Federal Communications Commission Technological Advisory Council Meeting

August 17, 2023

FCC Technological Advisory Council Agenda – August 17, 2023

10am – 10:30am	Introduction and Opening Remarks •Welcome Message (TAC Chair) •Opening Remarks by OET Chief •DFO/Deputy DFO Remarks •Member Introduction/Roll Call
10:30am – 11:15am	Emerging Technologies WG Presentation
11:15am – 12:00pm	Advanced Spectrum Sharing WG Presentation
12:00pm – 1pm	Lunch Break
1pm – 1:45pm	AI/ML WG Presentation
1:45pm – 2:30pm	6G WG Presentation
2:30pm – 2:45pm	Closing Remarks
2:45pm	Adjourned

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FCC TAC
Emerging Technologies Working Group

Chairs: Brian Markwalter, CTA
Henning Schulzrinne, SGE (Columbia University)

FCC Liaisons: Martin Doczkat, Bahman Badipour, Padma Krishnaswamy, Kamran Etemad

Date: August 17, 2023

Working Group Roster

Ahmad Armand	T-Mobile	Greg Lapin	ARRL
Mark Bayliss	Visual Link	Jason Livingood	Comcast
Ranveer Chandra	Microsoft	Jennifer Manner	Hughes
Lynn Claudy	NAB	Lynn Merrill	NTCA
Andrew Clegg	WInnForum	Michael Nawrocki	ATIS
Mischa Dohler	Ericsson	Jack Nasielski	Qualcomm
Jeff Foerster	Intel	Madeleine Noland	ATSC
Russ Gyurek	Cisco	Jesse Russell	Inc Networks
Dale Hatfield	UC Boulder	Lewis Shepard	VMWare
Frank Huang	Deutsche Telekom	Marvin Sirbu	SGE
Karri Kuoppamaki	T-Mobile	Ted Solomon	NRTC
Steve Lanning	Viasat		

Report from December 2022

Covered by Emerging Tech Working Group

- Direct to satellite from mobile devices
- Reliability/Restoration (Internet restoration) – further study?
- Device location use cases →

Possible Future Study

- AR, VR and related technologies →
- Reflective intelligent surfaces →
- Radar (e.g., 140 GHz)

Focus for 2023

- Positioning and Location Use Cases
- AR/VR (XR) and Spectrum
- Reconfigurable Intelligent Surfaces

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Positioning and Location Use Cases

- Proposed to examine location use cases, especially for precision location
- One presentation on Broadcast Positioning System – by NAB
  - Better for precision timing than location
- Have not (re-) examined combined sensing and communication

  "…where localization and sensing will coexist with communication, continuously sharing the available resources in time, frequency and space."

  - *6G White Paper on Localization and Sensing*, University of Oulu

Broadcast Positioning System (BPS)

Presented by Robert Weller, Tariq Mondal; NAB

A system and method of estimating time and position at a receiver using ATSC 3.0 broadcast signals

Compliant with ATSC 3.0 standard;

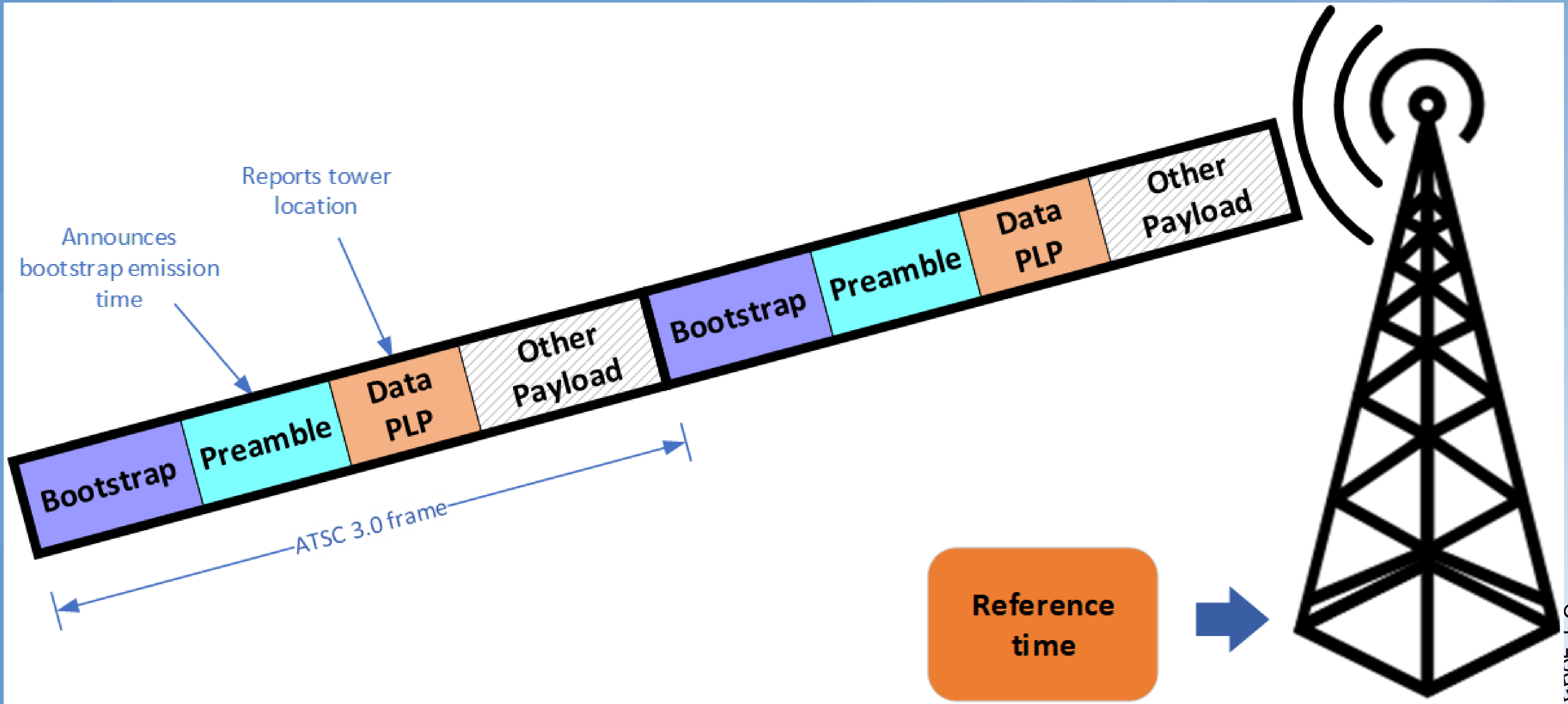
uses datacasting feature

Independent and stand-alone

- GPS, Internet or cellular connectivity not required

Time Delivery

Embed reliable, un-spoofable timing information from a known location in the robust portion of an ATSC 3.0 signal



Claimed PNT Capabilities of BPS

Working Group assessment: Strength is time distribution
Requires receiver investment (better for stationary applications)

One TV tower can provide accurate time at a known position

- 100 ns, 95% of the time

Four TV towers can provide both time and position estimation

- 100 m average accuracy expected

Can detect GPS spoofing

Can enable GPS-BPS hybrid location

Positioning Resources

"6G White Paper on Localization and Sensing"

