread effect on innovation, with the potential to contribute around $15.7 trillion to the global economy by 2030.

1. AI will be the driving force for Telecom Operators to enhance operational efficiency
2. Dynamic planning is driving enhanced performance for modern manufacturers
3. The EUR industry is using AI and automation to accelerate its evolution towards a composable environment
4. Utilizing AI will alleviate long-standing challenges for Construction and Engineering companies
5. Asset-centric service providers are using AI to transform fleet management
6. The increasing adoption of AI forces cyber-security to up its game for defense companies

Source: https://diginomica.com/six-ai-industry-trends-were-tracking-2024-and-beyond

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Significant Investments in AI/ML. – Including Telecommunications

➢ Investments in AI for Telecoms

1. AI will be the driving force for Telecom Operators to enhance operational efficiency

AI-powered automation is already playing a key role for telecom operators to optimize various tasks and processes such as network management, service provisioning, fault detection, resolution, security, billing, and customer support. The adoption of this technology is only set to increase in 2024 and is poised to improve network availability, performance, and operational efficiency. By leveraging AI and automation, telecom operators can create self-optimizing networks (SONs) that can adjust network parameters based on real-time data and feedback or automate customer service interactions using chatbots or voice assistants. Furthermore, the harmonization of data across various solutions such as EAM, FSM, APM, and ERP creates a world of possibilities for cross-data intelligence – automating the delivery of resources, anticipating asset health, and real-time scheduling and dispatching that automates the delivery of resources at the right place and the right time.

Source: https://diginomica.com/six-ai-industry-trends-were-tracking-2024-and-beyond

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The Inevitable Intertwining of Infrastructure

- The network will evolve from pure simple connectivity to an intertwined infrastructure consisting of compute, storage, connectivity and AI elements.
- Connectivity is an essential foundation, but it must conform to needs of the of these embedded elements, not the other way around. This era is an industry play - not a consumer play.
- Compute and connectivity and storage as no longer separate solutions, and the FCC will need to evolve a mindset to view the Network as this combined system of elements that are not traditionally the FCC's purview.
- AI combining with the network all the way to the "Far edge" is inevitable, with traffic patterns that will change to accommodate the new demands.
- In recent history, the "macro communications network" has been optimized for consumer use and has not been designed to optimize for the needs of industry and enterprises.

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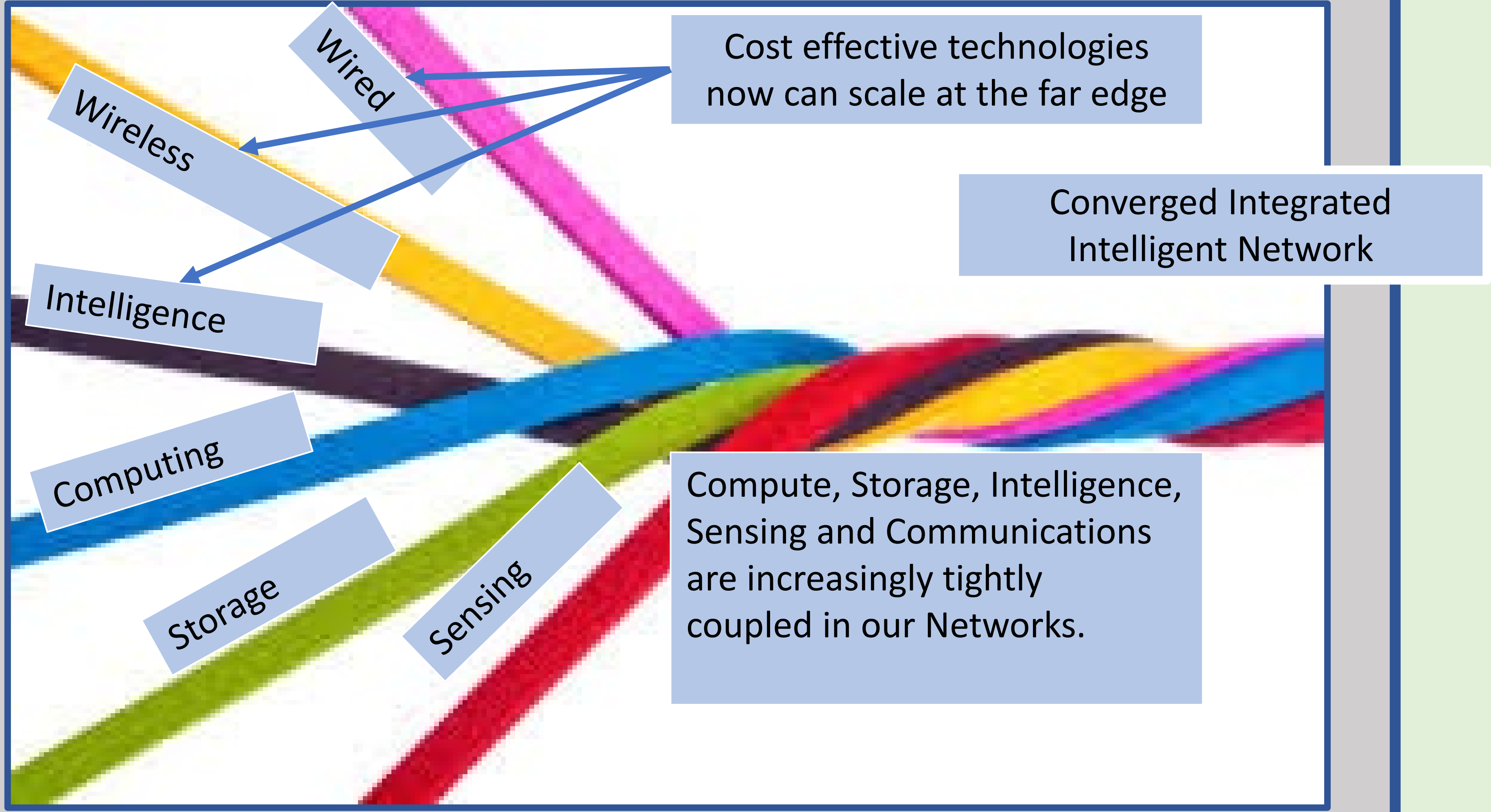
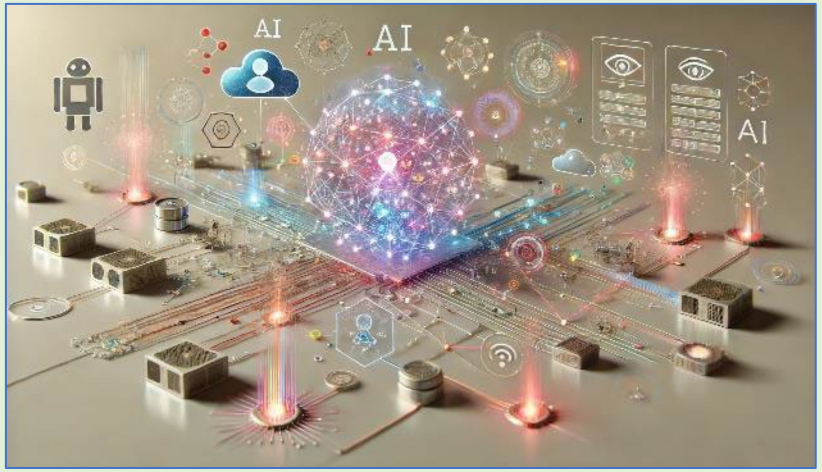
The Inevitable Intertwining of Infrastructures



The Inevitable Intertwining of Infrastructures: How this is going to happen



- Major Telecommunication upgrades to new technologies have historically required a complete near-simultaneous replacement equipment demanding large upfront investment and introducing high risk
- With the granularization of the network that comes with introducing AI embedded throughout the network, evolution will be driven by a succession of projects that have a purpose and an outcome.
- Learning curves will be iterative. Networks will be modular.
- The next generation "intertwined" communications systems make this possible – AI/ML accelerates these needs

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7 Dimensions of AI/ML Adoption

1. Commitment and Mindset
2. Strategic Business Cases
3. Organizational Structure and Capabilities
4. Allocation of Resources
5. Access to Technology (and Technology Maturity)
6. Customers, Partners, Vendors, and Suppliers
7. Investment and Participation in Ecosystem

Identification of Main Major

Use Cases and Priorities

Major Use Cases and Priorities

List of Use Cases for AI/ML in Telecommunications

Use Case 1 – **Efficient Spectrum Sharing**
Use Case 2 – **Open Radio Access Network (O-Ran, Open RAN, Intelligent Controllers)**
Use Case 3 – **Safety and Security of the Network**
Use Case 4 – **Network Control and Management**
Use Case 5 – **Network Planning**
Use Case 6 – **Modernizing FCC Databases and Other Information for Decision making and Public Use**
Use Case 7 – **Testing Regimes for Network Components/Devices**
Use Case 8 – **Testing Regimes for Network Functionality and Performance**
Use Case 9 – **Detection and Understanding of Spectrum Usage**
Use Case 10 – **Emergency Response and Recovery**
Use Case 11 - **NTN mobile communication combined with TN**
Use Case 12 - **Customer Quality of Service and Customer Experience**

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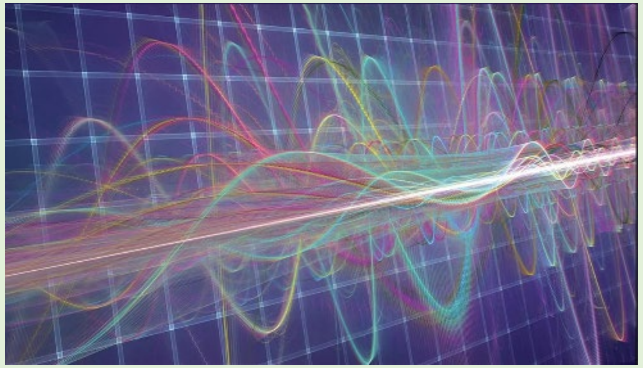
Major Use Cases and Priorities

Use Case 1 – **Efficient Spectrum Sharing**

Rules, Protocols, and Operational Procedures for Optimizing Spectrum Utilizations

Bucket 1



1.1 Propagation Models
1.2 Models for Interference
1.3 Automation for Real-Time Sharing Regimes
1.4 Digital Twin Models for Distributed Management of Local Data Driven Spectrum Sharing

Source: https://www.rcrwireless.com/20240402/ai-ml/why-ai-holds-major-promise-for-spectrum-sharing-at-scale-reader-forum

Source: https://5ghub.us/spectrum-sharing-to-ai-driven-networks-the-technical-evolution-in-3gpp-releases-16-to-18/

Source: https://www.analysysmason.com/contentassets/d3b90b84f09945b09f16a1fc6e869a01/analysys_mason_ai_spectrum_management_quarterly_jan2024.pdf

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Major Use Cases and Priorities

Use Case 1 – **Efficient Spectrum Sharing (Continued)**

Bucket 1

1.1 Propagation Models

Machine learning could significantly improve estimates of path loss. It has long been know that different models work better in different environments, e.g. path loss is quite different in dense urban areas than in rural areas. Machine learning can be used to determine which model works best in any given region.

Examples

- Seretis, A., & Sarris, C. D. (2021). An overview of machine learning techniques for radiowave propagation modeling. *IEEE Transactions on Antennas and Propagation*, *70*(6), 3970-3985.
- Huang, C., He, R., Ai, B., Molisch, A. F., Lau, B. K., Haneda, K., ... & Zhong, Z. (2022). Artificial intelligence enabled radio propagation for communications—Part II: Scenario identification and channel modeling. *IEEE Transactions on Antennas and Propagation*, *70*(6), 3955-3969.
- Zhang, J., Liu, L., Fan, Y., Zhuang, L., Zhou, T., & Piao, Z. (2020). Wireless channel propagation scenarios identification: A perspective of machine learning. *IEEE Access*, *8*, 47797-47806.
- Nguyen, T. T., Yoza-Mitsuishi, N., & Caromi, R. (2023). Deep Learning for Path Loss Prediction at 7 GHz in Urban Environment. *IEEE Access*, *11*, 33498-33508.

Major Use Cases and Priorities

Use Case 1 – **Efficient Spectrum Sharing (Continued)**

Bucket 1

Detecting Spectrum Usage

It is important to detect when a transmitter is active in a spectrum band. One example is when secondary users are trying to determine whether a primary user is active, because they are allowed to transmit when there are no active primaries. Another example is in exclusion zones, e.g. around passive spectrum users such as for radio astronomy. There should be no transmitters in that band, and when this rule is broken, operators of the passive radio system need to know. Machine learning can be used to detect transmissions. One advantage of this over traditional methods of detection is that one does not need a statistical characterization of noise in advance when deploying a system that uses machine learning, and these systems may work well even when received signals are below average noise levels.

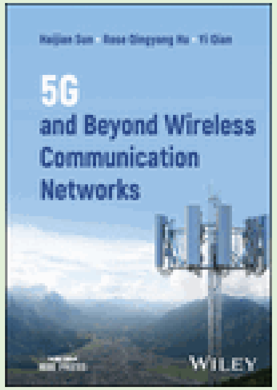
Examples

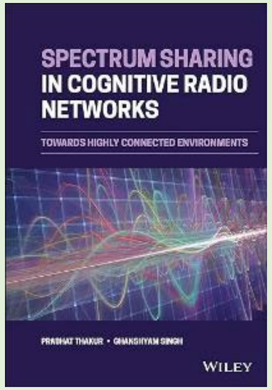
- Thilina, K. M., Choi, K. W., Saquib, N., & Hossain, E. (2013). Machine learning techniques for cooperative spectrum sensing in cognitive radio networks. *IEEE Journal on selected areas in communications*, *31*(11), 2209-2221.
- Gattoua, C., Chakkor, O., & Aytouna, F. (2020, December). An overview of cooperative spectrum sensing based on machine learning techniques. In *2020 IEEE 2nd International Conference on Electronics, Control, Optimization and Computer Science (ICECOCS)* (pp. 1-8). IEEE.

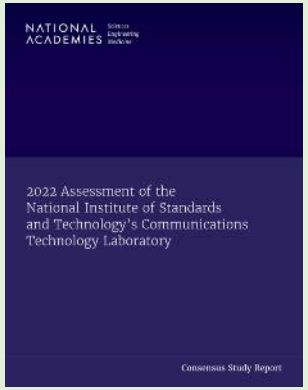
Major Use Cases and Priorities

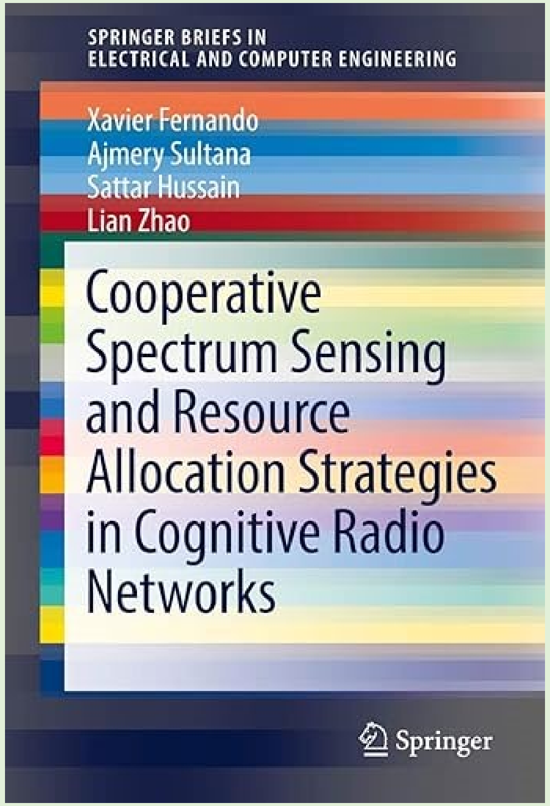
Use Case 1 – **Efficient Spectrum Sharing (Continued)**