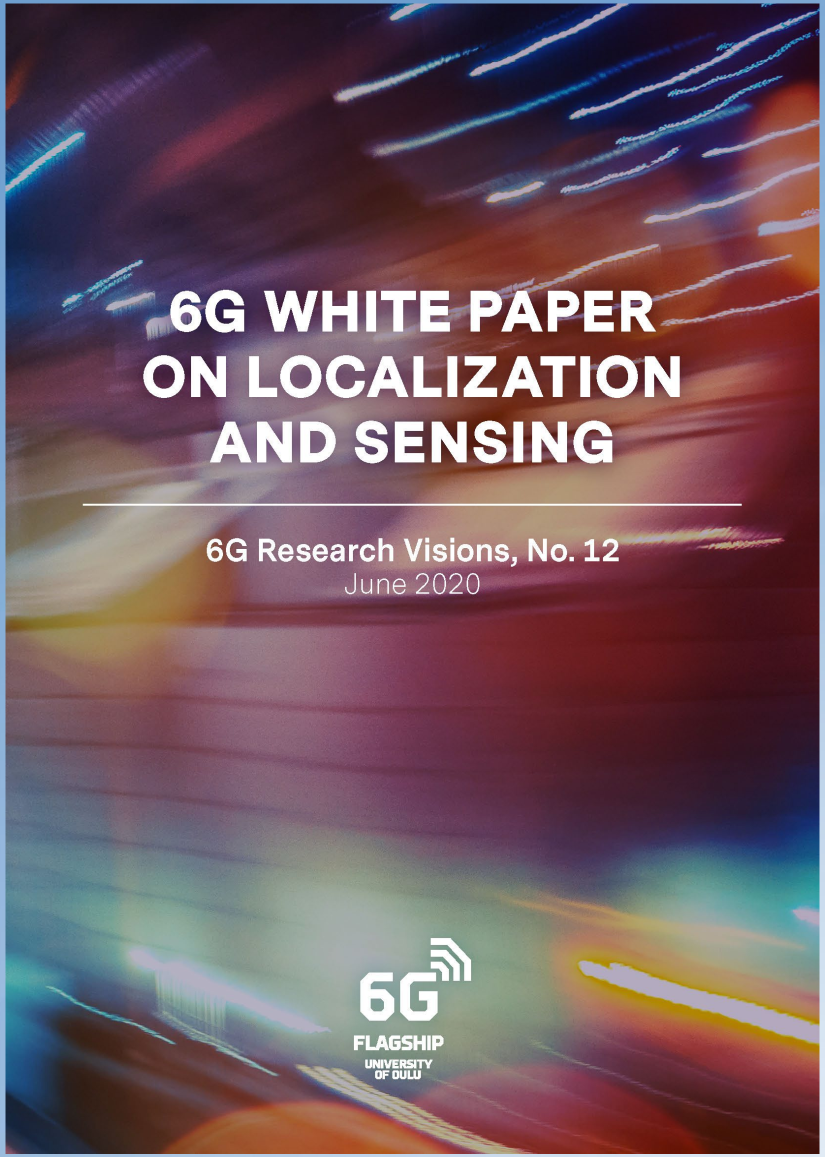
http://jultika.oulu.fi/files/isbn9789526226743.pdf

"An Overview of 3GPP Positioning Standards"

https://dl.acm.org/doi/pdf/10.1145/3539668.3539672

"A Survey of Recent Indoor Localization Scenarios and Methodologies"

https://www.mdpi.com/1424-8220/21/23/8086



Recommendations

- The FCC should continue to monitor developments in sensing and communications
  - Same spectrum, more uses improves efficiency
  - Demand for location and positioning solutions remains high:
    - Autonomous vehicles, pedestrians and other users
    - Whether a device is indoors
    - Precision location for industrial and commercial applications

Spectrum Needs of AR & VR

- **Question**: What future AR and VR services can be expected, and what are their spectrum needs both indoors as well as outdoors.

Topic	Speaker	Company
XR Evolution	Hemanth Sampath, VP Engineering	Qualcomm
XR urban capacity – Simulation analysis	Stephen G. Rayment, RAN Strategy North America, CTO Office	Ericsson

XR Evolution, presented by Qualcomm

- Wide range of AR and VR applications in consumer and enterprise markets, both indoors and outdoors, forming emerging “immersive internet”
- Thriving eco-system of VR and MR/AR headsets; notable players: Meta, HTC, Lenovo, Vuzix, Magic Leap, Niantic, Apple, etc
- Two modus operandi: tethered vs stand-alone
  - Tethered: today cable to 5G smart phone; in 1-4 years tethered via Wifi
  - Stand-alone: today direct to Wifi access point; in 1-4 years Wifi and 5G
- Edge-cloud rendering crucial to lower power consumption and thus extended battery lifetime, smaller form factors and/or cheaper consumer devices
- 20ms latency needed to avoid nausea in VR and jittery image in AR; however, smart techniques (e.g., time-warp) allow 50-100ms round-trip latencies, where:
  - 20-30ms are for communications
  - Rest is for server latencies, server processing (rendering, encoding) and on-device processing (6DoF, decode, time warp, display etc..)
- Both licensed spectrum and license-exempt spectrum critical to scaling XR applications due to substantial data offload:
  - Wifi: 6GHz useful because of clean large band; 60GHz radar co-existence also helpful
  - 5G/6G: more spectrum needed to support off-load outdoors for emerging AR applications

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XR urban capacity – simulation analysis, presented by Ericsson

- Assumptions:
  - Three offload scenarios: i) no offload, ii) low offload, iii) high offload
  - Three rollout phases: i) today-2025 (few users, 1k res per eye, static environment); ii) 2025-2027; iii) 2027-2030 (many users, 8k per eye, dynamic environment)
  - Typical simulation parameters (see Appendix)
  - Study examined only capacity, not latency thus acting as a “best case” for XR!
- Conclusions:
  - XR causes “double whammy” effect: increasing demand + reducing network capacity
  - XR UL demand (at cell edge) drives the need for additional capacity first
  - Site densification is needed starting 2025 to meet demand even with VERY spectrum rich operator
  - Shrinking cell size to meet demand requires 2.8~4x urban site count by 2027 - economic challenge!

  - **Spectrum allocations and network improvements will need to be traded off to expand the reach and capabilities of XR technologies towards their full potential.**

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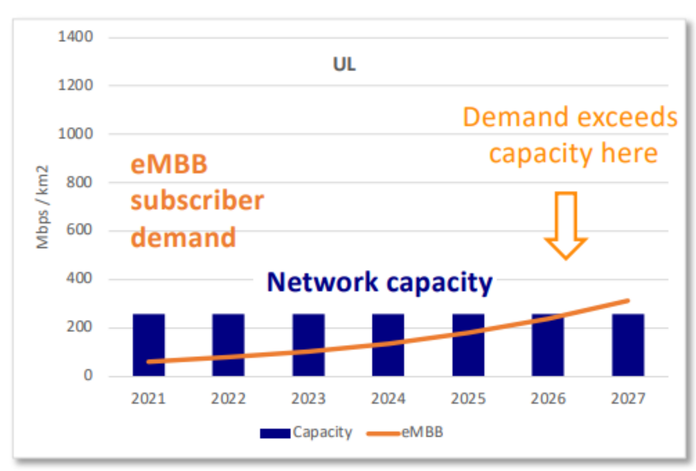
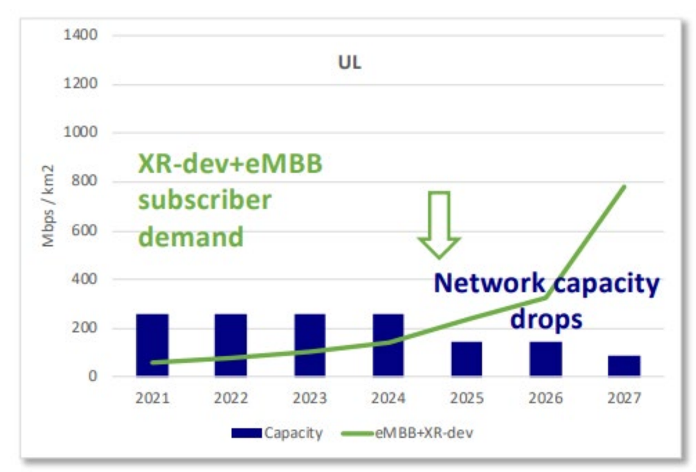
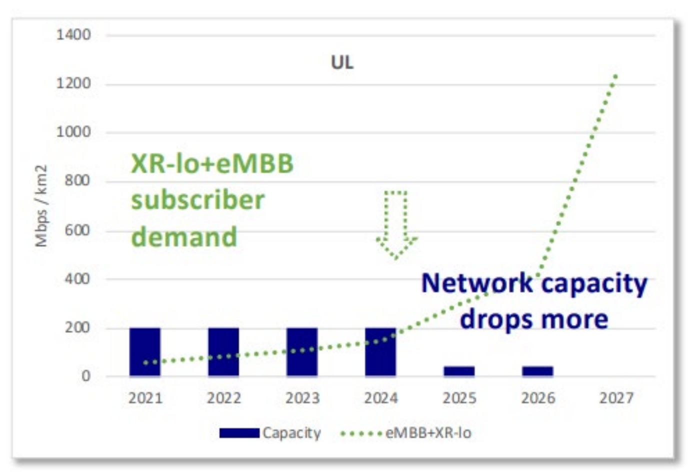
XR urban capacity – simulation analysis, presented by Ericsson



- **Reference simulation without XR traffic**
- *Blue bars*: offered network capacity
- *Orange line*: capacity demand due to eMBB
- *Observation*: without new spectrum, demand exceeds capacity in 2026-2027



- **XR introduced with content largely rendered on device**
- *Blue bars*: offered capacity; decreases due to UL@edge
- *Green line*: capacity demand due to eMBB + XR
- *Observation*: without new spectrum, demand exceeds capacity 2024-2025



- **XR introduced with low rate edge cloud rendering**
- *Blue bars*: offered capacity; decreases due to UL@edge
- *Green line*: capacity demand due to eMBB + XR
- *Observation*: Offered capacity drops even quicker due to edge offload

Recommendations

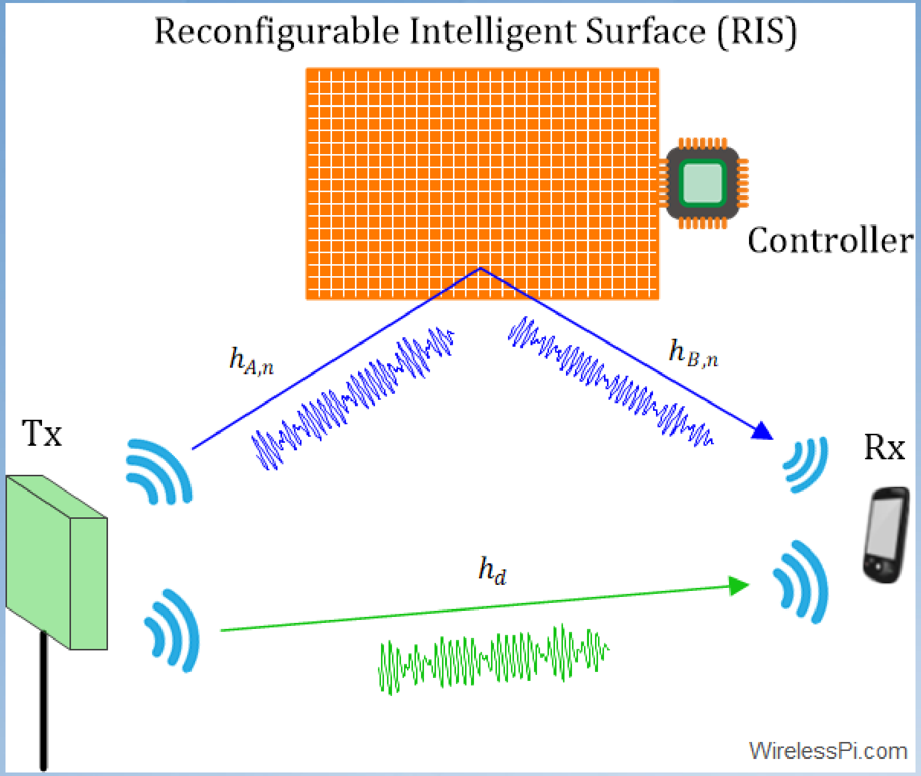
- FCC should conduct more internal research on the spectrum needs of the emerging immersive internet based on XR headsets
- FCC should encourage research and work on viable spectrum allocations and/or spectrum sharing mechanisms such that spectrum needs can be realistically met

- *Note: Market demand for immersive XR services will heavily depend on the quality of the headsets, availability of applications and readiness of networks.*

RIS: What and Why

Reconfigurable Intelligent Surfaces: are surfaces which are capable of steering an electromagnetic wave in specific direction(s). RIS proposes to improve wireless performance between transmitters and receivers. (aka Software-controlled metasurfaces)

- RIS acts as a beamformer
  - Signals at the receiver are summed together by aligning the phases and the multiple paths to maximize signal power
  - Also known as virtual/generalized beamforming
- Benefits:
  - Allow greater signal to receiver without additional radio/repeater
- Challenges:
  - Channel estimation is difficult Tx→RIS←Rx
  - Cost-effectiveness unknown at this time (vs cell-free mMIMO)
  - Unknown benefit in mmWave due to limited propagation
  - Marginal gains, potential high cost

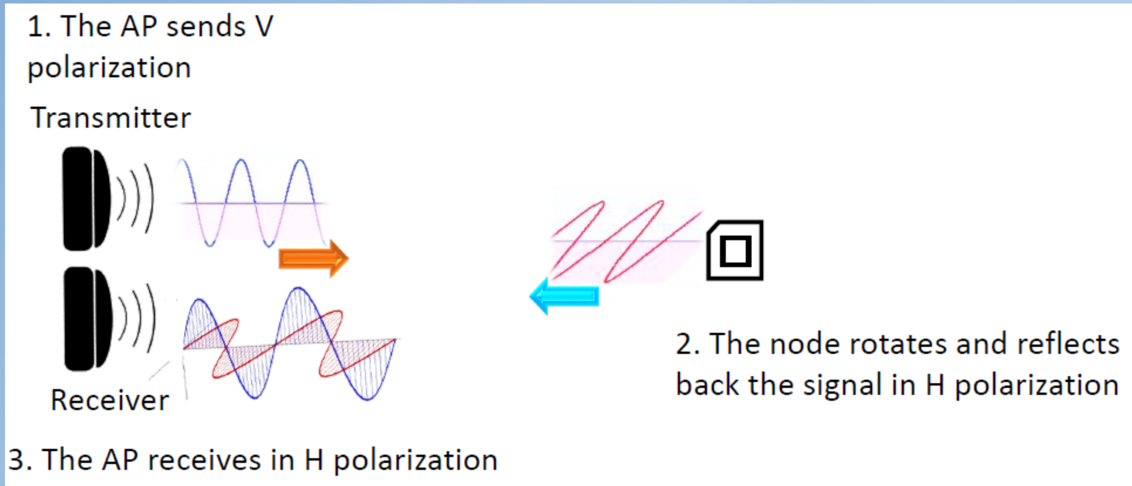


Reference: https://wirelesspi.com/wp-content/uploads/2022/07/figure-reconfigurable-intelligent-surfaces.png

Research Presentation to TAC

Backscatter communication in 6G networks- Omid Abari, Professor Computer Science/Electrical & Computer Engineering UCLA (ICONLAB)

- Focused on mmWave and THz spectrum
- Proposal: Node/UE piggybacks data onto signal from Tx eliminating need for signal regeneration; polarization conversion and then reflecting back to Tx/Rx
- Benefits: low-power, simple design
- Work to be done:
  - Radio ability to track node
  - Node ability to create and steer beam back to Radio
  - Integration into protocols



RIS Related References

Reference links on RIS that we have explored:

- https://www.etsi.org/technologies/reconfigurable-intelligent-surfaces
  - ETSI: Potential enhancements to the capacity, coverage, positioning, security, and sustainability, as well as the support of further sensing, wireless power transfer, and ambient backscattering capabilities
  - RIS Industry specification Group (ISG): a new type of system node with surfaces that may have reflection, refraction, and absorption properties through many small antennas or metamaterials elements which can be adapted to a specific radio channel environment
- https://jwcn-eurasipjournals.springeropen.com/articles/10.1186/s13638-021-02048-5
  - Sept 10, 2021 Paper: Survey on reconfigurable intelligent surfaces below 10 GHz
  - Framework related to changing, controlling and sensing the radio environment
  - Exploration of metasurfaces for us in wireless systems
- https://ghasempour.princeton.edu/publications
  - Multiple research projects and papers covering RIS metasurfaces security, wavefront manipulation, sustainable benefits, use above 100GHz (backscatter), and support of satellite networking
  - Paper: investigates the security vulnerabilities associated with the deployment of reconfigurable surfaces, i.e., an adversary may deploy new rogue surfaces or tamper with already-deployed surfaces to maliciously engineer the reflection pattern
- https://arxiv.org/abs/2302.01508
  - Whitepaper explores the use of reconfigurable intelligent surfaces (RIS) in mitigating cross-system interference in spectrum sharing and secure wireless applications
  - Proposes “Absorptive RIS” to modify the phase of an incoming signal
  - Benefits include: spectral coexistence of radar and communications, spectrum sharing related to D2D communications, adding physical layer security to downlink communication signal/system

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Recommendations

- FCC should have future TAC Working Group explore RIS technologies and consider impact to spectrum and challenges, particularly in the cmWave and mmWave bands
  - Backscatter: for low-power devices
  - RIS: for high-power commercial mobile systems
- FCC should encourage and support research related to RIS

- Advisement: metasurfaces have the potential to be used maliciously to intercept signals
- Advisement: RIS work in 3GPP has dropped in urgency, expected to become more important as we get closer to 6G

Summary

<u>Covered by Emerging Tech Working Group</u>

- Positioning and Location Use Cases
  - The FCC should continue to monitor developments in sensing and communications
- Spectrum needs of AR & VR
  - Edge-cloud rendering enables power savings
  - License-exempt and licensed spectrum vital for direct & tethered connectivity
  - AR/VR causes “double whammy” effect: increased demand + reduced network capacity
- Reconfigurable Intelligent Surfaces
  - TAC should explore RIS technologies and consider impact to spectrum and challenges, particularly in the cmWave and mmWave bands

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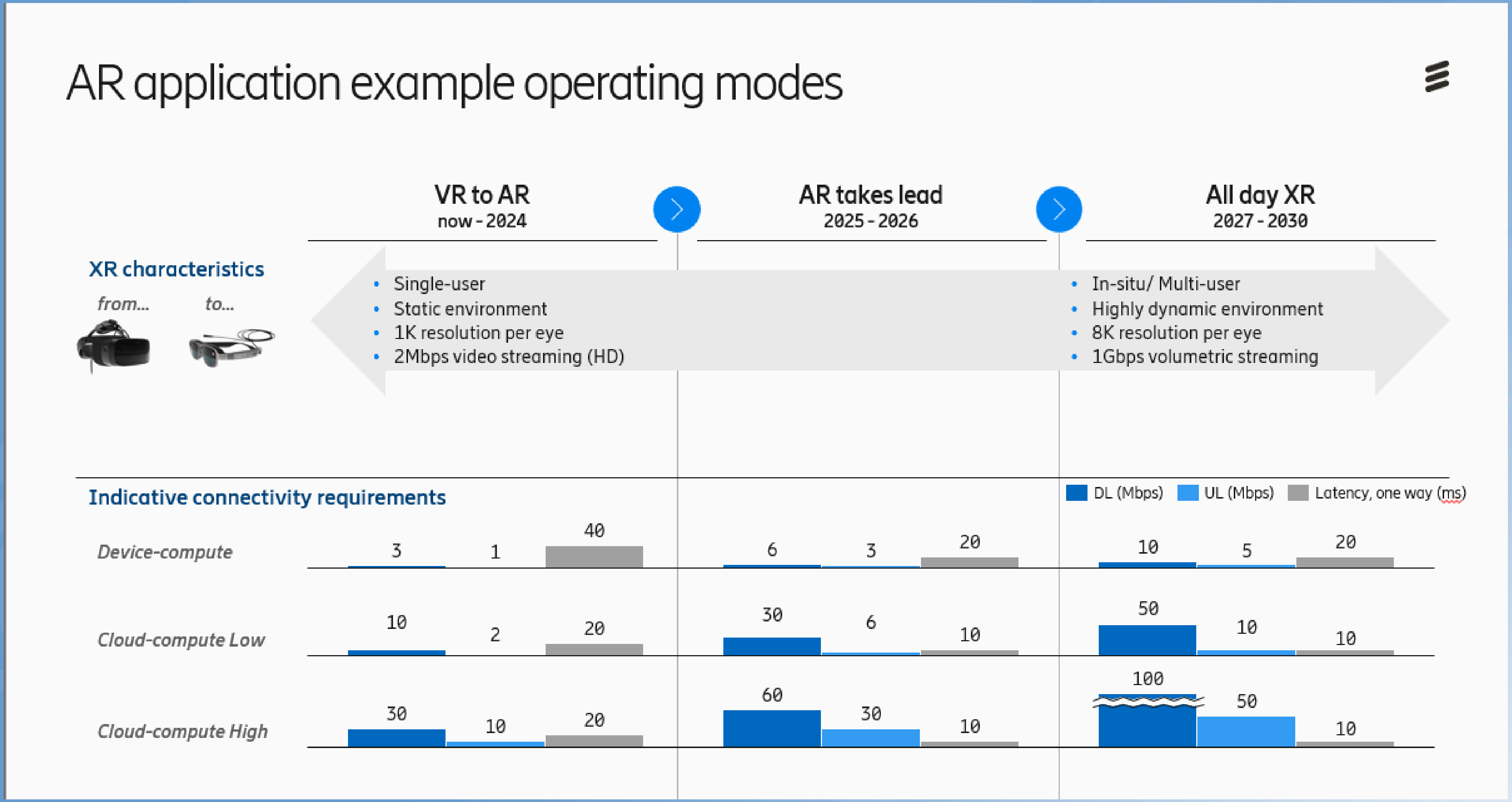
Thank You

Appendix

Ericsson XR urban capacity simulation assumptions



Ericsson XR urban capacity simulation assumptions

Simulation key parameters
eMBB + XR in low-density urban markets

Capacity	
LB_FDD	50 MHz (UL+DL)
MB_FDD	110 MHz (UL+DL)
MB_TDD	240 MHz
All NR	Assume all sites have all bands
ISD (median 800 m)	400 ~ 1200 m
Indoor subscribers	80%

- "Low density" urban
  90% of total urban area 6000 km^2 30M subs
- VERY spectrum rich operator assumption

Demand	
Current eMBB tonnage	22 GB / month / sub
CAGR	32%
Subscriber density (urban-low)	2000 subs / km2 / operator
DL / UL traffic split	80 / 20 %
eMBB t'put - 5th %ile	10 / 1 Mbps
XR # devices	14M devices on cellular by 2027 per operator assumes 65% went on Wi-Fi
XR usage	1.0 hr/day > 5.0 hr/day
XR-dev t'put	3>6>10 / 1>3>5 Mbps [1]
XR-lo t'put	10>30>50 / 2>6>10 Mbps
XR-hi t'put	30>60>100 / 10>30>50 Mbps

[1] DL / UL now~2024 > 2025~26 > 2027~30

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FCC TAC Advanced Spectrum Sharing Working Group

Co-Chairs: Andrew Clegg, Wireless Innovation Forum
Monisha Ghosh, Wireless Institute, University of Notre Dame

FCC Liaisons: Michael Ha, Martin Doczkat, Nicholas Oros, Bahman Badipour, Robert Pavlak, Navid Golshahi