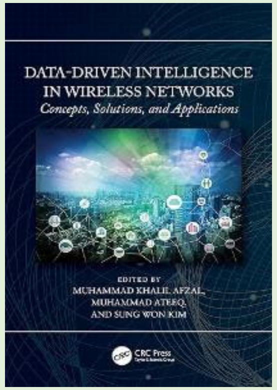
Bucket 1

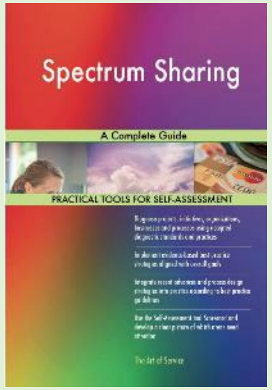


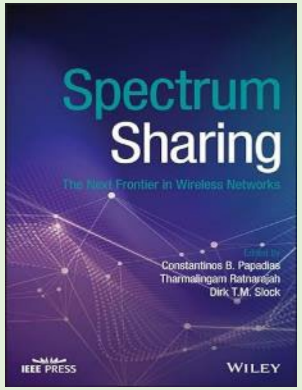












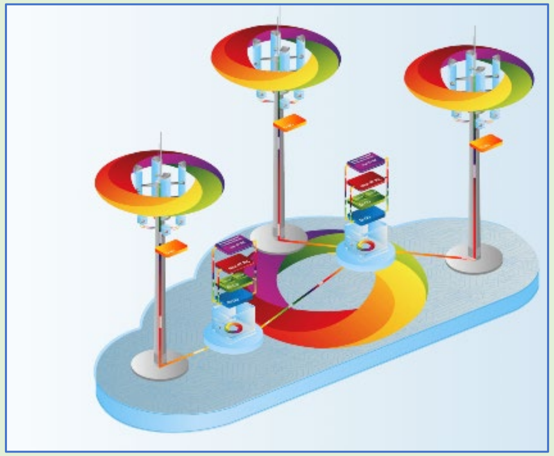
Major Use Cases and Priorities

Use Case 2 – **Open Radio Access Network (O-Ran, Open RAN, Intelligent Controllers)**

Bucket
2 and 4

- AI-Driven OpenRAN RIC (Radio Intelligent Controller) Apps
  - Predictive Maintenance and Fault Diagnosis & Mitigation
  - Dynamic Spectrum Allocation & Cell Parameter Tuning
  - Automated Network Performance & Efficiency Optimization
- AI-Native Algorithms in O-RU and O-DU for performance & efficiency
  - Neural Receiver, AI in Air Interface and Massive MIMO & Beamforming Optimization
  - AI in Scheduling, Resource Allocation, Channel Prediction & Feedback, Localization

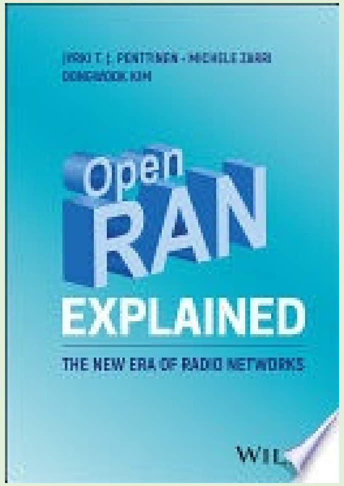
Source: "AI-Native Open RAN for 6G", Alex Jinsung Choi, Chair of O-RAN ALLIANCE, SVP Deutsche Telekom, ITU-T SG13 IMT2030 Workshop, July 24, 2023, https://www.o-ran.org/, https://mediastorage.o-ran.org/ngrg-rr/nGRG-RR-2023-03-Research-Report-on-Native-and-Cross-domain-AI-v1_1.pdf - O-RAN Alliance
Source: https://rimedolabs.com/blog/ml-framework-in-o-ran/ - Rimedo.
Source: https://research.samsung.com/blog/Enabling-Intelligent-RAN-Framework-in-O-RAN - Samsung.
Source: https://www.ericsson.com/en/reports-and-papers/ericsson-technology-review/articles/ai-enabled-ran-automation - Ericsson.
Source: https://www.deepsig.ai/deepsig-presents-artificial-intelligence-solutions-for-5g-o-ran/ - DeepSig.

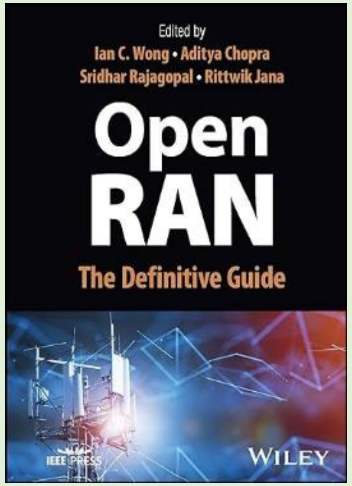


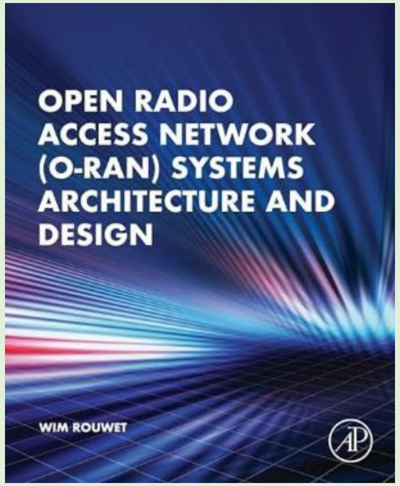
Major Use Cases and Priorities

Use Case 2 – **Open Radio Access Network (O-Ran, Open RAN, Intelligent Controllers) Continued**

Bucket
2 and 4







Major Use Cases and Priorities

Use Case 3 – **Safety and Security of the Network**

Buckets 2 and 4

1. Prevention
   - Trusted execution environment (TEE)
   - Privacy Preserving techniques
2. Detection
   - Remote attestation
   - AI/ML based security & rapid new threat detection
3. Counter Measure
   - Certificate Revocation
   - Re-authentication
4. Recovery

Source: https://rimedolabs.com/blog/tag/security/ - Rimedo Labs
Source: https://www.ericsson.com/en/reports-and-papers/further-insights/ai-ml-in-telecom-network-security - Ericsson
Source: https://www.nokia.com/networks/security/ai-security/ - Nokia
Source: https://www.juniper.net/us/en/solutions/threat-detection-and-mitigation.html - Juniper
Source: https://www.cisco.com/c/en/us/products/security/artificial-intelligence-ai.html - Cisco
Source: https://cybersecurity.att.com/blogs/security-essentials/ai-in-cybersecurity-8-use-cases-that-you-need-to-know - AT&T
Source: https://www.verizon.com/about/news/secure-connectivity-and-ai-are-key-success-2024 - Verizon

Major Use Cases and Priorities

Use Case 3 – **Safety and Security of the Network (Continued)**

Buckets 2 and 4

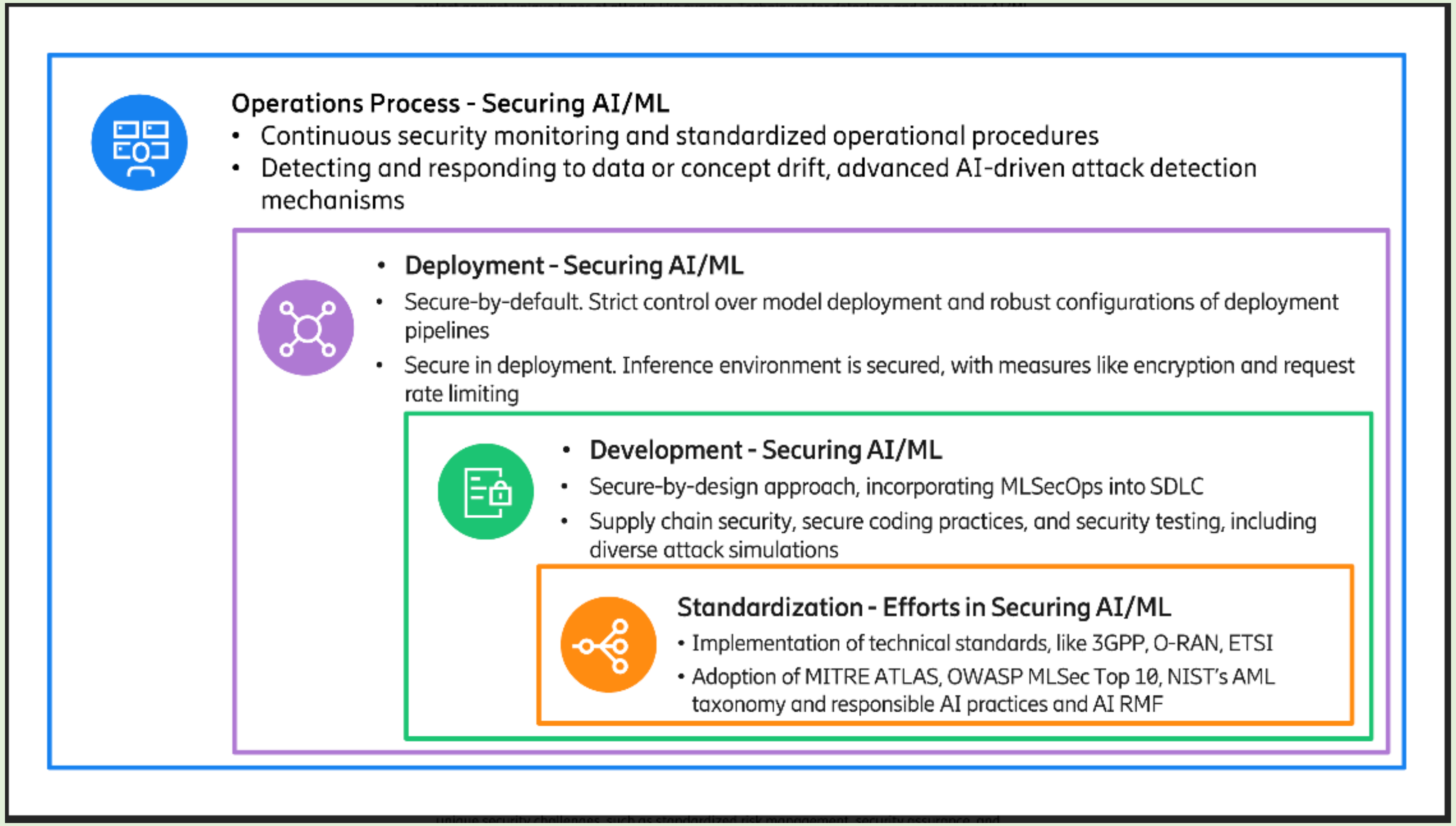
10 Predictions How AI Will Improve Cybersecurity

Source: https://www.forbes.com/sites/louiscolumbus/2019/11/24/10-predictions-how-ai-will-improve-cybersecurity-in-2020/

Major Use Cases and Priorities

Use Case 3 – **Safety and Security of the Network (Continued)**

Buckets
2 and 4



Source: https://www.ericsson.com/en/reports-and-papers/further-insights/ai-ml-in-telecom-network-security - Ericsson

Major Use Cases and Priorities

Use Case 4 – **Network Control and Management**

Buckets 2 and 4

AI and ML Network Control, Network Management, and Network Maintenance

- Traffic Engineering/Management
- Intelligent Routing
- Data Collection/Generation for the AI/ML algorithms
- Fault management (Root Cause Analysis)
- Predictive Maintenance (Diagnostics and Prognostics)
- Automated Network Optimization

Source: https://netop.cloud/blog/how-ai-and-machine-learning-are-revolutionizing-network-management/ - NetOp
Source: https://www.fujitsu.com/us/products/network/products/ai-and-analytics/ - Fujitsu
Source: https://www.ust.com/en/insights/data-driven-connectivity-the-rise-of-ai-and-machine-learning-in-telecommunications - UST
Source: https://www.sdxcentral.com/articles/feature/how-a-global-telecom-company-relies-on-ai-and-ml-for-network-management/2023/12/ - SdxCentral
Source: https://www.uipath.com/resources/automation-whitepapers/telecom-business-automation - UiPath
Source: https://relevant.software/blog/ai-in-telecommunications/ - Relevant Software

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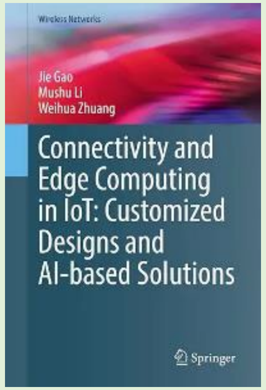
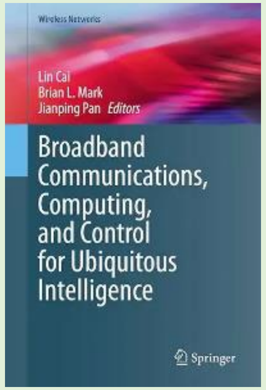
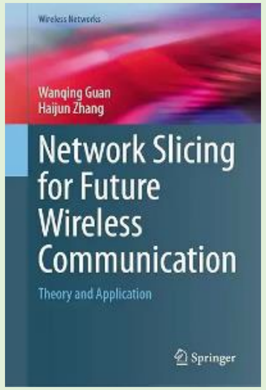
Major Use Cases and Priorities

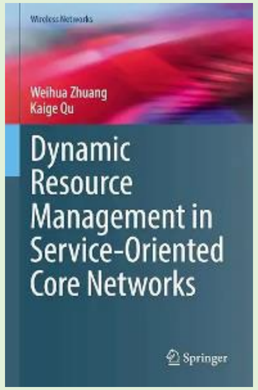
Use Case 4 – **Network Control and Management (Continued)**

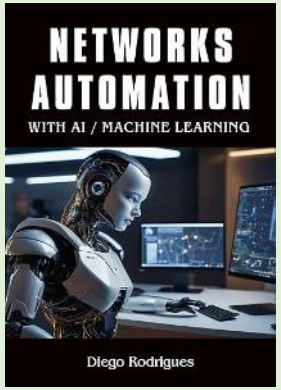
Buckets
2 and 4

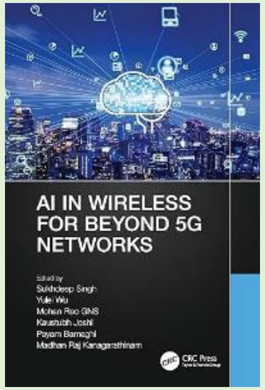


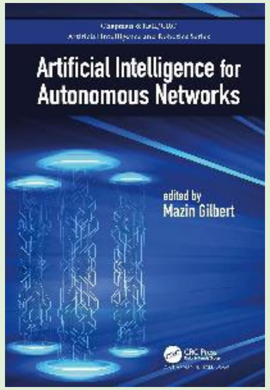


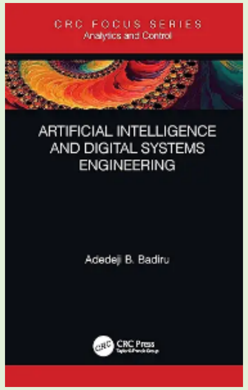


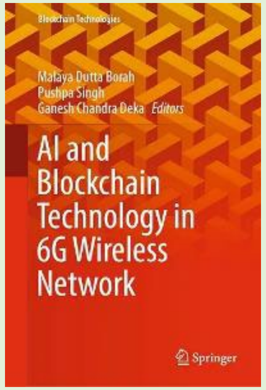


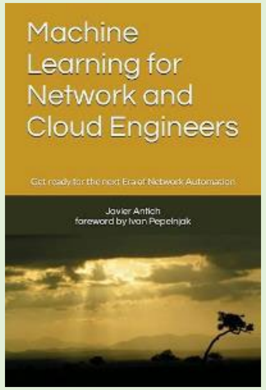












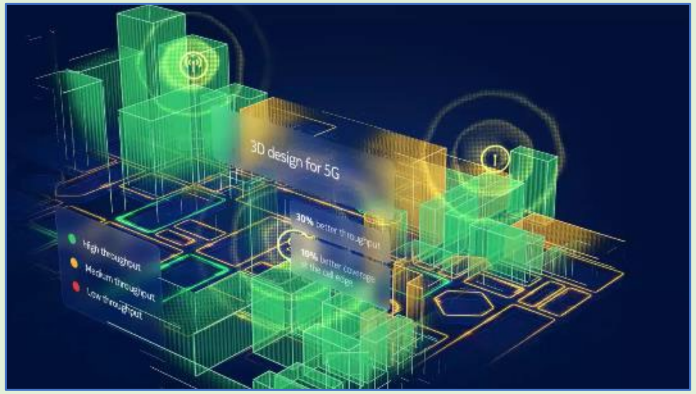
Major Use Cases and Priorities

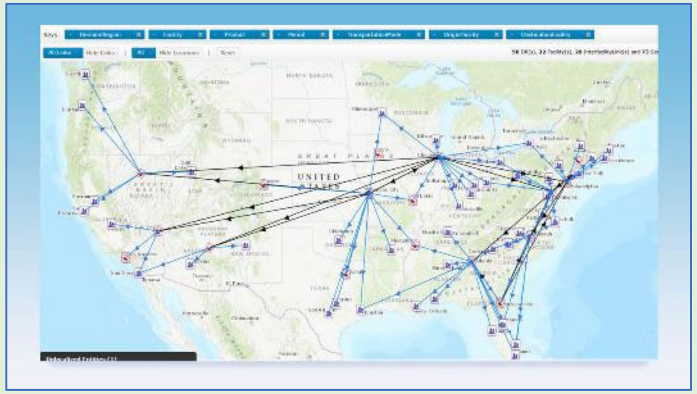
Use Case 5 – **Network Planning**

Bucket
2

AI and ML for Network Planning and Support

- Traffic Forecasting
- Capacity Planning
- Site and Support Infrastructure Development
- Digital Twins for Spectrum Planning (Propagation, Coverage, Interference)
- Broadband Coverage and Deployments Strategies (National Map)





Major Use Cases and Priorities

Use Case 5 – **Network Planning (Continued)**

Bucket 2

Source: https://www.5gamericas.org/how-generative-ai-could-impact-network-planning-ran-configuration-and-spectrum-management/ - 5G Americas
Source: https://www.eino.ai/ - EINO
Source: https://www.infovista.com/resources/planning/planet-ai-model-worldfirst-machine-learning-for-wireless-planning - Infovista
Source: https://www.blare.tech/post/5g-nr-network-planning-with-ai - Blare.Tech
Source: https://www.kyndryl.com/us/en/services/network/consulting Kyndryl
Source: https://www.sas.com/sas/offers/move2nextlevel/webinars/the-role-of-ai-and-machine-learning-in-network-planning.html - SAS
Source: https://www.iqgeo.com/blog/ai-based-network-design-automation-for-the-telecom-industry - IQGEO
Source: https://www.networkworld.com/article/1286465/should-ai-initiatives-change-network-planning.html - Network World
Source: https://about.att.com/sites/labs/our-work/analytics-ai-automation - AT&T

Major Use Cases and Priorities

Use Case 6 – **Modernizing FCC Databases and Other Information for Decision making and Public Use**

Bucket 2

- Using LLM to summarize and improve search of information
    - Providing the tools and analytical techniques that makes it easier to extract information from FCC Databases and past Orders and Regulations for Consumers and for Industry.
- Generating customized Reports based on the Database information
- Analysis of Responses to NPRMs
- Internal FCC Processes in Search for Information
- Use in Auction Processes

Source: https://www.akkio.com/post/customer-feedback-analysis-with-ai - Akkio
Source: https://www.lumoa.me/blog/5-creative-ways-to-use-ai-for-sentiment-analysis/ - Lumoa
Source: https://www.looppanel.com/blog/ai-qualitative-data-analysis - Looppanel
Source: https://www.mckinsey.com/featured-insights/artificial-intelligence/notes-from-the-ai-frontier-applications-and-value-of-deep-learning - McKinsey

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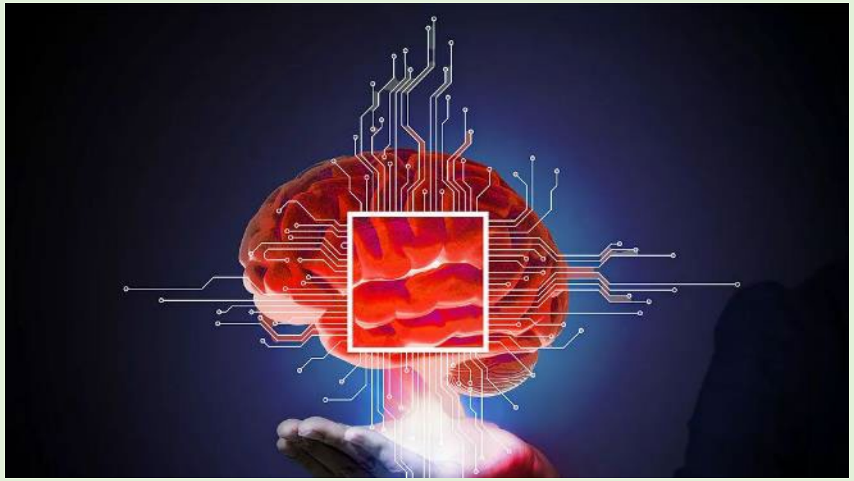
Major Use Cases and Priorities

Use Case 7 – **Testing Regimes for Network Components/Devices**

Bucket 3

The use of AI and ML Techniques to Improve the testing of Radiating Devices and Components,
Including Embedded and off Device Software.

- Automate the processes for creating appropriate test cases to test against
- Generative AI Models to Emulate Real World Conditions/Effects for Test/Optimization
- Interoperability
- EMC/EMI Analysis
  (Compatibility and Interference Pathways)
- Compliance



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Major Use Cases and Priorities

Use Case 7 – **Testing Regimes for Network Components/Devices (Continued)**

Bucket 3

Source: https://www.responsible.ai/scc-launches-accreditation-pilot-for-ai-management-systems/ - ISO/IEC 42001

Source: https://www.keysight.com/us/en/cmp/2023/ai-software-testing.html, https://news.lockheedmartin.com/lockheed-martin-keysight-test-5g-solutions-aerospace-defense-communications , and https://www.keysight.com/us/en/learn/hubs/ai-technology.html - Keysight

Source: https://www.ni.com/partners/s/partner/aDx3q00000000IlCAI/simplicity-ai?language=en_US, https://www.ni.com/en/perspectives/the-future-of-ai-ml-taking-a-human-centric-approach-to-innovation.html, and https://www.emerson.com/en-us/news/2024/05-emerson-continues-to-invest-in-advanced-ni-test-and-measurement-ai-tools – National Instruments

Source: https://www.rohde-schwarz.com/us/solutions/test-and-measurement/wireless-communication/cellular-standards/6g/ai-and-ml-for-6g-networks_257029.html - Rhode & Schwarz

Source: https://www.epdtonthenet.net/article/202701/AI-its-Bearing-on-the-Future-of-Test.aspx - Electronic Product Design and Test

Source: https://iq.appvance.ai/autonomous-testing-ebook - Appvance

Major Use Cases and Priorities

Use Case 8 – **Testing Regimes for Network Functionality and Performance**

Bucket 3

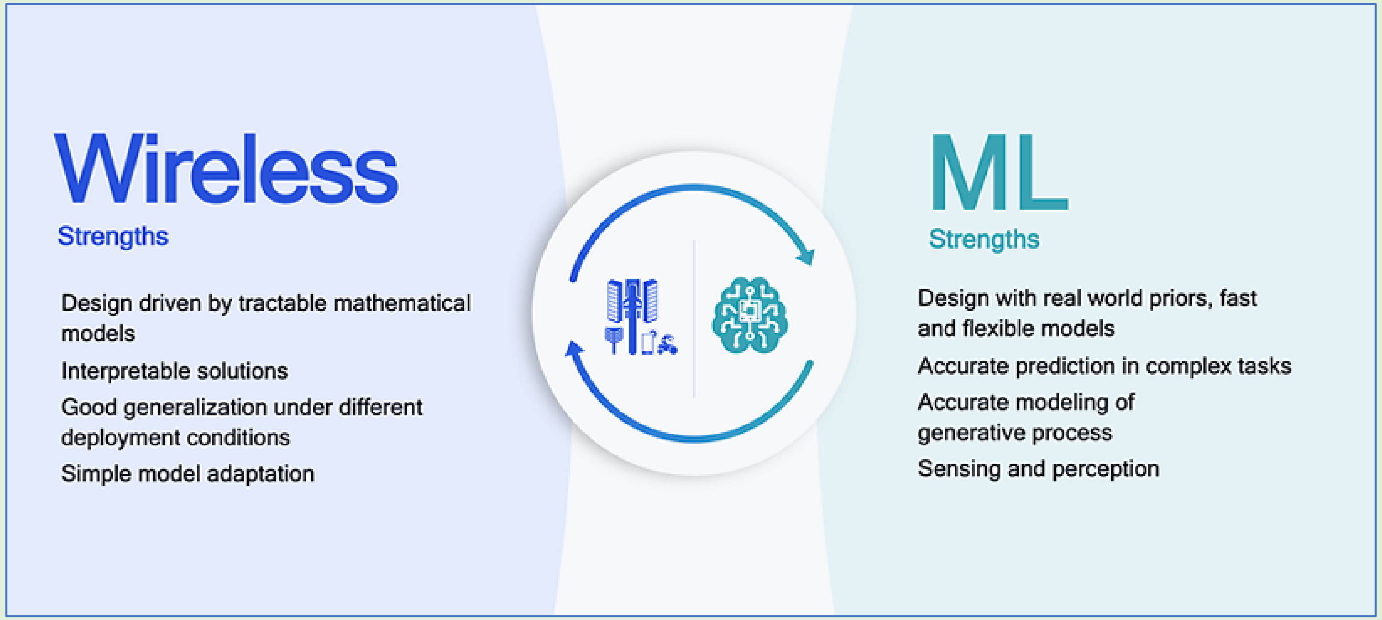
- Digital twins for evaluating network performance in a 'safe' manner
- Role of synthetic data in testing regimes
- Need for continuous testing through AI/ML lifecycle, as well as network deployment lifecycle

Source: https://www.juniper.net/us/en/forms/2024/on-demand-demo-for-ai-native-networking-platform-campus-branch.html - Juniper
Source: https://www.spirent.com/solutions/testing-for-ai-networking - Spirent
Source: https://www.cyient.com/whitepaper/artificial-intelligence-in-network-testing - Cyient
Source: https://www.keysight.com/us/en/about/newsroom/featured/1102-advancing-ai-learning-for-wireless-communications-testing.html - Keysight
Source: https://www.b-yond.com/post/ai-and-machine-learning-in-network-performance-management - B-Yond
Source: https://www.rohde-schwarz.com/us/solutions/test-and-measurement/wireless-communication/cellular-standards/6g/ai-and-ml-for-6g-networks_257029.html - Rohde & Schwarz

Major Use Cases and Priorities

Use Case 8 – **Testing Regimes for Network Functionality and Performance (Continued)**

Bucket 3



Source: https://www.qualcomm.com/news/onq/2022/05/bringing-ai-research-to-wireless-communication-and-sensing - Qualcomm

Bringing AI research to wireless communication and sensing

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Major Use Cases and Priorities

Use Case 9 – **Detection and Understanding of Spectrum Usage**

Bucket 4

AI-Driven Spectrum Sensing Drives Greatly Improved Spectrum Sensing Performance

- Easier monitoring of spectrum access usage, trends, vacancy, changes, anomalies
- Enables Spectrum Sharing, Wireless Security, Fault Diagnosis, Spectrum Coordination
- AI Improves Energy Efficiency, Sensitivity, Cost, Practicality vs Traditional Methods
- Data-Driven Approach Rapidly Adds Signatures and Scales to Diverse Broad Spectrum
- Identification of Illegal Devices and Evidence Enforcement

Major Use Cases and Priorities

Use Case 9 – **Detection and Understanding of Spectrum Usage (Continued)**

Bucket 4

Source: https://www.deepsig.ai/anritsu-and-deepsig-revolutionizing-spectrum-sensing-with-artificial-intelligence/ - DeepSig and Anritsu
Source: https://www.deepsig.ai/spectrum-awareness/ - DeepSig
Source: https://deepwavedigital.com/software-products/spectrum-sensing/ - Deepwave Digital
Source: https://www.usni.org/magazines/proceedings/2023/august/implement-ai-electromagnetic-spectrum-operations - U.S. Naval Institute
Source: https://ndupress.ndu.edu/Portals/68/Documents/jfq/jfq-95/jfq-95_116-123_Florenzen-Skulkitas-Bair.pdf - Joint Doctrine Journal
Source: https://s3.amazonaws.com/ThinkRF/Published/Solution+Sheets+%26+Use+Cases/ThinkRF+CS+74-0090+AD+Keysight+Use+Case.pdf – Think RF
Source: https://www.datashapes.com/ - DataShapesAI

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Major Use Cases and Priorities

Use Case 10 – **Emergency Response and Recovery**

Buckets
2 and 4

Uses of AI and ML in Predicting, Preventing, and Responding Emergencies

- Improving Disaster Response
  - Assessment
  - Improving location detection
  - More efficient routing of responders
  - Using LLM for emergency response team
  - Coordination and planning
  - Managing Recovery Resources and Actions

- We are expanding the ways that individuals can request help from 911 dispatch operators during emergencies. This has the potential to create a large volume of requests during big emergencies, and lives depend on rapidly prioritizing those requests. Artificial intelligence can help with prioritization.

Example: Nelson, C., & Pottenger, W. M. (2013, November). Optimization of emergency response using higher order learning and clustering of 911 text messages. In *2013 IEEE International Conference on Technologies for Homeland Security (HST)* (pp. 486-491).

Major Use Cases and Priorities

Use Case 10 – **Emergency Response and Recovery (Continued)**

Buckets 2 and 4

Source: https://www.intrado.com/blog/ai-powered-innovations-transforming-emergency-communications-centers - Intrado
Source: https://nwncarousel.com/blog/how-artificial-intelligence-can-help-9-1-1-admins-dispatchers/ - NWN Carousel
Source: https://solve.mit.edu/challenges/solv-ed-youth-innovation-challenge-2/solutions/68882 - SOLVE
Source: https://www.prnewswire.com/news-releases/rapidsos-introduces-harmony--the-first-ai-copilot-for-911-302150884.html - PR Newswire
Source: https://www.dhs.gov/sites/default/files/2023-12/23_12_08_st_aiemscallcentersoftware__market_survey_report.pdf - NUSTL
Source: https://www.tidalbasingroup.com/harnessing-artificial-intelligence-for-ai-in-emergency-management/ - Tidal Basin Group
Source: https://havrion.com/5-uses-of-ai-in-emergency-management - Havrion
Source: https://ttecdigital.com/articles/supporting-emergency-dispatchers-with-ai-reinforcements - TTEC Digital

Major Use Cases and Priorities

Use Case 11 - **NTN mobile communication combined with TN**

Use of AI and ML for Integration and Operation of combined Non-Terrestrial Networks (Satellites etc.) and Terrestrial Networks (Ground-based)

Buckets 2 and 4

- AI/ML for dynamic spectrum allocation
- AI/ML for improved NTN handover, routing, prediction
- End and Network allocation of "best" connectivity path
- Area Coverage for hard to serve regions

Source: https://www.scip.org/news/663269/The-Intelligence-behind-Satellite-Communication-Enhancing-Global-Connectivity.htm - SCIP
Source: https://www.sciopen.com/article/10.23919/ICN.2021.0015 - Artificial intelligence for satellite communication: A review
Source: https://widenetworks.net/artificial-intelligence-is-changing-the-way-of-satellite-communication/ - WideNetwork Solutions
Source: https://www.mdpi.com/1424-8220/22/21/8544 - Hybrid Satellite - Terrestrial Networks towards 6G: Key Technologies and Open Issues

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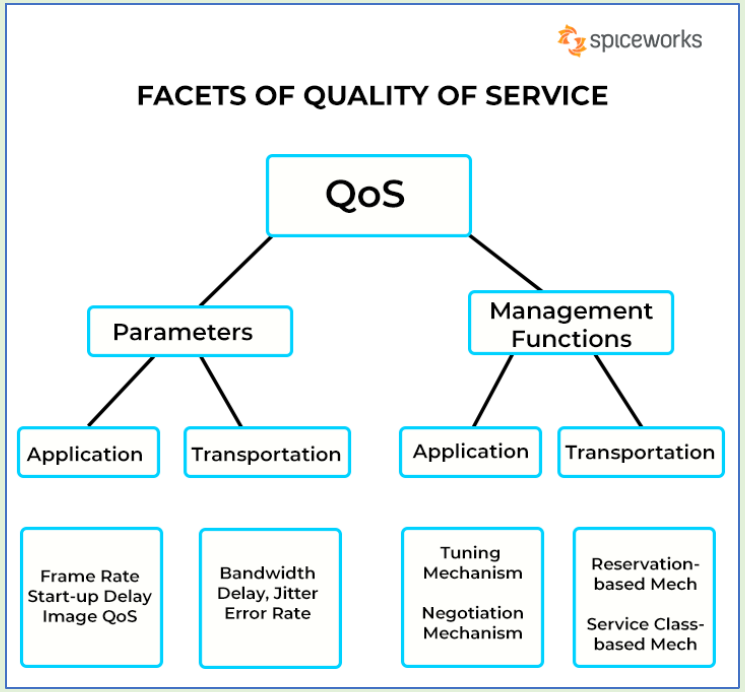
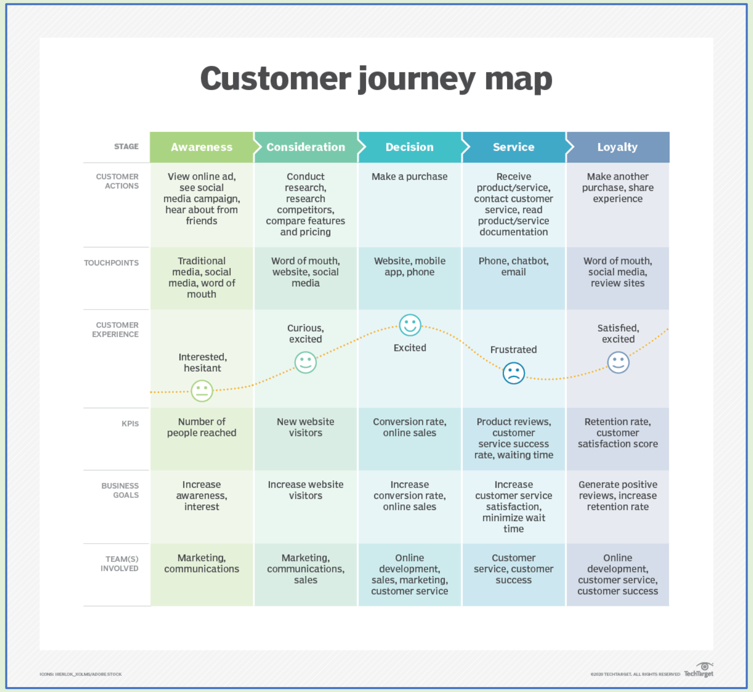
Major Use Cases and Priorities

Use Case 12 - **Customer Quality of Service and Customer Experience**

Application of AI and ML Techniques for Data Driven Improvements in Telecommunication Systems for better Customer Experience and better Quality of Service.