Date: August 17th, 2023

2023 Spectrum Sharing Work Group Participants

Balachandran, Kumar	Ericsson
Chandra, Ranveer	Microsoft
Claudy, Lynn	NAB
Clegg, Andrew	Wireless Innovation Forum
Daly, Brian K.	AT&T
Damnjanovic, Aleksandar	Qualcomm
Drobot, Adam	Open Techworks
Foerster, Jeffrey	Intel
Ghosh, Monisha	Notre Dame
Gurney, Dave	Motorola Solutions

Gyurek, Russ	Cisco
Hatfield , Dale N.	University of Colorado
Jindal, Manish	Charter
Lanning, Steve	Viasat
Lapin, Greg	ARRL
Manner, Jennifer	Hughes
Mansergh, Dan	Apple
Marcus, Michael	Northeastern U
Markwalter, Brian	CTA
Merrill, Lynn	NTCA

Mukhopadhyay, Amit	Nokia
Peha, Jon	Carnegie Mellon University
Rames, Patrick	VMWare
Russell, Jesse	incNetworks
Sawanobori, Tom	CTIA
Scott, Andy	NCTA
Thompson, Michelle	Open Research Institute, Inc.
Welsh, Patrick	Verizon
Zimmermann, Ute	Deutsche Telekom

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Agenda

- Group Charter
- Summary of discussions
- Work product

Advanced Spectrum Sharing WG - 2022-2023 Charter

- Several sharing mechanisms (static/dynamic or centralized/decentralized) have been deployed to enable sharing between Federal and non-Federal users, licensed and unlicensed users or among licensed users. What are the long-term goals of these approaches? How can AI/ML and sensing-based cognitive radio techniques enhance the effectiveness of the sharing mechanisms and optimize network performance?
- What steps can be taken to better facilitate spectrum repurposing efforts? How can potential intra-band and inter-band issues be identified and addressed early in the process? 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? What steps and processes should be used regarding adjacent band spectrum users' wide receiver bandwidths (i.e., the passband extends into adjacent bands)?
- What state of the art filter technologies can be utilized to mitigate potential harmful interference? How can advanced antenna systems help reduce both inter-system and intra-system interference and enhance intra-system performance? What are the cost benefit tradeoffs on utilizing the current filter technologies or advanced antenna systems?
- What are the candidate bands or services that can co-exist with low-power, indoor-only operation such as factory automation? What are the sharing mechanisms to consider?What are the sharing mechanisms to consider among various services above 95 GHz, including passive services?

Areas of Mutual Interest with Other Working Groups (Verbatim from the Charter)

- “How can AI/ML and sensing-based cognitive radio techniques enhance the effectiveness of the sharing mechanisms and optimize network performance?” (AI/ML WG)

- "What state of the art filter technologies can be utilized to mitigate potential harmful interference? How can advanced antenna systems help reduce both inter-system and intra-system interference and enhance intra-system performance? What are the cost benefit tradeoffs on utilizing the current filter technologies or advanced antenna systems?” (Emerging Technologies WG) (May include any other technology related to sharing)

- "What are the sharing mechanisms to consider among various services above 95 GHz, including passive services? (May also consider lower bands)” (6G WG)

Discussions and Key Recommendations

Singular Focus this Abbreviated Period: Examining Bands Between 7.125 and 24 GHz for Potential Sharing Opportunities

- The sole focus of the Advanced Spectrum Sharing WG during this abbreviated session was completing an analysis of bands between 7.125 and 24 GHz for potential sharing opportunities; along with a summary of some of the existing spectrum sharing frameworks
- This continued work that was begun during the 2022 session
- We had weekly meetings from April through August, with considerable discussion that focused on many topic areas, including:
  - Types of spectrum sharing
  - The extent to which particular technologies support shared spectrum
  - The needs of terrestrial vs non-terrestrial networks (spectrum needs, protection needs, etc.)
  - Licensed and unlicensed spectrum and systems
  - The potential role of sensing in spectrum sharing systems
  - International/harmonization aspects

Significant Challenge: Lack of Information on Federal Spectrum Use

- There are substantial allocations for federal government services throughout most of the 7.125-24 GHz band, particularly the lower portion
- There is very little information on actual federal use of these bands.
- NTIA is apparently working on extending their Spectrum Use Summaries above 7.125 GHz, but these results were not (and are not) available to consider when analyzing the bands. Their recent comment on the 12 GHz proceeding provided information on unclassified federal usage in 12.75 - 13.75 GHz.
- The NTIA Federal Spectrum Use Summary is available and was used in the creation of our report, but the document is somewhat dated (2010) and is very high level with very few details
- We therefore examined bands primarily from a non-federal perspective, but took federal use into account the best we could
- This report should be revisited when additional information on federal use becomes available, for example, when NTIA issues more details on their national spectrum strategy and their extended spectrum use summaries

Summary of Report

- "A Preliminary View of Spectrum Bands in the 7.125 - 24 GHz Range; and a Summary of Spectrum Sharing Frameworks"
  - The WG would like to thank Amit Mukhopadhyay for his substantial work as editor of the report.

Federal Communications Commission – Technological Advisory Council
Advanced Spectrum Sharing Working Group

A Preliminary View of Spectrum Bands in the 7.125 - 24 GHz Range; and a Summary of Spectrum Sharing Frameworks

FCC-TAC Advanced Spectrum Sharing Workgroup

Table of Contents

1 Executive summary

The need for additional spectrum for future applications has been expressed by numerous federal, scientific and commercial entities. However, spectrum is a finite resource and can be exclusively allocated to only a handful of users. Additionally, many wireless systems prefer to deploy in certain parts of the spectrum due to various technical and commercial reasons, such as better propagation and infrastructure cost. Hence, the only practical way to satisfy the demands of all applications -- commercial, scientific and federal -- is to encourage spectrum sharing among incumbent users and new entrants. However, this is a challenging task, because the feasibility of robust and efficient spectrum sharing that protects incumbents from harmful interference while allowing new entrants sufficient performance depends upon the operational characteristics and use cases of the systems that will share the band: often, these are not publicly available with the level of detail required to develop efficient spectrum sharing methods.

This document summarizes the current allocations in the 7.125 - 24 GHz band and spectrum sharing frameworks that could be considered for sharing between mobile wireless and incumbent services.This band is largely allocated for federal use today. However, there is additional demand for various commercial applications due to the favorable propagation characteristics compared to mmWave and higher bands and the availability of larger bandwidths compared to the lower

How can we add capacity to meet the needs of future wireless applications?

- Improved **spectral efficiency**: the theoretical limits of spectral efficiency (bits/sec/Hz) on a per link basis have been approached with current technologies such as Low Density Parity Check (LDPC) codes and MIMO and while research will continue in this area, the pace of further enhancements has slowed.

- Increased **spatial density** for cellular deployments: dense urban deployments often reach the limits of interference mitigation and thus incur performance degradation; multi-user MIMO (MU-MIMO) methods do not always lead to improved performance since they incur overhead for channel estimation and control signaling. Site densification also faces challenges of site acquisition, operational complications (including costs), and sustainability.

- Enhanced **amount of spectrum**: spectrum in desired frequency ranges is already occupied by various services so it is nearly impossible to find any spectrum with no incumbents. However, effective spectrum sharing can potentially unlock additional spectrum for certain new services, while protecting important incumbent uses.