Buckets 2 and 4





Customer journey map

STAGE	Awareness	Consideration	Decision	Service	Loyalty
CUSTOMER ACTIONS	View online ad, see social media campaign, hear about from friends	Conduct research, research competitors, compare features and pricing	Make a purchase	Receive product/service, contact customer service, read product/service documentation	Make another purchase, share experience
TOUCHPOINTS	Traditional media, social media, word of mouth	Word of mouth, website, social media	Website, mobile app, phone	Phone, chatbot, email	Word of mouth, social media, review sites
CUSTOMER EXPERIENCE	Interested, hesitant	Curious, excited	Excited	Frustrated	Satisfied, excited
KPIS	Number of people reached	New website visitors	Conversion rate, online sales	Product reviews, customer service success rate, waiting time	Retention rate, customer satisfaction score
BUSINESS GOALS	Increase awareness, interest	Increase website visitors	Increase conversion rate, online sales	Increase customer service satisfaction, minimize wait time	Generate positive reviews, increase retention rate
TEAM(S) INVOLVED	Marketing, communications	Marketing, communications, sales	Online development, sales, marketing, customer service	Customer service, customer success	Online development, customer service, customer success

ICONS: IIIERLOK_XOLMS/ADOBE STOCK

Major Use Cases and Priorities

Use Case 12 - **Customer Quality of Service and Customer Experience (Continued)**

Buckets 2 and 4

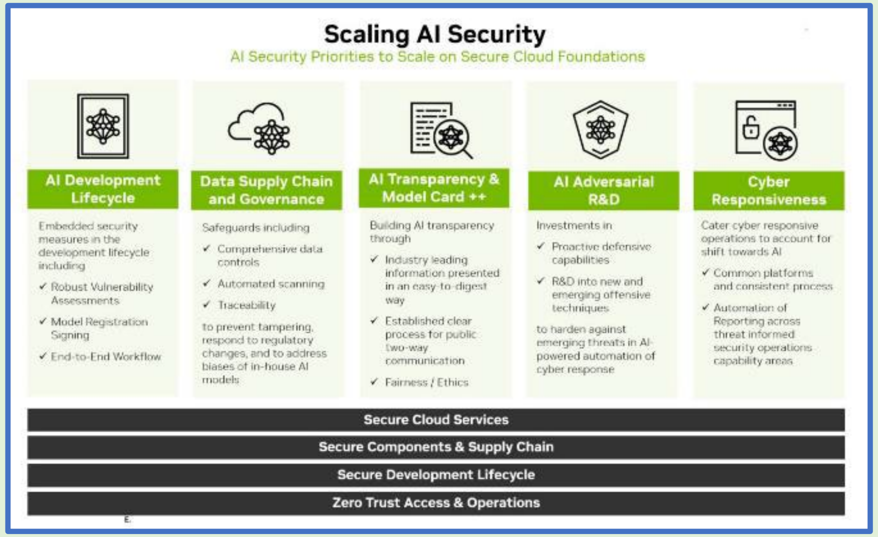
Source: https://aiforgood.itu.int/event/ai-ml-challenge-finale-qos-prediction-network-traffic-scenario-prediction-sdn-security / - AI for Good
Source: https://storage.qsan.com/blog/quality-of-service-qos-in-5g-ai/ - Qsan
Source: https://www.researchgate.net/publication/349859376_Artificial_Intelligence_Empowered_QoS-Oriented_Network_Association_for_Next-Generation_Mobile_Networks – Article - Artificial Intelligence Empowered QoS-Oriented Network Association for Next-Generation Mobile Networks
Source: https://www.sciencedirect.com/science/article/abs/pii/S0167739X18320314 - Artificial Intelligence based QoS optimization for multimedia communication in IoV systems.
Source: https://www.vastdata.com/blog/introducing-qos-per-user-a-finer-level-granularity-in-vast-5-0 - Vast

Infrastructure and Other Considerations for AI/ML

Infrastructure and Other Considerations for AI/ML

1. Trust that AI/ML applications are Safe, Secure, and Effective

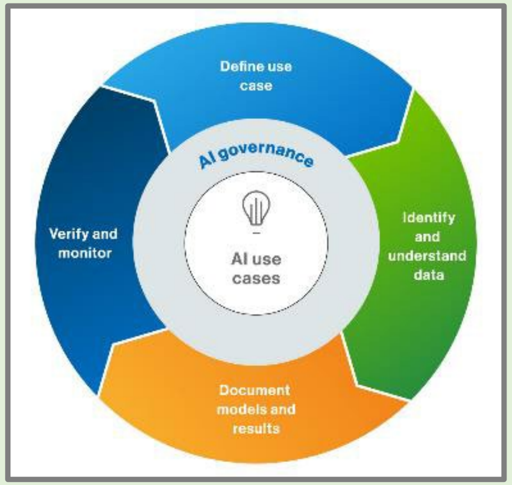
   ➢ Governance Regimes in Place, Performance Metrics Established, Guardrails Understood and Implemented, Testing Methodologies Vetted , Standards for Interoperability Adopted, and Certification Organizations in Place.

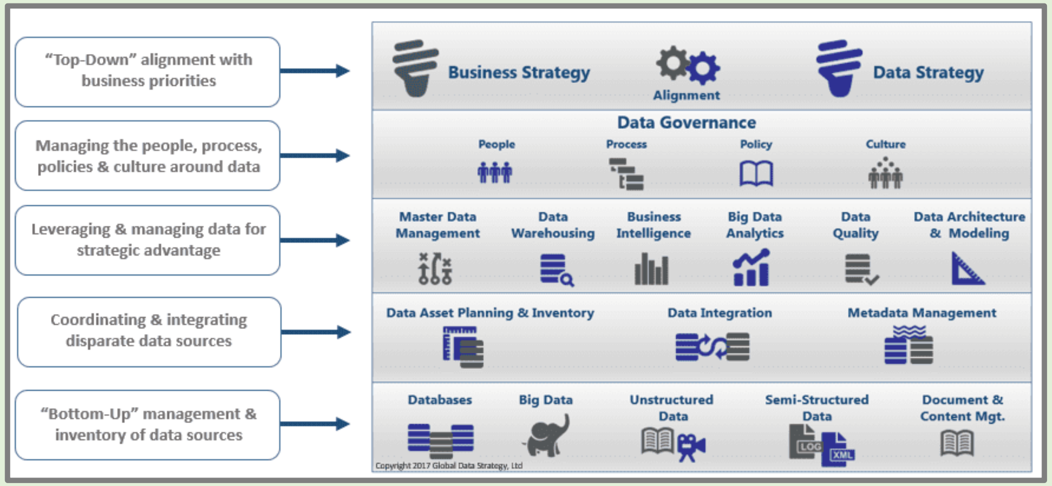


Infrastructure and Other Considerations for AI/ML

2. Relevant Data fit for purpose: This is at the heart of AI/ML

- ➢ Objectives agreed on, solution architecture identified (common sense balance of AI/ML and other methods as needed to buildout AI/ML Models), tractability established, data requirements identified across applications, access to open and proprietary data sources secured, collection of "owned" data (initial and ongoing) implemented. Mechanisms for iteration of Objectives and Data Requirements driven by Experience and Solution Results in place.

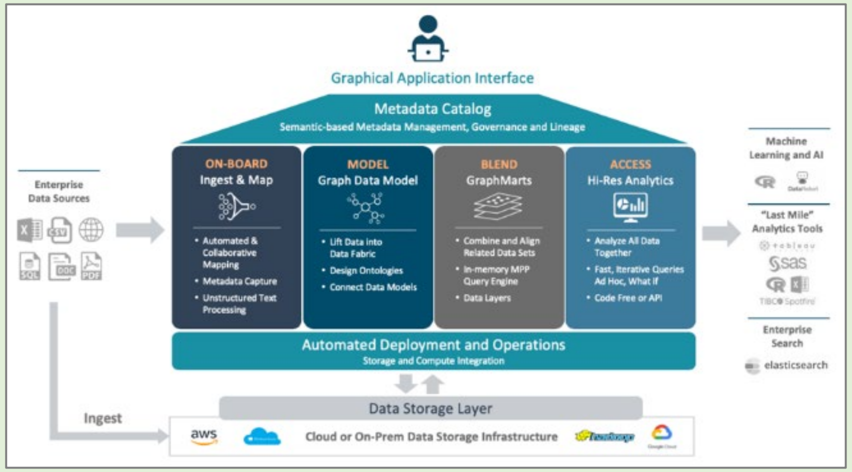


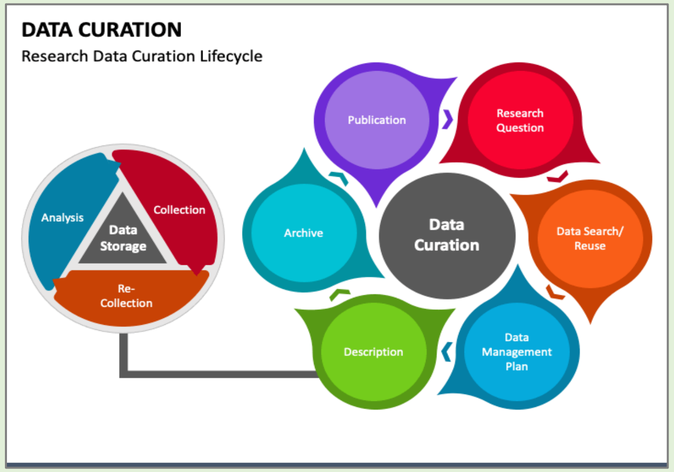


Infrastructure and Other Considerations for AI/ML

3. Data Curation, Management, and Storage

- Data Governance and Oversight in Place; Policies for Data Acquisition, Provenance, Access, Maintenance, Distribution, Refresh, and Retention developed; Management framework for Data Systems and Libraries acquired/developed; Data specialists on board, organization personnel trained; Processes, Facilities, and Devices for Data Storage deployed/contracted,

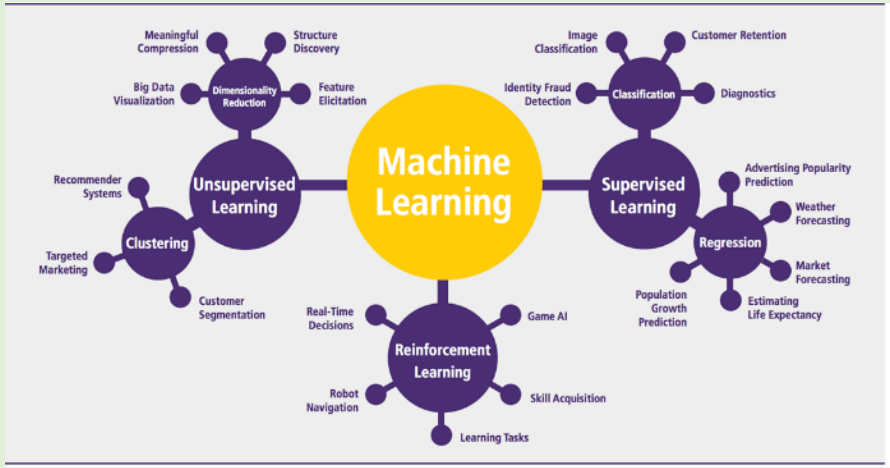


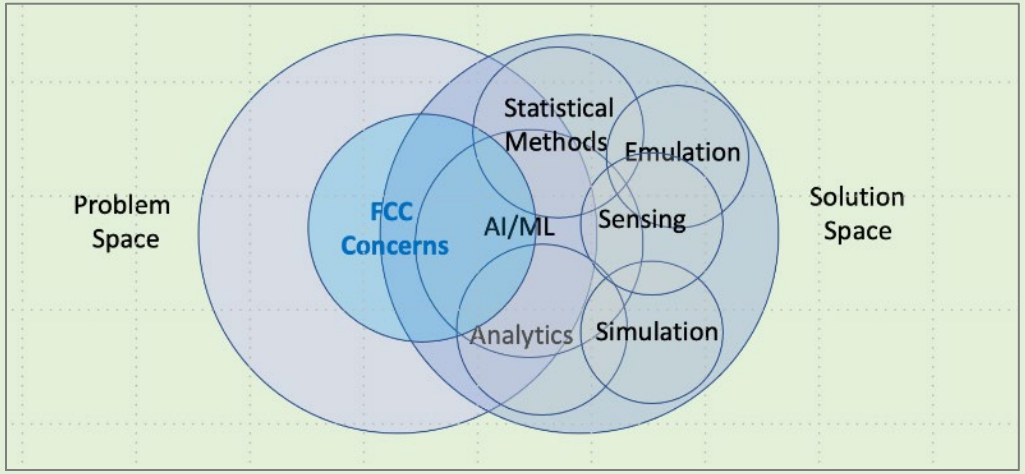


Infrastructure and Other Considerations for AI/ML

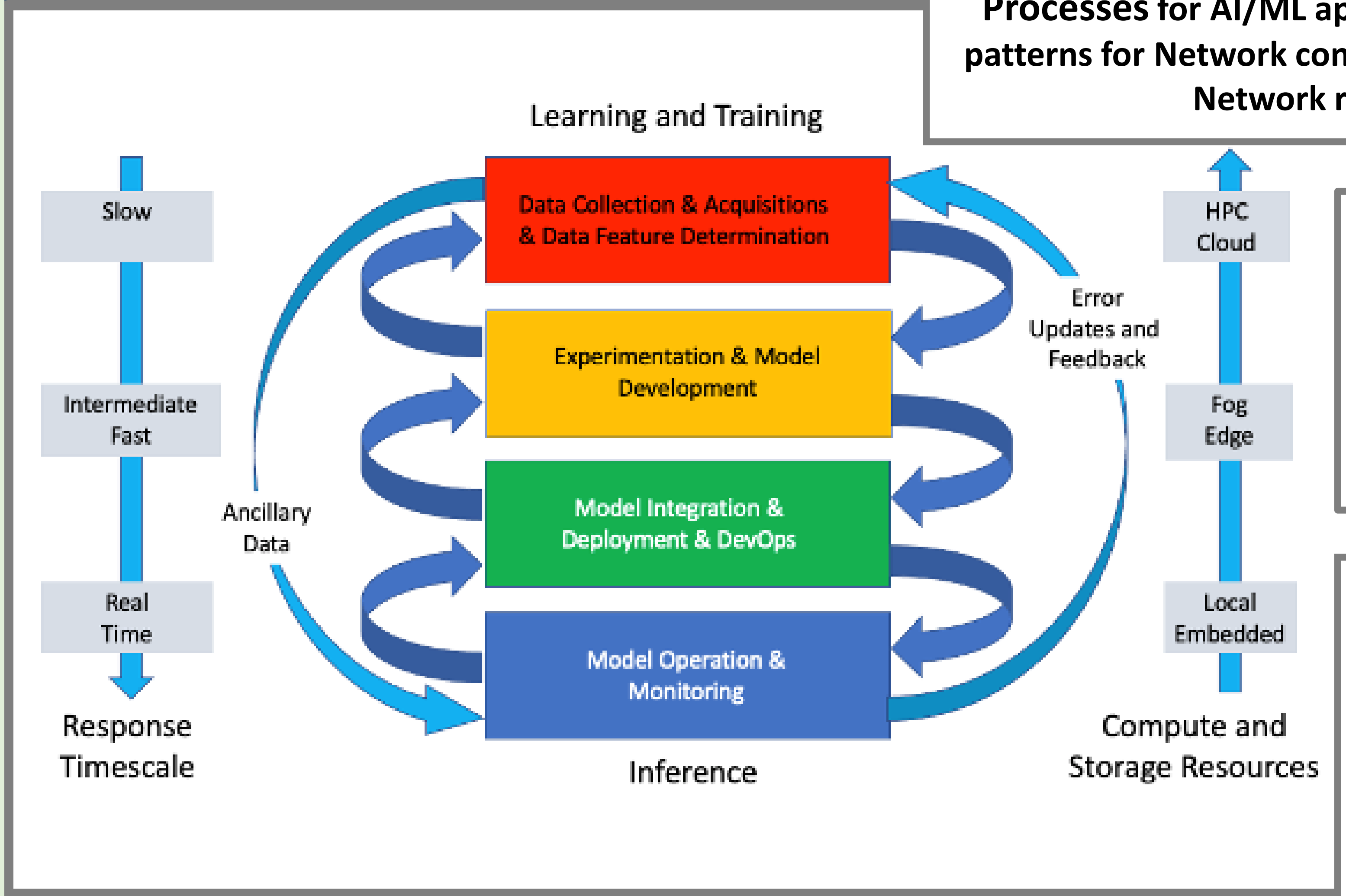
4. AI/ML Models (including accompanying software applications)

- Define Objectives, Examine problem space and solution space (Including AI/ML based approaches, statistical methods, analysis techniques, data sources, etc, Synthesize Solution, Gather Data, Develop Model, Test, Iterate, and Fine Tune.





Infrastructure and Other Considerations for AI/ML From 2020 AIWG Presentation



Processes for AI/ML applications create new patterns for Network connectivity and access to Network resource

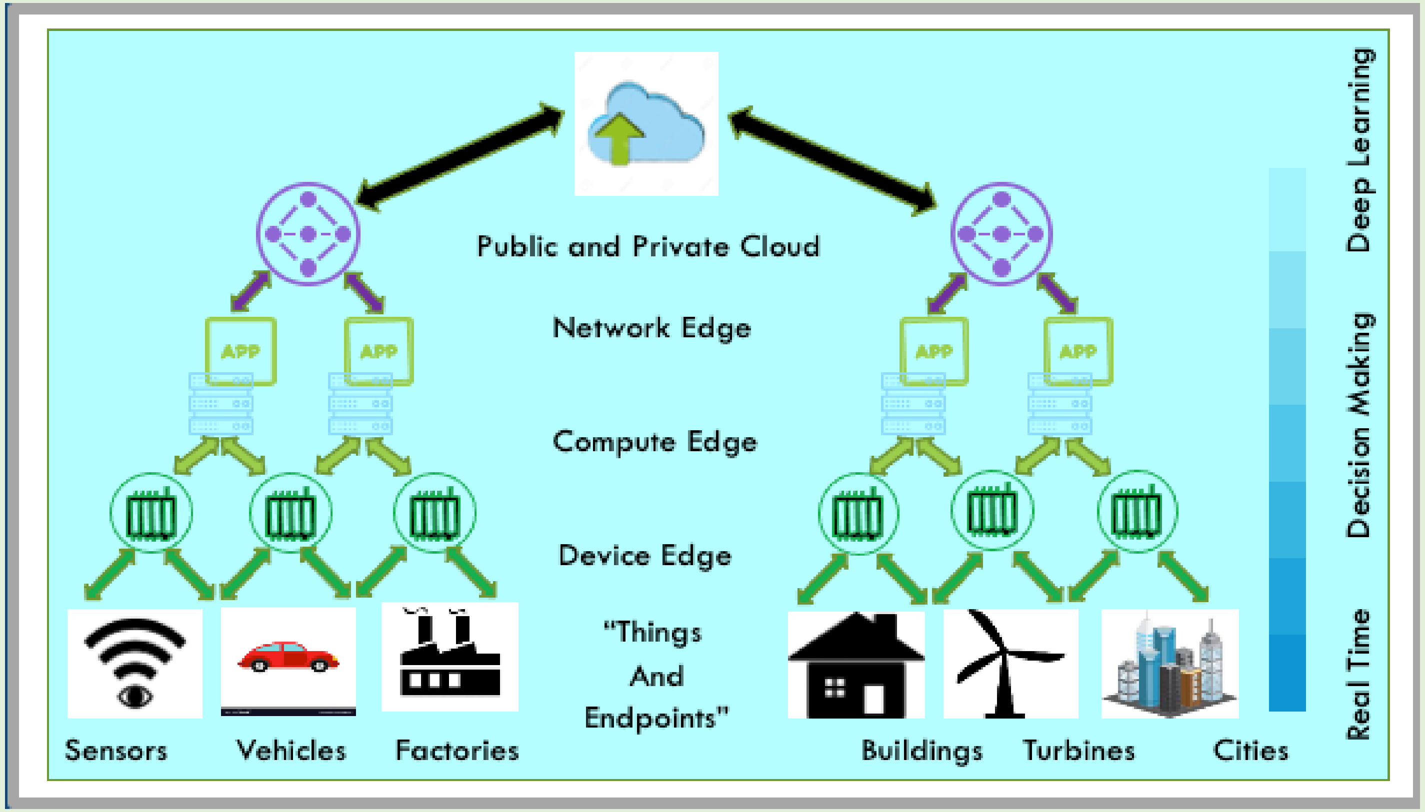
Typical AI/ML Application Cycle and requirements for Connectivity

Complex flows and connectivity patterns across logical, spatial and temporal dimensions

Infrastructure and Other Considerations for AI/ML

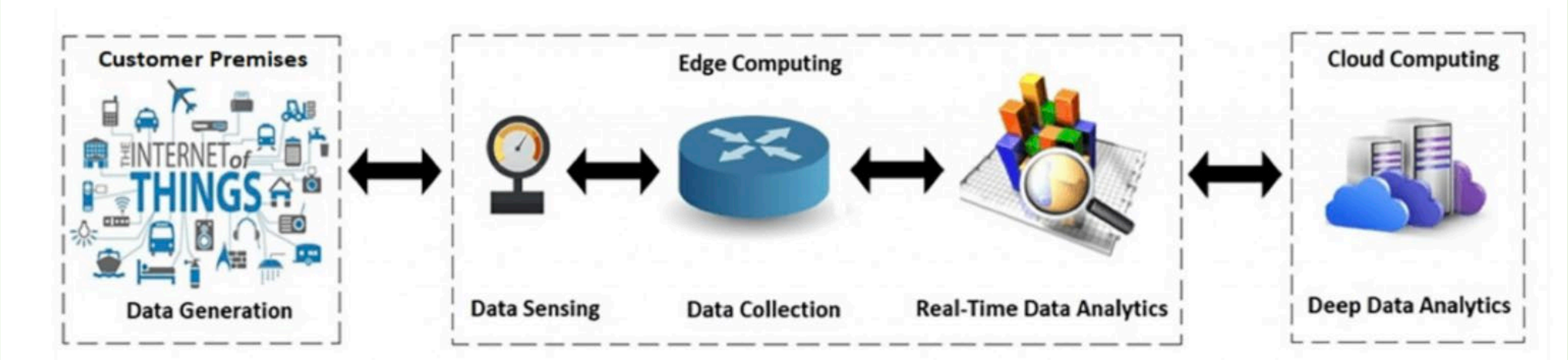
5. Computing Facilities and Devices

The intertwining of Communications, Computing, and Storage Technologies



Infrastructure and Other Considerations for AI/ML

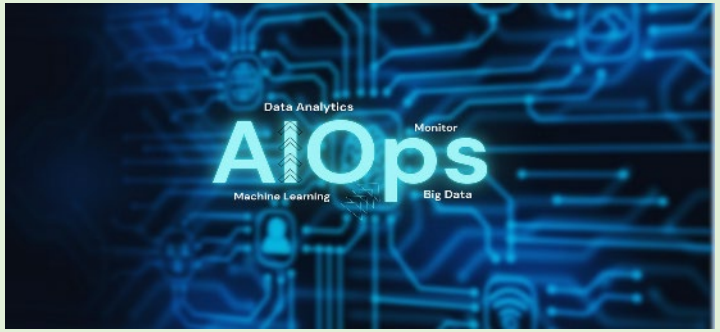
6. Connectivity and Access

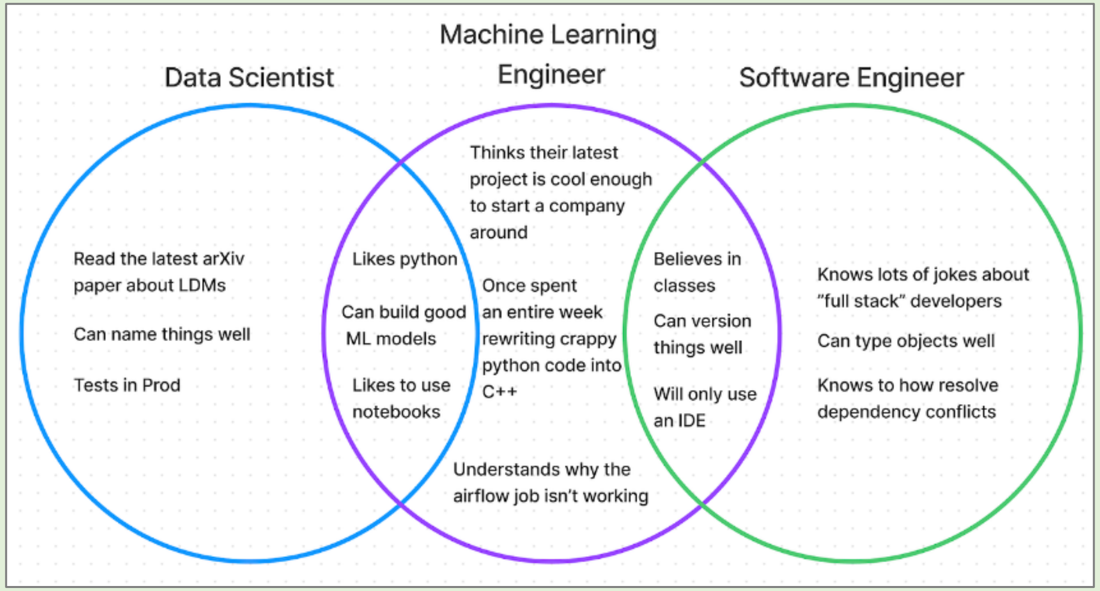


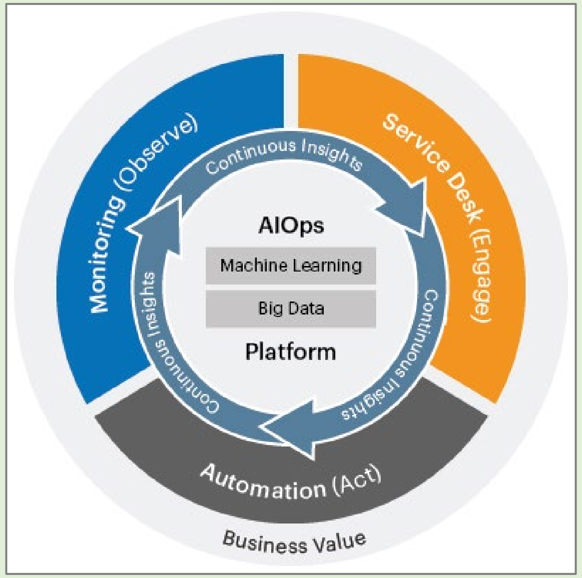
Source: https://www.cablelabs.com/blog/moving-beyond-cloud-computing-to-edge-computing

Infrastructure and Other Considerations for AI/ML

7. AI Operations

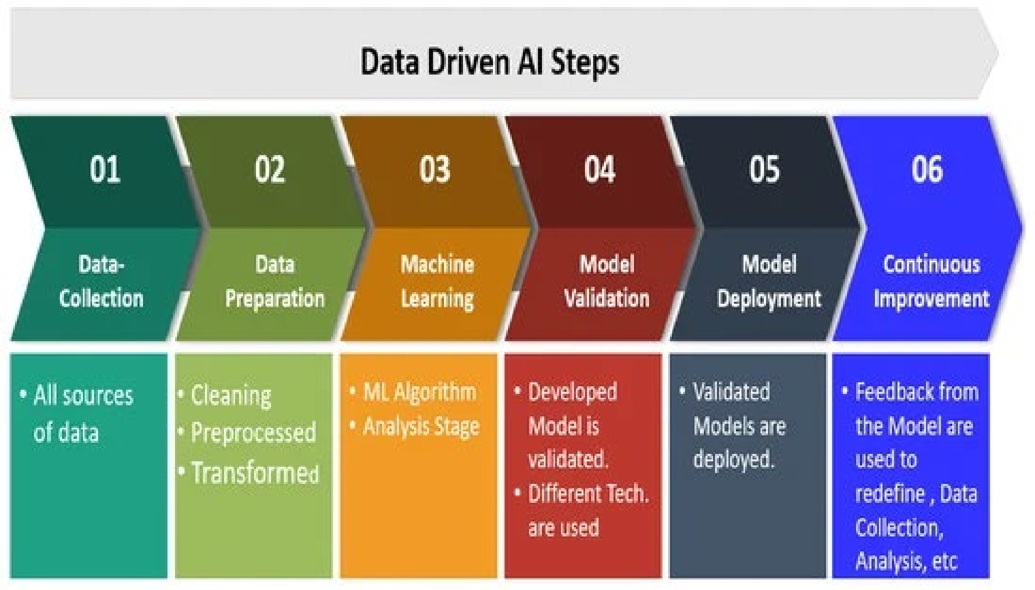






Infrastructure and Other Considerations for AI/ML

8. Special Facilities, Testbeds, and Instrumentation



Deliverables

Recommendations – Short Presentation Format

Issues Addressed

1. Spectrum Sharing and Management
2. Safety, Security, Assurance, and Performance
3. Testing Regimes for Telecommunications
4. Softwarization of Telecommunications

Considerations

1. The FCC's Strategic Priorities
2. Industry Trends
3. Technology Maturity
4. Timeliness
5. Impact

The FCC
Service Providers
Consumers
Industry
The Public Sector

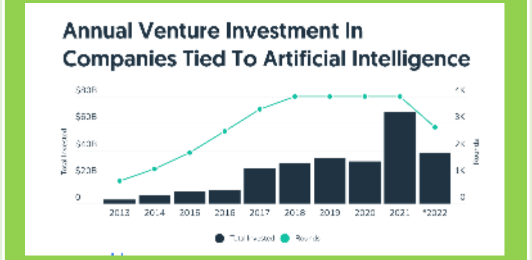
Inputs

1. AIWG SME Discussions
2. External Presentations
3. Supporting Documents
4. FCC Liaisons

Strategic Priorities

1. "100 Percent Broadband"
2. Empower Consumers
3. Advance US Global Competitiveness
4. Public Safety and National Security
5. Foster Operational Excellence
6. Diversity and Inclusion

Industry & Federal Trends



Nature of Recommendations

In Process

In closing - Deliverables

Bucket	Output	Format	
WG-Bucket1	1. Recommendations	Short Presentation	
(1.1-1.2)	2. Summary Brief	In Depth Presentation	
	3. White Paper	Summary Findings and Rationale	2025
WG-Bucket 2	1. Recommendations	Short Presentation	
(2.1-2.3)	2. Summary Brief	In Depth Presentation	
SWG-Bucket 3	1. Recommendations	Short Presentation	
(3.1)	2. Summary Brief	In Depth Presentation	
	3. White Paper	Summary Findings and Rationale	2025
SWG-Bucket 4	1. Recommendations	Short Presentation	
(4.1-4.4)	2. Summary Brief	In Depth Presentation	

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Scheduled and Prospective Speakers

Speaker	Talk Title	Date		
Andy Clegg	Propagation Challenges	May 1st		
Parul Kapur	AI and ML Status of Legislation and Regulations	May 22nd		
Aniket Bera Purdue	Details of AI Model Building - LLMs	June 5th	Tim, Tian George Mason	
Etienne Chaponniere	Regulations and Legislation (EU, US, etc)	June 12th	Jack Nasielski Qualcomm	
Tim O'Shea Deepsig.AI	AI and ML – Understanding what's in the Spectrum	June 19th		
Rajesh Gadiyar Nvidia	AI/ML Digital Twins for Telcos	June 26th	Bejoy Mavenir	

Speaker	Talk Title	Date		
Michele Polese Northeastern	AI/ML in Radio Access Networks	July		
Alex Jinsung Choi O-RAN Alliance and DT	O-RAN Alliance AI/ML WG Plans and Progress	July		

Andrew M. Clegg

CTO, Wireless Innovation Forum, and Spectrum Engineering Lead at Google

Background: Andrew Clegg is Spectrum Engineering Lead for Google, where he was one of the principal architects of the CBRS band. He also serves as the Chief Technical Officer for the Wireless Innovation Forum (WInnForum). He represents WInnForum on the FCC Technological Advisory Council where he Co-Chairs the Spectrum Sharing Working Group - SSWG.