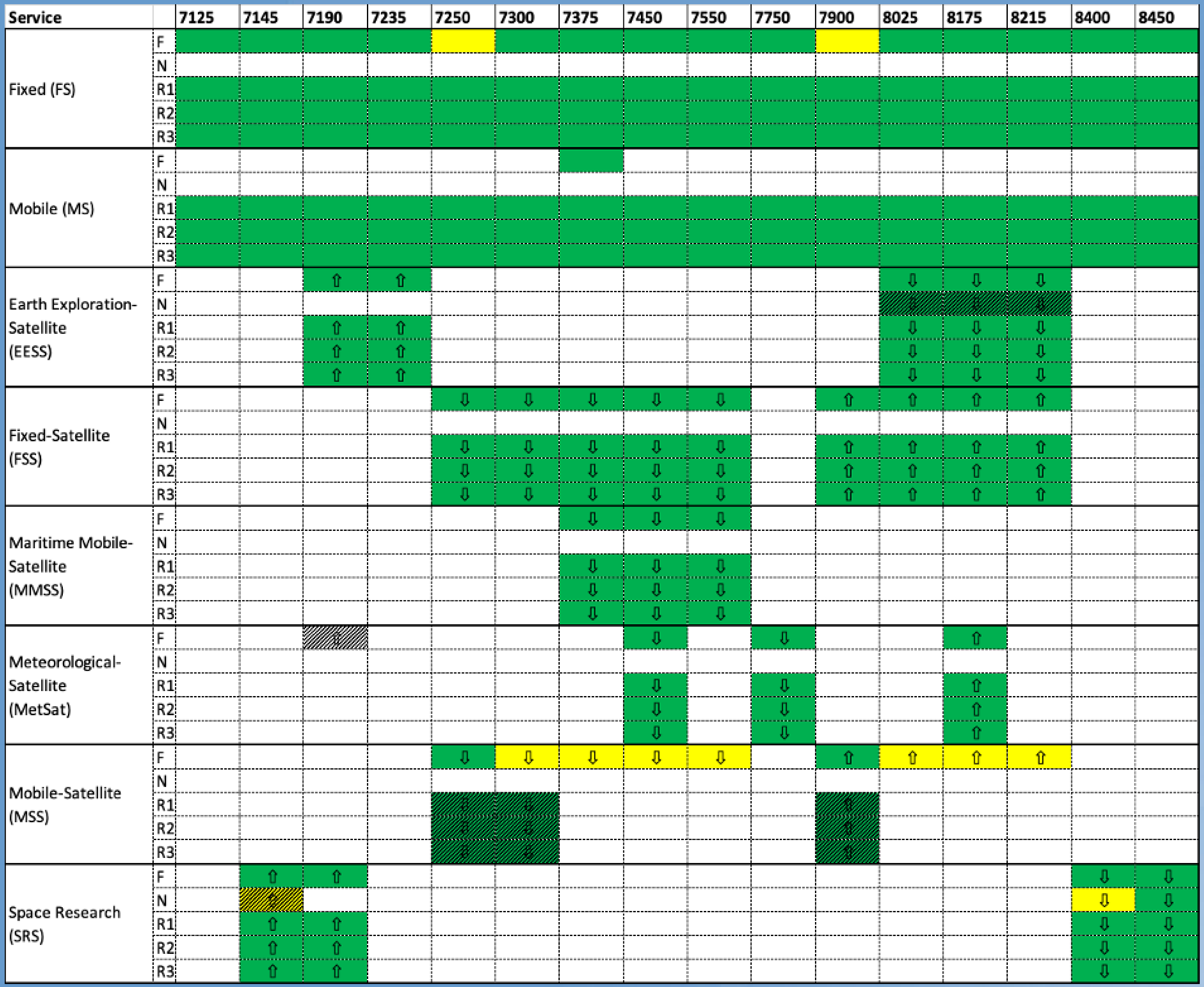
Spectrum requirements and spectrum sharing

- Mobile terrestrial wireless requirements are for 2 GHz of spectrum by 2030.
  - The preference is for this to made available in 7.125 - 15 GHz due to propagation characteristics and infrastructure costs being more favorable than 15 - 24 GHz.

- Non-terrestrial networks (NTN) have increasing spectrum requirements as well, over 10 GHz of new spectrum is desired.
  - This will not be in 7.125 - 24 GHz.
  - Existing allocations in 7.125 - 24 GHz need to be protected.

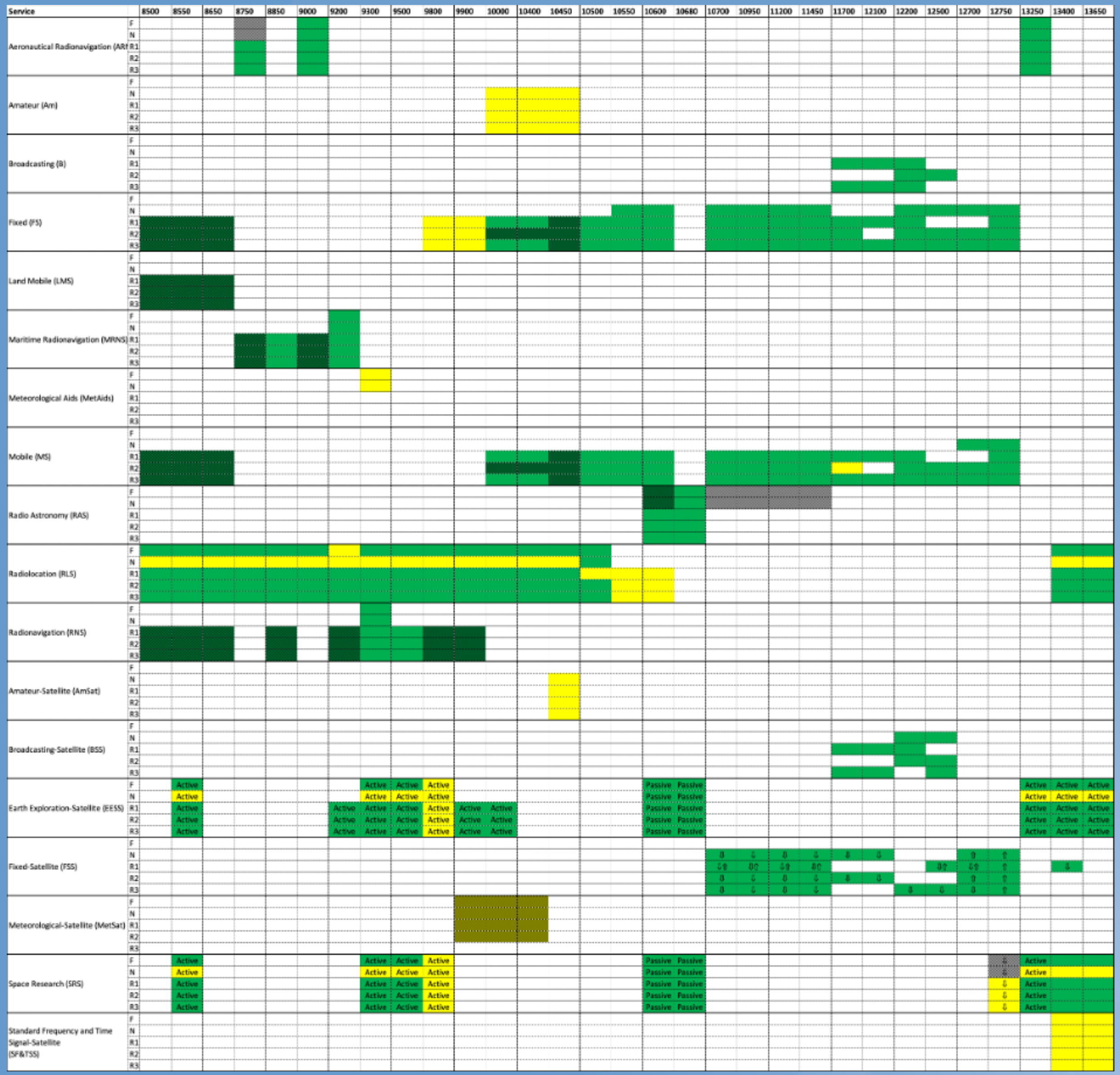
- Clearly, obtaining even 2 GHz of unallocated spectrum in 7.125 - 15 GHz is impossible.
  - Hence spectrum will need to be shared, amongst existing federal and non-federal allocations and new entrants.