Talk Title: What could we learn using AI/ML if we had access to (obfuscated) CBRS deployment data?

Abstract: This talk will describe the CBRS deployment data that are shared among Spectrum Access Systems each evening, from which aggregate interference calculations and other tasks are performed. The interchange specification is in Wireless Innovation Forum Technical Standard TS-0096. FCC rules prohibit the release of data about specific CBSDs (96.55(a)(3)), and permission from the SASs would need to be obtained to access even obfuscated data. A manner will be proposed to obfuscate the data (and additional proposals would be welcome), and then the question will be asked to the group if there is something to be learned by applying AI/ML techniques to the resulting dataset, if such a dataset were available.

linkedin.com/in/andrew-clegg-32935a2

Parul (Paula) Kapur

Founder Kap Ocean LLC

Background: Parul (Paula) Kapur is a Founder of Kap Ocean LLC, an Artificial Intelligence and Innovation consulting firm. Her focus is on Artificial Intelligence, Innovation and Partnership initiatives. Paula has expertise in Strategy, Policy, Ethics, Responsibility, Risk and much more. She focuses on Telecommunications, Medical, and Software technologies. Paula is also an Intellectual Property and Patent Attorney. She has a JD, a MS in Electrical Engineering and a BS in Biomedical Engineering. Moreover, Paula has been a Speaker and Panelist in various Artificial Intelligence, Innovation and Patents activities.

Talk Title: "Legislation, Regulations and Policies Related to Artificial Intelligence and Telecommunications."

Abstract: The presentation will focus on the current status of Legislation, Regulations and Policies related to the use of Artificial Intelligence and Machine Learning, generally applied to Telecommunications. In particular, discussion areas will include Executive Order No. 14410; National Telecommunications and Information Administration; Federal Communications Commission; Federal Trade Commission; European Union Artificial Intelligence Act; Intellectual Property & Artificial Intelligence; and State Legislation & Regulation. Moreover, topics such as robocalls, robotexts and deepfakes will be included in the presentation.

https://www.linkedin.com/in/parulkapur/
https://kapocean.com/index.html

Aniket Bera

Purdue University

Background: Dr. Aniket Bera is an Associate Professor at the Department of Computer Science at Purdue University. He directs the interdisciplinary research lab IDEAS (Intelligent Design for Empathetic and Augmented Systems) at Purdue, working on modeling the "human" and "social" aspects using AI in Robotics, Graphics, and Vision. He is also an Adjunct Associate Professor at the University of Maryland at College Park. He received his Ph.D. in 2017 from the University of North Carolina at Chapel Hill. He is also the founder of Project Dost. He is currently serving as the Senior Editor for IEEE Robotics and Automation Letters (RA-L) in the area of "Planning and Simulation" and the Conference Chair for the ACM SIGGRAPH Conference on Motion, Interaction and Games (MIG 2022). His core research interests are in using Machine Learning models for understanding human behaviors using multi-modalities, Augmented Intelligence, Multi-Agent Simulation, Social Robotics, Autonomous Agents, Cognitive modeling, and planning for intelligent characters.

Talk Title: “Building the Future with Machine Learning and Foundation Models: A Practical Guide.”

Abstract Follows

https://www.linkedin.com/in/abera/
https://www.cs.purdue.edu/homes/ab/

Aniket Bera

Purdue University

Continued

Abstract: Machine learning (ML) and foundation models are at the forefront of technological innovation, driving significant advancements across various industries. This talk offers an introductory guide to understanding these powerful tools. We will explore the essential principles of machine learning, including supervised, unsupervised, and reinforcement learning, providing a solid foundation for understanding how ML models are developed and optimized. The discussion will then shift to foundation models, highlighting their architecture, capabilities, and transformative potential in areas such as natural language processing, computer vision, and more.

Real-world examples and practical applications will be showcased to illustrate how ML and foundation models are being utilized in telecommunications, customer service, and content creation, among other fields. These examples will demonstrate the tangible benefits and challenges of integrating these technologies into existing systems. By the end of this session, attendees will have gained a deeper understanding of the foundational concepts of ML and foundation models, as well as practical insights into their application in modern industries. This talk aims to equip industry leaders with the knowledge and tools necessary to leverage these technologies effectively, fostering innovation and building the future.

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Etienne Chaponniere
Vice President
Technical Standards

Qualcomm

Background: Telecommunication professional with 25 years' experience in the cellular industry in ASIC design, System Engineering in 3G & 4G, technical standardization leadership, technical standards group chairmanship and board representation; Etienne Chaponniere, VP of Technical Standards, currently leads Qualcomm's standardization efforts in Artificial Intelligence, Security and regional standards worldwide. Etienne holds a Masters in Télécommunication from the École Polytechnique Fédérale de Lausanne (Switzerland)

Talk Title: "Regulatory and Legislative Landscape for AI/ML in Telecommunications."

https://www.linkedin.com/in/etienne-chaponniere-34203836/

Tim O’Shea
CTO at DeepSig

and

Research Assoc. Professor
Virginia Tech University

DeepSig

Background: Tim O’Shea is a Research Assistant Professor at Virginia Tech and the CTO and Co-Founder at DeepSig Inc in Arlington, VA. He is focused on leveraging machine learning and data-driven approaches within the wireless physical layer to help improve baseband processing spectral efficiency, energy efficiency, and environmental awareness and automation in 5G, 5G Advanced, and 6G. His research focuses also include AI/ML applications in cryptocurrency, cybersecurity, generative applications, and other interesting emerging verticals.

He has run numerous applied R&D efforts for DARPA, NSF, DOD, IARPA, EU HORIZON-2020, Industry, and others. Previously he worked with wireless startups Hawkeye 360 and Federated Wireless in seed stage and held engineering R&D positions with both the US DOD and with Cisco Systems. He is the author of over 100 academic works and patents in this area and is involved in IEEE ComSoc, IEEE MLC ETI, Next-G Alliance, and OpenRAN Alliance, OpenRAN Policy Institute, the GNU Radio project and other efforts to accelerate AI driven communications system technology and its adoption within next generation RAN systems.

Talk Title: “AI/ML for Understanding Spectrum Usage.”

https://www.linkedin.com/in/osheatim/
https://nationalsecurity.vt.edu/personnel-directory/oshea-tim0.html

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Rajesh Gadiyar

VP of Engineering
for Telco and Edge

NVIDIA

Background: Rajesh Gadiyar is the VP of Engineering for Telco and Edge at Nvidia. He is building technologies for virtualized 5G Radio Access Network (RAN) in the cloud. A key area of focus for him is the intersection of Artificial Intelligence (AI), Cloud Technologies and 5G/6G Networks. He works with communications service providers (CoSPs) to modernize their networks. Before joining Nvidia in 2022, Rajesh was the Vice President and Chief Technology Officer (CTO) for the Network Platforms Group at Intel. He led the architecture and product development efforts to accelerate cloud native network applications in 5G infrastructure, edge clouds, video processing and AI in Networking and delivered many generations of network server platforms. Prior to joining Intel, he led various engineering teams at Trillium Digital Systems and Wipro Ltd. Rajesh brings several years of experience in networking products, architecture, standards, and software development for Voice over IP, cellular, broadband, mobile telephony, and data networks. Rajesh has a B.S. in Electronics and Telecommunications engineering from National Institute of Technology, Trichy, India, and an MBA from UCLA Anderson School of Management. He is a regular speaker at industry events and conferences

Talk Title: "Digital Twin for 6G Networks."

Abstract Follows

https://www.linkedin.com/in/osheatim/
https://nationalsecurity.vt.edu/personnel-directory/oshea-tim0.html

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Continued

Abstract: Digital Twins are becoming increasingly popular in many industry verticals. Digital twins offer up data and insights that can significantly improve the way their real-world versions operate. There is a real opportunity to create Digital Twins of next generation wireless networks that can foster research and rapid innovations in new algorithms to improve spectral efficiency, network capacity planning for operators, and rapidly debugging complex network issues. Nvidia has developed Aerial Omniverse Digital Twin – a site-specific, large-scale, and highly accurate platform for system level simulation of 5G, 5G adv and 6G radio networks. Our goal is to foster rapid innovations in 1) Tackling the design of the 6G air interface 2) Studying the effect of AI on the data and control plane of 5G/6G cellular networks and enabling cost-effective open RAN infrastructure. In this presentation, we will discuss the key goals and attributes of a network digital twin, present Aerial Omniverse Digital Twin as a possible solution, and discuss how the community can collaborate with Nvidia to drive innovations in this critical area.

Rajesh Gadiyar

VP of Engineering
for Telco and Edge

NVIDIA

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Alex Jinsung Choi

SVP Head of T-Labs
Deutsche Telekom

and

Chair of O-RAN Alliance

Background: Dr. Alex Jinsung Choi is SVP of Strategy and Technology Innovation (STI) of Deutsche Telekom with responsibility for the Network Differentiation strategy to transform Deutsche Telekom's infrastructure to an open, distributed and cloud-native architecture with an automated production model. Dr. Choi is also Chief Operating Officer of the O-RAN Alliance. Dr. Choi has more than 20 years of experience in the mobile telecommunication industry & consumer electronics and has been thought leader driving forward key strategic and research topic in TelCo and AI. Dr. Choi was the first Chairman of the Telecom Infra Project (TIP) and previously served as CTO for SK Telekom. With the introduction of "NUGU", the first AI-based virtual assistant in Korea, Dr. Choi was influential in the development of AI solutions.

Talk Title: "O-RAN and AI/ML for Telecommunications."

https://www.linkedin.com/in/jinsung-choi-48a8b61/
https://www.o-ran.org/blog/o-ran-alliance-announces-its-new-chairman-of-the-board-and-new-coo
https://www.telekom.com/en/blog/515926-515926

Michele Polese

Assistant Research Professor
Electrical and Computer Engineering

Northeastern University

Background: Michele Polese is a Principal Research Scientist at Northeastern University, Boston, since March 2020, working with Tommaso Melodia. He received his Ph.D. at the Department of Information Engineering of the University of Padova in 2020 under the supervision of with Michele Zorzi. He also was an adjunct professor and postdoctoral researcher in 2019/2020 at the University of Padova. During his Ph.D., he visited New York University (NYU), AT&T Labs in Bedminster, NJ, and Northeastern University, Boston, MA. He collaborated with several academic and industrial research partners, including Intel, InterDigital, NYU, AT&T Labs, University of Aalborg, King's College and NIST.
He was awarded with the Best Journal Paper Award of the IEEE ComSoc Technical Committee on Communications Systems Integration and Modeling (CSIM) 2019, the Outstanding Young Researcher Award 2019 from the IEEE ComSoc EMEA Region, the Best Paper Award at WNS3 2019 and 2020, and the IEEE MedComNet Mario Gerla Best Paper Award 2020. His research interests are in the analysis and development of protocols and architectures for future generations of cellular networks (5G and beyond), in particular for millimeter-wave communication, Open RAN, and in the performance evaluation of complex networks.

Talk Title: "AI/ML for Open Radio Access Networks."

https://www.linkedin.com/in/michelepolese/
https://coe.northeastern.edu/people/polese-michele/

Thank You

FCC Technological Advisory Council Agenda – June 21, 2024

10:00am – 10:15am	Opening Remarks
10:15am – 10:25am	Records Management Overview
10:25am – 11:05am	Advanced Spectrum Sharing WG Presentation
11:05am – 11:45am	AI/ML WG Presentation
11:45am – 12:25pm	6G WG Presentation
12:25pm – 12:30pm	Closing Remarks
12:30pm	Adjourned

FCC TAC
6G WG

Chairs: Brian Daly (AT&T)
Manu Gosain (Northeastern University)

FCC Liaison: Martin Doczkat

Date: June 21, 2024

2024 6G Working Group Team Members

Bayliss, Mark	Visual Link Internet		**Young, David**	ATIS
Bhatt, Tejas	Marvell			
Brenner, Dean	Special Government Employee		**Daly, Brian**	AT&T
Cataletto, Michael	Scientel Solutions		**Gosain, Manu**	Northeastern University
Chakraborty, Tusher	Microsoft			
Clegg, Andrew	Wireless Innovation Forum		**Acacio, Robert**	FCC
Ditchfield, Skyler	GeoLinks		**Davis, Michael**	FCC
Drobot, Adam	Stealth Software Technologies		**Doczkat, Martin**	FCC
Gammel, Peter	Ubilite		**Etemad, Kamrad**	FCC
Ghosh, Monisha	Notre Dame		**Ha, Michael**	FCC
Guess, Lisa	Ericsson North America		**Lu, Jonathan**	FCC
Gupta, Sachin	NRECA		**Mathur, Rajat**	FCC
Laskowsky, Mike	United Telecom		**Pavon, Barbara**	FCC
Lapin, Greg	ARRL		**Repasi, Ronald**	FCC
Mansergh, Dan	Apple		**Young, Janet**	FCC
Merrill, Lynn	NTCA		**Yun, Sean**	FCC
Mukhopadhyay, Amit	Nokia			
Nasielski, Jack	Qualcomm			
Nicols, Roger	Keysight Technologies			
Sung, LiChing	NTIA			
Tehrani, Ardavan	Samsung			
Thakker, Rikin	NCTA			
Thompson, Michelle	Open Research Institute			

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6G WG Charter (1)

- Provide information on the development and deployment of 6G technology, make recommendations and provide insights on new developments and expectations from technological and regulatory perspectives that FCC should pay attention to.

- How do openness and customization capabilities in 6G benefit supporting flexibility and agile services and its coexistence with 5G?

- What are the infrastructure needs for 6G, and how can the FCC proactively address them?

- How is 6G progressing or expected to progress at standards and international fora? What are the key points of emerging consensus or disagreement?

- What are competing 6G visions and expectations on key technological points between operators to compare and contrast?

6G WG Charter (2)

- What is the status of small satellite development, what frequency bands are under consideration for non-terrestrial network (NTN) use, and what services are envisioned?

- What are the opportunities for using mmW/terahertz bands for 6G systems?

- How is 6G technology envisioned to enhance or be utilized in various verticals, including autonomous driving, augmented and virtual reality, edge computing, emergency alerting, and smart cities?

- What advancements in localization and positioning will 6G need for network optimization of beam steering antennas and metasurfaces?

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6G WG Charter (3)

- What are the potential privacy and security risks that 6G networks will need to address regarding massive data collection and processing, as well as the ethical and social impacts of emerging applications such as brain-computer interfaces and holographic communications?

- How does 6G ensure the security and privacy of users' data and identity in various scenarios, such as distributed ledger technologies, physical layer security, distributed AI/ML, visible light communication (VLC), THz bands, and quantum communication?

- How will 5G/6G networks support massive volume of mobile and IoT and XR devices with low-latency and seamless connectivity for near- and non-real time, trending toward real-time applications?