7.125 - 8.5 GHz



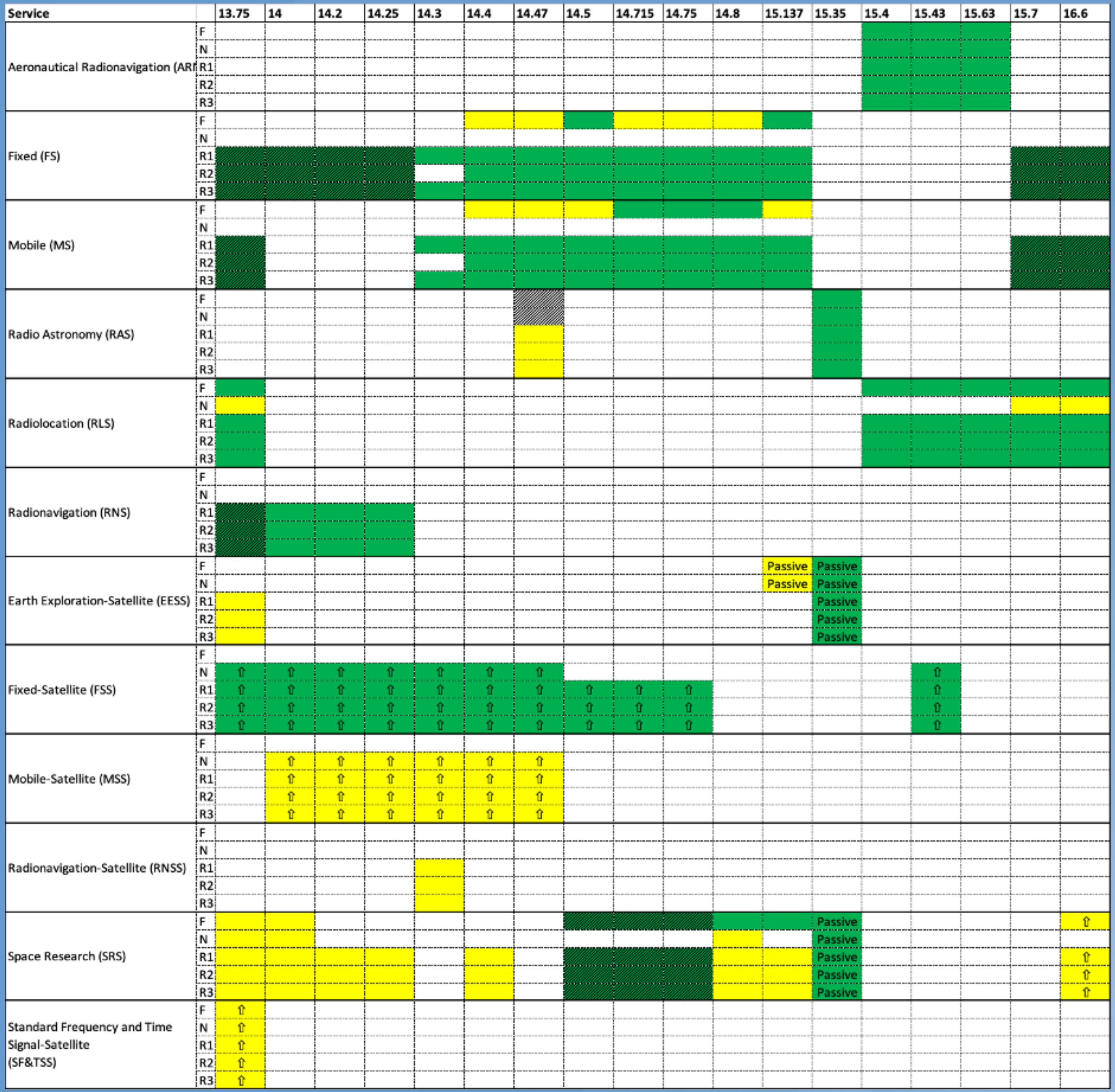
- Key takeaways:
  - FS, FSS and MSS are the largest current allocations and will be the biggest challenge for sharing with terrestrial mobile systems.
  - Approximately 20% of FS use is by the Department of Defense (DoD), and the satellite allocations also include DoD operations.
  - Other uses may not be ubiquitous and hence perhaps more amenable to sharing.

8.5 - 13.75 GHz



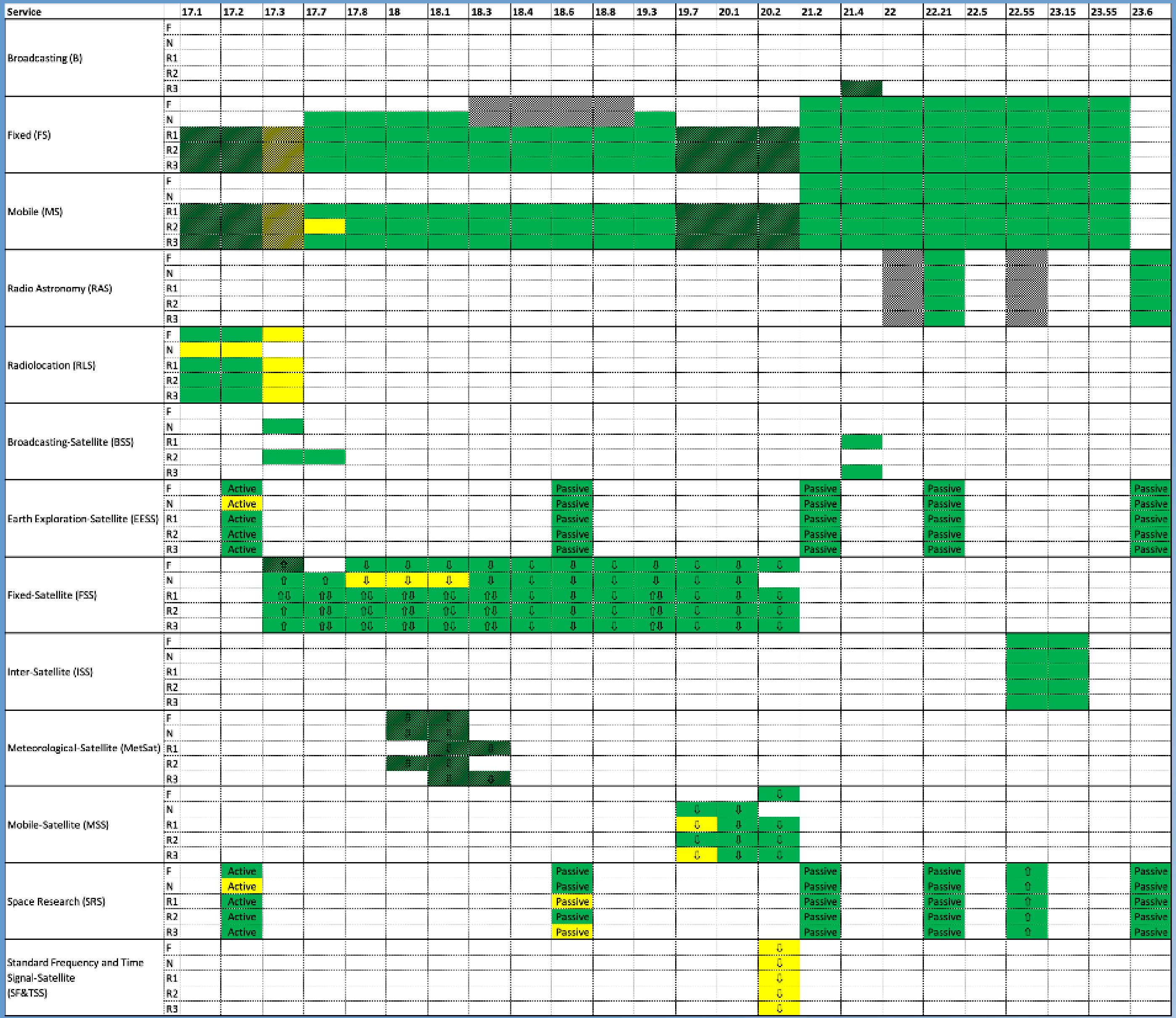
- Key takeaways:
  - RLS is the single largest allocation.
  - ~2500 MHz in 10.7 – 13.25 GHz is allocated for non-federal use, of which 12.2 - 13.25 GHz is already under consideration by the FCC for sharing with other services.
  - 13.25 - 13.75 may also be available for sharing with limited restrictions.