Standardization, Development and Use Case(s) towards 6G

- WG received an update on the first 3GPP SA1 6G Use Case Workshop held in May [1]
- Workshop objective was to bring 3GPP closer to the ongoing initiatives of various global/regional research organizations and MRPs related to the 6G use cases.
  - This collaborative effort is of utmost importance as SA1 undertakes the task of defining the requirements and use cases for 6G starting from Rel-20.
  - >200 participates plus almost 400 remotely
- Invited workshop presenters included: GSMA, NGMN, 5GAA (automotive), 5G-ACIA (industrial), 5GMAG (multimedia), Satellite (GSOA), TCCA (public safety), Wireless Broadband alliance, B5GPC (Japan), 6G forum (South Korea), IMT2030 Promotion Group (China), Bharat 6G alliance (India) ATIS Next G alliance (North America), and 6G-SNS (Europe).
- <u>No priority or ranking of the 6G use cases</u> discussed during the 3GPP Stage-1 workshop on IMT2030 use cases

[1] https://www.3gpp.org/technologies/stage1-imt2030-uc-ws

Some Potential Drivers for 6G:

Some Potential Drivers for 6G: A table view

	Security	AI	Immersive Com	Sustainability, Energy Efficiency	Ubiquitous and resilient coverage	Sensing	"Smart life"	Native Vo6G	FWA-FWC	LPWA	Northbound API	Healthcare	Autonomous Driving	Positionning	Backward Compatibility
GSMA	✓	✓	✓	✓				✓							
NGMN	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓
5GAA	✓	✓	✓	✓	✓	✓							✓	✓	
5G-ACIA	✓	✓	✓	✓		✓					✓				✓
5G-MAG	✓	✓	✓	✓	✓	✓	✓				✓				
GSOA	✓				✓									✓	
TCCA	✓	✓			✓										✓
WBA	✓	✓				✓									
B5GPC	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	
6GForum	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	
IMT-2030RG	✓	✓	✓	✓	✓	✓	✓							✓	
B6GA	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
NextGA	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓		✓	
6GSNS-ICE	✓	✓	✓	✓	✓	✓	✓					✓		✓	
ITU	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	

Note: Non-exhaustive list, showing the topics appearing in at least two presentations

Commonly Heard Use Cases

Security:

- Network security and user data confidentiality, maintaining continuity of service and robust security, identify all relevant new threat-factors for 6G, and develop mitigation solution (e.g. detection and protection against electromagnetic threats)
- Quantum-safe security mechanisms
- Support of Artificial Intelligence:

  Both for: Network-design/performance & Enabling AI at the application level
- Immersive Communications:

  Holographic, telepresence, Multi-sensorial communication, Digital twin
- Sustainability

  Energy efficiency/reduction of energy consumption
- Ubiquitous and resilient coverage

  Non-Terrestrial Networks, remote & underserved areas
- Sensing

  Human Activity Recognition; Localization and Tracking;

  Environmental Object Reconstruction; Monitoring Tasks

ITU's "wheel" and "palette" for IMT-2030

Three Usage Scenarios are extensions from IMT-2020 (5G):

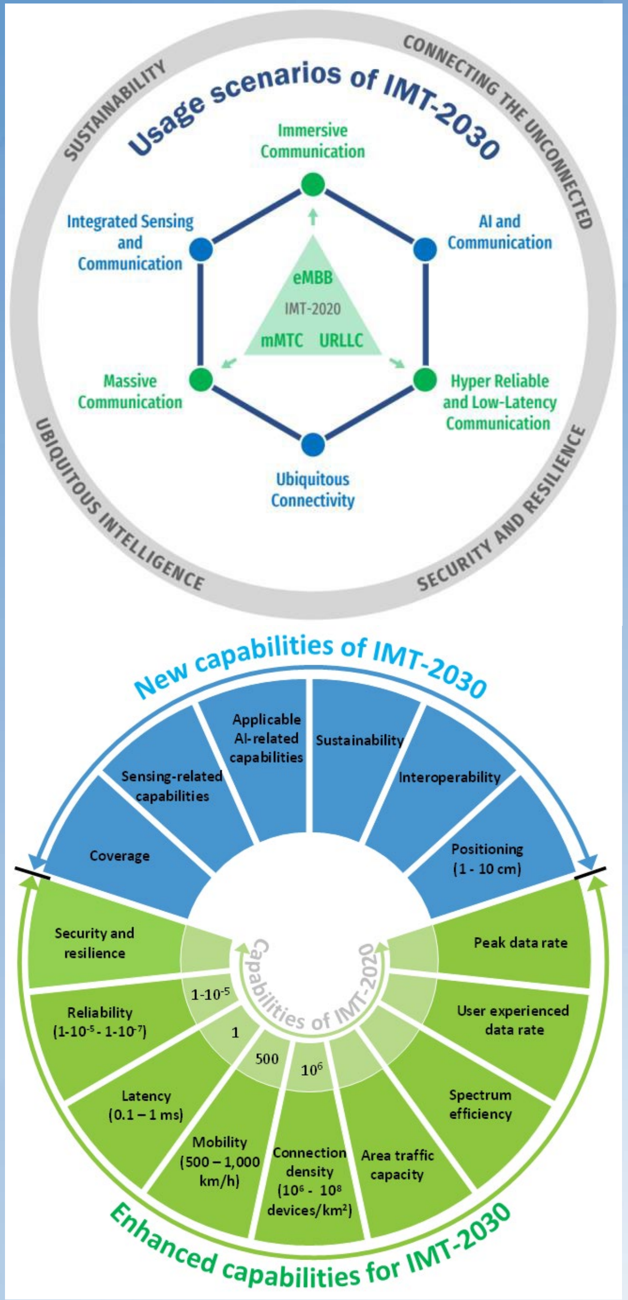
- Immersive Communication (from "eMBB")
- Massive Communication (from "mMTC")
- HRLLC (Hyper Reliable & Low-Latency Communication) (from "URLLC")

Three Usage Scenarios are new:

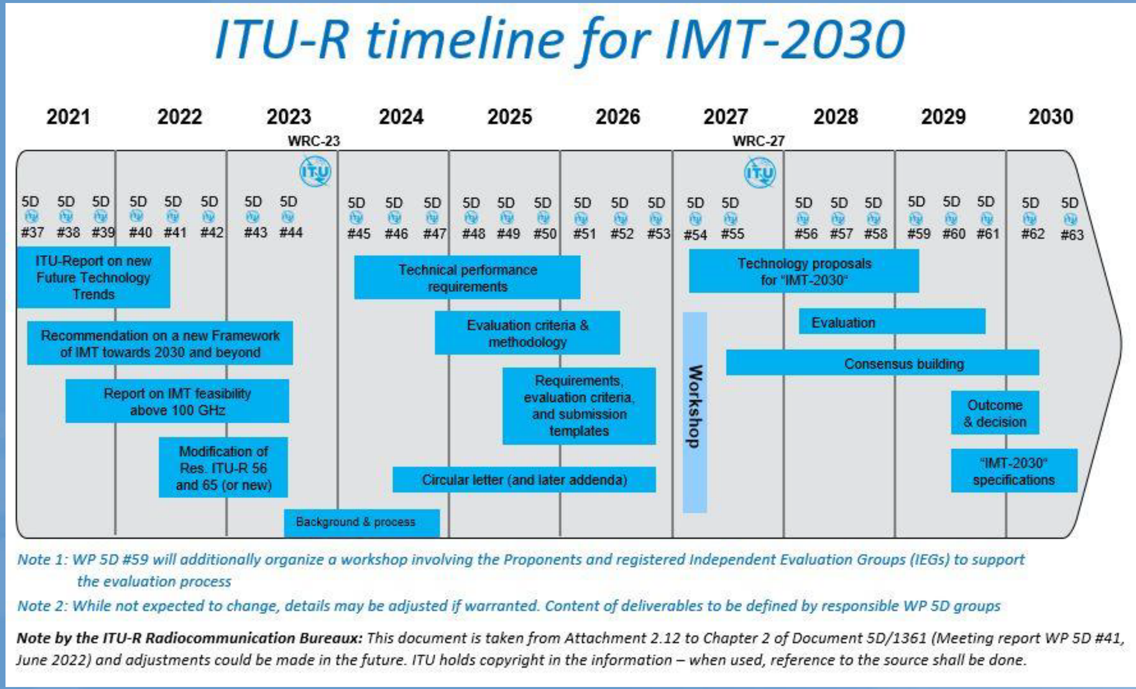
- Ubiquitous Connectivity
- AI & Communication
- Integrated Sensing & Communication

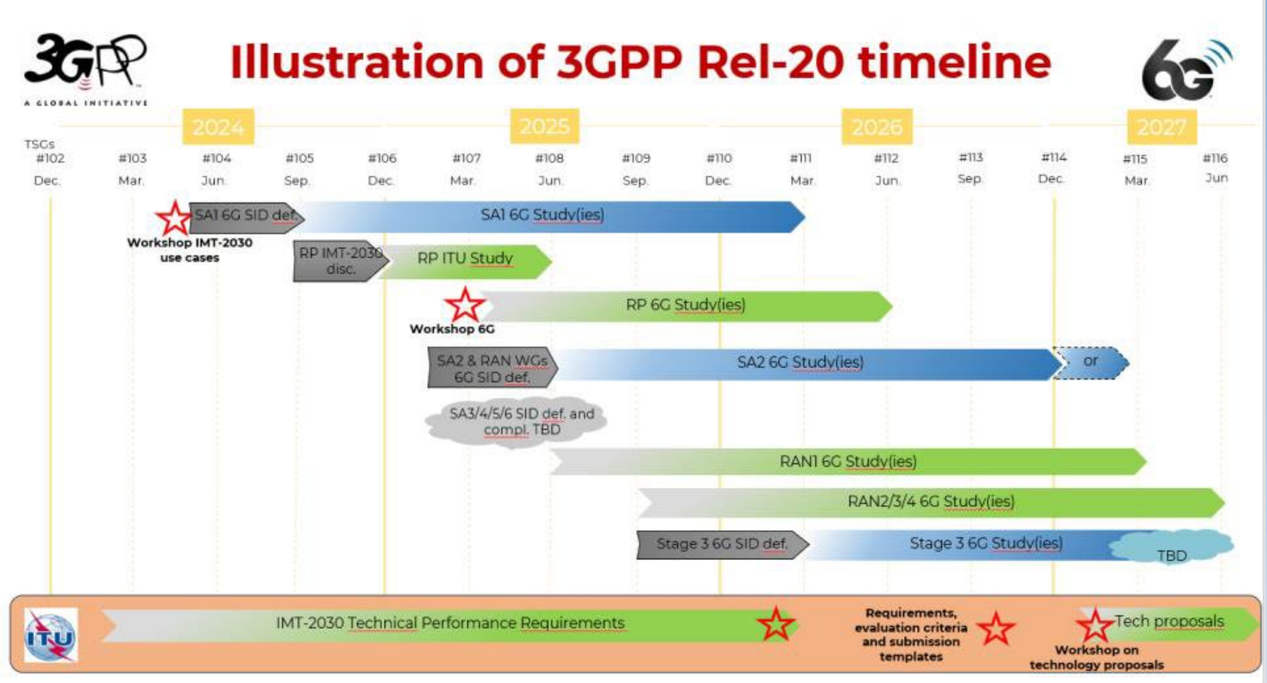
The "palette diagram": the 15 Capabilities of the IMT-2030

- Fifteen capabilities for IMT-2030, including nine derived from IMT-2020



Tentative Timelines





Next Steps in 3GPP

SA1#106 (27-31 May 2024 - Korea, Jeju) invited presentations from 3GPP Members on:

- their views on 6G Use Cases
- the study item organizational aspects: one or several study(ies) on 6G?

Approval of SA1 6G SIDs is targeted for September 2024 (TSG SA#105)

TSG wide (SA, CT, RAN) 6G Workshop is planned for Mar 10 – 11, 2025.

IEEE802 & WFA (How is 6G progressing or expected to progress at standards and international fora?)

200+ IEEE Working Groups Developing NEW Standards

IEEE 802.11 and ongoing standards development

- IEEE 802 LAN/MAN Standards Committee standard development covers both Wireless & Wired Media
- Focus on link and physical layers of the network stack
- Leverage IETF protocols for upper layers

In progress: New 802.11 Radio technologies are under development to meet expanding market needs and leverage new technologies

- P802.11be – Extremely High Throughput in 2.4, 5 and 6 GHz bands, aka Wi-Fi 7
- P802.11bf – WLAN Sensing
- P802.11bh – Randomized MAC Addresses
- P802.11bi – Enhanced Data Privacy
- P802.11bk – 320 MHz Ranging
- P802.11bn – Ultra High Reliability
- P802.11bp – Ambient Power Communication

Wi-Fi 6 & 6E

IEEE 802.11ax (Wi-Fi 6 & 6E) meets the MAC/PHY requirements for 5G IMT-2020 Indoor Hotspot and Dense urban test environments defined by ITU-R

	Metric (Indoor Hotspot)	ITU-R Evaluation Method	Minimum Requirement	802.11ax Performance
1	Peak data rate	Analytical	DL/UL : 20/10 Gbps	DL/UL : 20.78 Gbps
2	Peak spectral efficiency	Analytical	DL/UL : 30/15 bits/s/Hz	DL/UL : 58.01 bits/s/Hz
3	User experienced data rate	Analytical for single band and single layer; Simulation for multi-layer	Not applicable for Indoor Hotspot	Not applicable
4	5th percentile user spectral efficiency	Simulation	DL/UL : 0.3/0.21 bits/s/Hz	DL/UL : 0.45/0.52 bits/s/Hz
5	Average spectral efficiency	Simulation	DL/UL : 9/6.75 bits/s/Hz/TRxP	DL/UL : 9.82/13.7 bits/s/Hz/TRxP
6	Area traffic capacity	Analytical	DL : 10 Mbit/s/m^2	Required DL bandwidth = 170 MHz with 3 TRxP/site
7	Mobility	Simulation	UL : 1.5 bits/s/Hz	UL : 9.4 bits/s/Hz
8	Bandwidth	Inspection	100 MHz, scalable	20/40/80/80+80/160 MHz
9	User plane latency	Analytical	DL/UL : 4 ms	DL/UL : 80 us

P802.11be features support increased throughput and performance

Throughput and spectral efficiency

- 320 MHz bandwidth operation
- 16 Spatial Streams and 4096-QAM (Quadrature Amplitude Modulation)
- Multi-band/multi-channel aggregation and operation (MLO)
- Multiple Resource Unit Operation (MRU)
- MIMO protocol enhancements, Enhanced Sounding protocol

Low latency

- Multi-band/multi-channel aggregation and operation (MLO)
- Target Wait Time (TWT) enhancements and Restricted-TWT
- TXOP Sharing
- Stream Classification Service Enhancements
- National Security and Emergency Preparedness (NSEP) priority access operation

Enhancements re: 6 GHz support

- Static Puncturing to avoid pre-defined 20 MHz subchannels, supports efficient, higher bandwidth 6GHz operation
- GCMP-256 support (High performance cipher)

802.11be (est 2024)
Wi-Fi 7

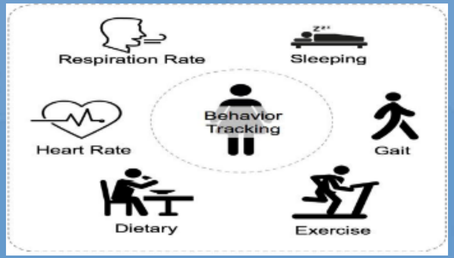
- **2.4GHz, 5GHz and 6GHz supported**
- Wider channels (40, 80, 160, 240, **320MHz**)
- Better modulation (**4096-QAM**)
- Backward compatibility with 11a/b/g/n/ac/ax
- Standard targets throughput minimum of 30Gbps, expect 40Gbps+

802.11bf WLAN sensing

WLAN sensing is the use of received WLAN signals to detect features of an intended target in a given environment.

- Measure range, velocity, angular, motion, presence or proximity
- Detect objects, people, animals: Enables touchless applications
- Use in room, house, car, enterprise environments

Target frequency bands are between 1 GHz and 7.125 GHz (MAC Service interface) and above 45 GHz (MAC/PHY)



https://www.cse.ust.hk/~qianzh/research/sensing-2.jpg

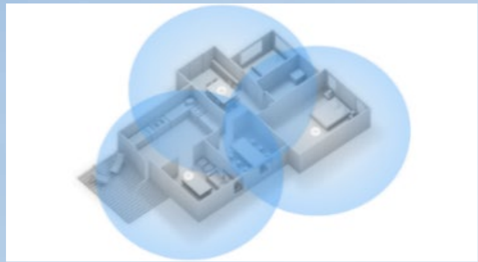
Smart home

https://www.pressebox.com/pressrelease/gb-pronova-gmbh/HoloPro-and-the-magic-of-interactive-control/boxid/129647#

Gesture recognition

http://4.bp.blogspot.com/-_krIAHPdn-8/T02hISBvOnI/AAAAAAAAA1A/jAufr2N8k4c/s1600/Kinect%2BGames.jpg

Gaming control



https://www.lastampa.it/tecnologia/news/2018/06/27/news/router-google-wifi-internet-senza-fili-in-ogni-angolo-della-casa-1.34027426

Presence and proximity detection (Home/Enterprise/Vehicle)

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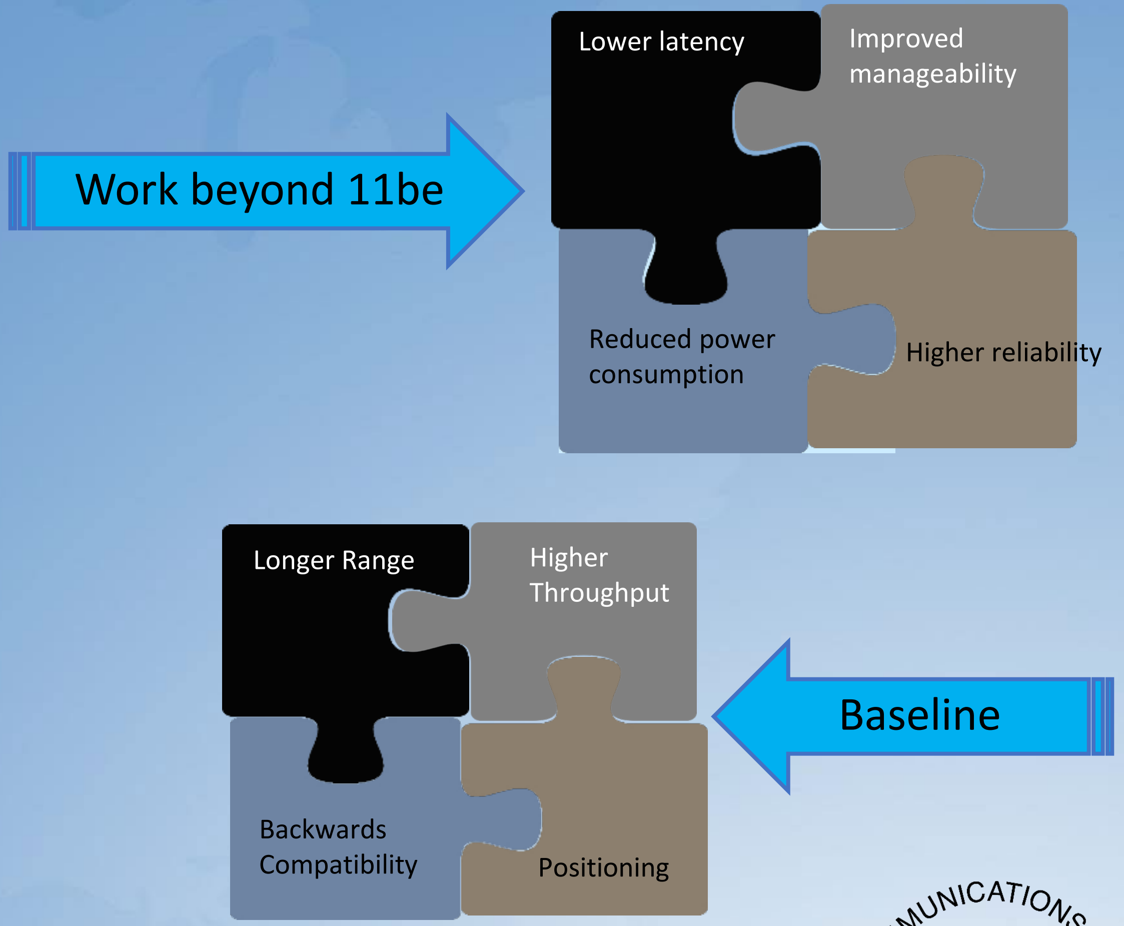
P802.11bn: Ultra High Reliability Task Group was approved in Sept 2023

Define technology to

- improve reliability of WLAN connectivity,
- reduce latencies,
- increase manageability,
- increase throughput including at different SNR levels, and
- reduce device level power consumption



The Task Group for P802.11bn began work in November 2023

Specification Framework document is under development

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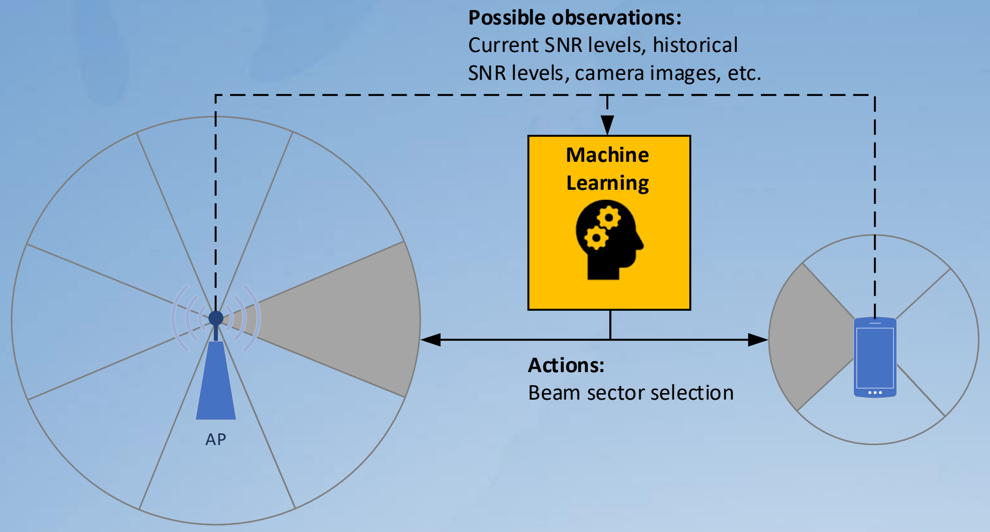
AIML Standing Committee: Investigate WLAN support of Artificial Intelligence/ Machine Learning

Use of AIML for 802.11 applications is an active area of work in the research community. See Applying ML to 802.11: Current Research and Emerging Use Cases and Current Report



Current applications focus on performance improvement parameter selection for channel access control and link adaptation, multi-user parameters, contention window sizes, channel usage, improved BSS transition

Work underway:

- Describe use cases for AI/ML applicability in 802.11 systems
- Investigate the technical feasibility of features
- enabling support of AI/ML.

802.11bd Next Generation V2X Use Cases

5.9 GHz band mainly, and optionally 60 GHz; Completion in 2022, published 2023

V2X Use Cases:

- Support all defined DSRC/802.11p use cases, including Basic safety message (safety, range, backward compatibility, fairness)
- Sensor sharing (throughput)
- Multi-channel operation (safety channel + other channels)
- Infrastructure applications (throughput)
- Vehicular positioning & location (LoS and NLOS positioning accuracy)
- Automated driving assistance (safety, throughput)
- Aerial vehicle IT application (video)
- Train to train (high speed)
- Vehicle to train (high speed, long range)

Key additions :

- Backward compatibility with 11p
- Higher throughput (2x) than 802.11p
- Longer range (3dB lower sensitivity level)
- Support for positioning

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Wi-Fi connects vehicles and international infrastructure in space

Wi-Fi in Space: Wi-Fi enables next generation space exploration, 9th Access Point Installed. Plans for Artemis/moon.

- “The first Wi-Fi network in space was installed in January 2008 using Wi-Fi 4, the IEEE 802.11n standard.”

- “In May 2020, Wi-Fi connected vehicles in space for the first time when the Japanese HTV-9 cargo transfer vehicle–operated by the Japan Aerospace Exploration Agency(JAXA)–demonstrated a high-definition, live video streaming application using Wi-Fi during its final approach to the Space Station.

- “..it is hard to imagine the Space Station without Wi-Fi.” Chatwin Lansdowne, Subsystem manager for the IEEE 802.11-based wireless communications system, International Space Station

NASA astronauts install the ninth Wi-Fi® access point outside Space Station

December 1, 2022 by Chatwin Lansdowne

This access point (AP) is the first to be installed on the International Space Station’s port truss.

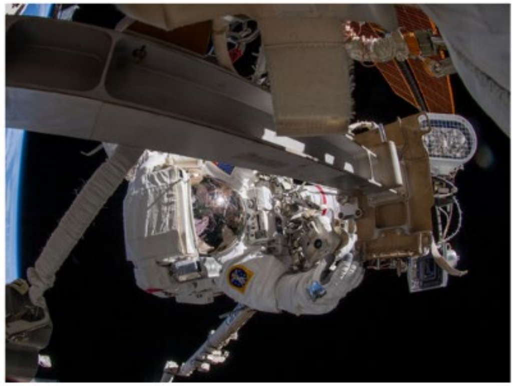


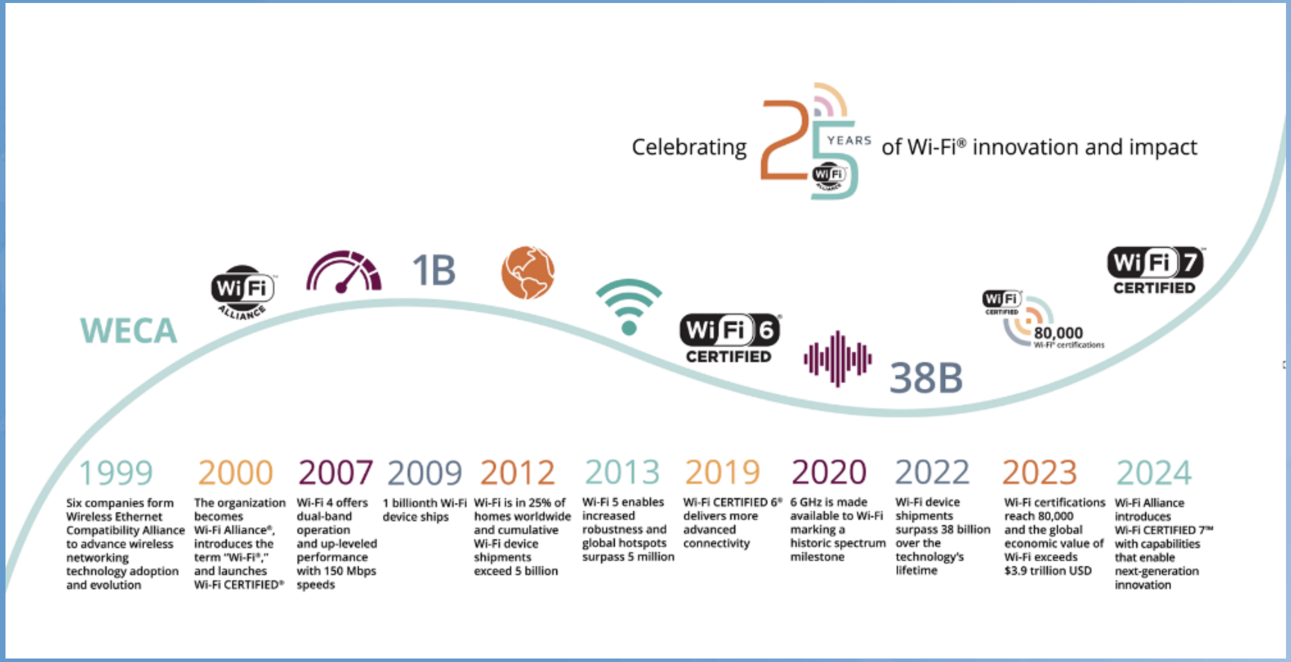
Figure 1: NASA astronaut Raja Chari connects an Ethernet cable to a wireless high-definition camera assembly on the main truss of the International Space Station, converting it to operate as a Wi-Fi access point. (Source: NASA)

During a seven-hour spacewalk on **March 23, 2022**, NASA astronaut **Raja Chari** and ESA astronaut **Matthias Maurer** installed a Wi-Fi CERTIFIED™ access point (AP) on the port side of the International Space Station’s main truss. The access point is the first to be sited on the port truss, and from this vantage, the newest AP provides not only a great camera view but also an open Wi-Fi® line-of-sight for the port side of the Russian segment and the **Japanese Experiment Module External Facility (JEM-EF) experiment porch**. The station’s solar panels partially block radio signals but the new access point is close enough to penetrate the port solar panels enough to reach the worksite where **astronauts recently installed additional panels (iROSA)**.

IEEE 802.11 Working Group Standards development and Wi-Fi Alliance Interoperability Certification ecosystem enable a robust market ecosystem

Wi-Fi Alliance: a 25-year success story

- Interoperability Certification
- Market Advocacy
- Regulatory Advocacy



Wi-Fi Alliance® surpasses 80,000 certifications

Austin, Texas and Prague, Czech Republic – October 17, 2023 – Wi-Fi Alliance® has surpassed 80,000 certified products, bringing a momentous number of high-quality, **Wi-Fi CERTIFIED™** devices to users worldwide.

Wi-Fi CERTIFIED helps ensure products meet high standards for interoperability and security. Achieving this milestone comes at a time of incredible momentum for the Wi-Fi® industry, including the addition of **new Wi-Fi CERTIFIED 6® testing** to support authorization of 6 GHz standard power devices and Wi-Fi 7 certification coming in the first quarter of 2024. Wi-Fi products can be certified for core functionality like the various Wi-Fi generations, and different applications such as **multiple access point Wi-Fi systems** and **seamless connectivity experiences** while mobile. Certifying a product through Wi-Fi Alliance demonstrates a company is committed to providing the highest quality devices and bringing the best experience for their customers.

Wi-Fi CERTIFIED products offer benefits across the Wi-Fi ecosystem. Certified interoperability supports lower return rates, reduced support costs, higher customer satisfaction, and increased sales volumes. Retailers and service providers request Wi-Fi CERTIFIED products to offer customers high quality, secure devices that deliver good user experiences.

Learn more about the value of Wi-Fi CERTIFIED in our **video** or visit **www.wi-fi.org/certification** for more information.

About Wi-Fi Alliance® | **www.wi-fi.org**

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How is 6G technology envisioned to enhance or be utilized in various verticals?

State of the Art

3GPP continues to work on 5G NR and discussions for 6G have started

Some evolution of 5G NR has been towards automotive vertical

- ❑V2X is the most notable example

However, most evolution has been towards eMBB enhancements

- ❑Focus is on higher data rate, coverage extension and lower latency
- ❑Addressing the quick refresh cycle associated with smartphones

5G NR deployment in automotive is ongoing

Evolution Towards 6G

Evolution should enable new use cases to increase value

New services and increased value needs to be added in a cost-effective manner

Leverage different components of the vehicle to deliver these services

Enable new & enhanced services in a cost-effective manner using “reuse & synergy”

Automotive Requirements for Beyond 2030

Ubiquitous Connectivity is key for most automotive use cases

Secure, Reliable, resilient, low latency, high-mobility communication for safety, advanced driving and remote vehicle services.

Enhanced communications for immersive multimedia, immersive infotainment/applications in vehicle,

Pedestrian protection by improved location information availability of UE (<1 m)

Enabling 6G technologies

Functional-Critical automated driving services → Resilient Communication

Improve service continuity → Hybrid TN and NTN Architecture

Improved Sensing Capabilities → Integrated Sensing and Communications

Antenna Placement outside the vehicle → Refractive Meta Surfaces

SME Speakers

Organization	Topic	Speaker	Summary
NEXTG ALLIANCE	NGA perspective on 3GPP SA-1 Use Case Workshop	Mr. David Young	• Sustainability native 6G: Privacy and Trust, Digital Equity and quality of Life Key value indicators (KVI) • Target shared investments in 6G Proof of Concepts and testbeds • Multi-sensory XR, Digital Twin, Connected vehicles, Cooperative Robots, Massive Sensors enabling new solutions • KPI's for positioning, reliability, sensing and sustainability
Hewlett Packard Enterprise	An update and roadmap for IEEE 802 Standards	Ms Dorothy Stanley	• Investigate WLAN support of Artificial Intelligence/ Machine Learning • IEEE 802.11 Working Group Standards development and Wi-Fi Alliance Interoperability Certification ecosystem enable a robust market ecosystem • Roadmap goals include: improve reliability of WLAN connectivity, reduce latencies, increase manageability, increase throughput including at different SNR levels, and reduce device level power consumption
Qualcomm	6G For Automotive	Dr Shailesh Patil	• Allow deployment of 6G without requiring hardware upgrade for already deployed 5G vehicles • Improved remote driving using reliable communication • Use transparent meta surfaces to replace RF cables for cost benefits • Remote Intervention for Automotive Safety Integrity Level (ASIL)

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6G WG Next Steps, Meetings & Call for Participants

- Additional SME presentations addressing the Charter items

- Meeting schedule is Thursday's from 4-5 PM Eastern (same as previous cycle)
  - Initial meeting cadence will be every other week

- Please send an email to brian.k.daly@att.com, agosain@coe.northeastern.edu , and tac@fcc.gov to be added to the list of participants in the 6G WG, added to the meeting invites, and subscription to the working group email list
  - Be sure to include all three email addresses on your request
  - We can only add those who have been vetted by the FCC for TAC membership

Thank You

FCC Technological Advisory Council Agenda – June 21, 2024

10:00am – 10:15am	Opening Remarks
10:15am – 10:25am	Records Management Overview
10:25am – 11:05am	Advanced Spectrum Sharing WG Presentation
11:05am – 11:45am	AI/ML WG Presentation
11:45am – 12:25pm	6G WG Presentation
12:25pm – 12:30pm	Closing Remarks
12:30pm	Adjourned