13.75 - 17.1 GHz



- Key takeaways:
  - RLS, SRS, FS and MS are the largest allocations in this part of the spectrum.
  - 200 MHz between 14.2 – 14.4 GHz is not allocated for federal use.

17.1 - 24 GHz



- Key takeaways:
  - 100 MHz spectrum in 17.7 – 17.8 GHz is not allocated for federal use.
  - 2,200 MHz of spectrum in 17.8 – 18.6 GHz and 18.8 – 20.2 GHz may be practical for coexistence if used for earth stations rather than user devices. However, there are widely deployed earth stations and user devices for commercial FSS to support broadband.

Information Required About Incumbents to Facilitate Sharing

- **Fixed and mobile services:** How widely is service in this frequency band used (e.g., number of links, geographical distribution etc.)? What are they used for (e.g., backhaul/transport, last mile connectivity, etc.)? Is it used for civil or military purposes? Are there future plans for adding new services or consolidating operations in another band?

- **Fixed-Satellite Services:** What are the operational characteristics (e.g. power, EIRP, beam-width, altitude)? What is the geographical coverage and are there adjacent country issues? Are the services direct to users or distributed via ground stations? How many subscribers and/or ground stations? Which part of the spectrum is for uplink vs. downlink?

- **Mobile-Satellite Services:** What is the geographical coverage? How many users? How much spectrum uplink vs. downlink?

- **Radiolocation Services:** Are these confined to limited geographies? Are these for military or civilian use? What are the protection criteria?

- **Radionavigation Services:** How much spectrum is truly used? What is the geographical coverage?

- **Space Research Services:** Where are the main sites located? What protection criteria need to be considered?

- **Tx/Rx characteristics of existing incumbent devices:** what is the state of technical capability of the incumbent systems and what would be the cost to upgrade?

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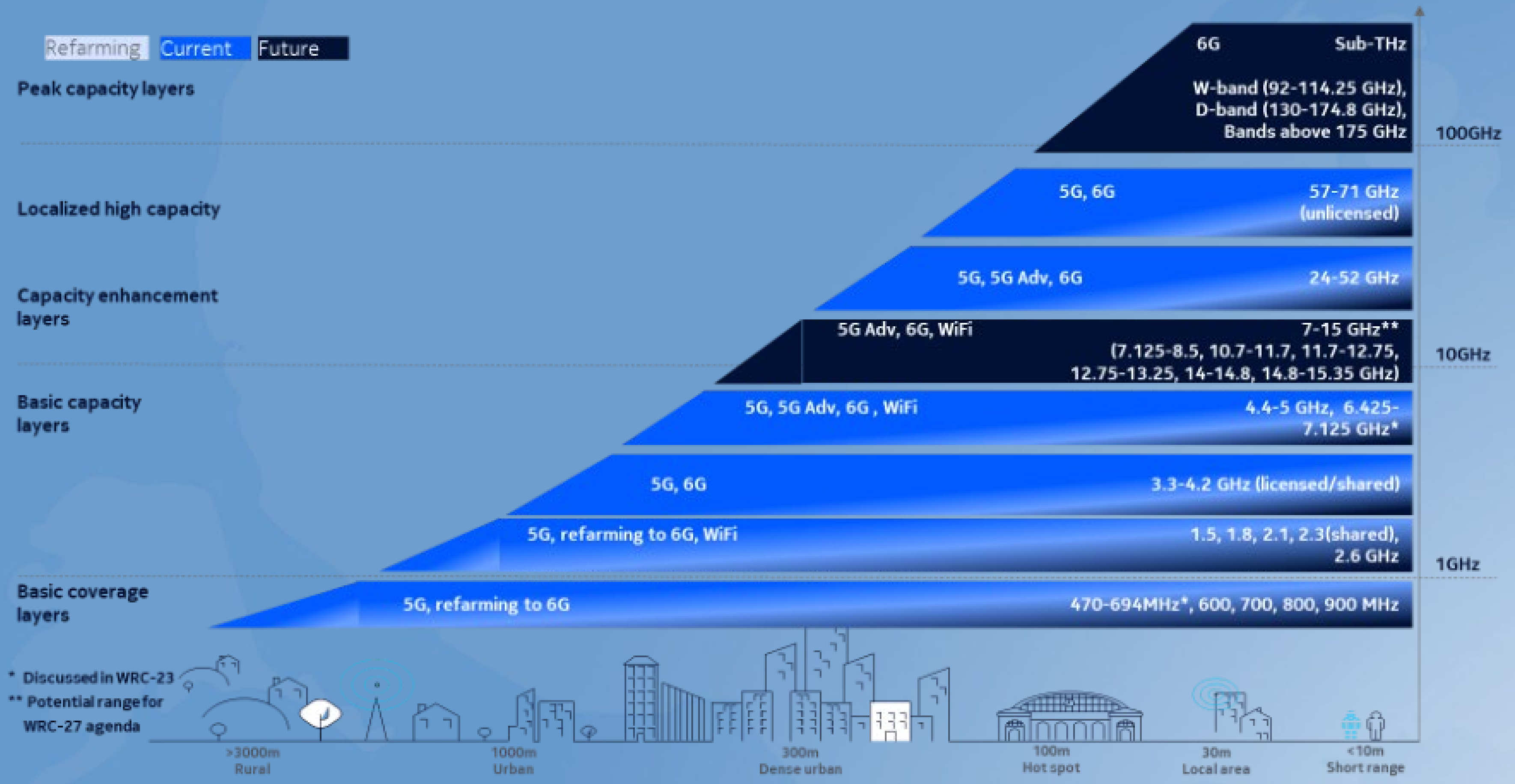
Sharing Scenarios And Use Cases

- **Mobile broadband with licensed spectrum:** this is the traditional wide area commercial mobile service as it evolves from 5G to 5G-Advanced/6G in the foreseeable future.
- **Wireless broadband with unlicensed spectrum:** evolution of wireless local area networks, e.g., Wi-Fi, to deliver enhanced performance with Wi-Fi 7 and beyond.
- **Local licensing:** used by private entities/enterprises within a relatively small geographic area (e.g., campus, factories, warehouses, stadium, airports etc.)
- **Indoor use:** to be used only indoors, to minimize interference with outdoor incumbent deployments; low power in conjunction with building penetration loss will mitigate interference.
- **Low Power Wide Area Networks (LPWAN):** such as IoT/sensor networks where the systems and applications are designed such that wide area coverage is achieved without high power communication, which reduces interference to other services in the same or adjacent bands.
- **Geographic regional licensing**, covering areas larger than typically covered for local licensing.
- **Point-to-Point or Point-to-MultiPoint communication networks:** these services focus on directed communications so may not cause interference to other services so long as some geographical separation is maintained or directional transmission is employed.

Band Preference for Terrestrial Wireless Use Cases



- **7.125 - 8.5 GHz:** of interest to Wi-Fi and terrestrial mobile.
- **8.5 - 10.6 GHz:** Low-power UWB. Studies are needed to understand opportunities for other licensed or shared allocations in this range, coexisting with federal use.
- **10.7 - 13.25 GHz:** Minimal federal allocations. Significant use of commercial satellite in parts of this spectrum.

Spectrum Sharing Dependencies

- **New entrant capabilities**: Understand the interference mitigation capabilities; avoid causing harmful interference that degrades the performance of incumbents (as well as other potential new entrants) ; be resilient to acceptable levels of interference from other users of the spectrum.
- **Incumbent capabilities and limitations**: Understand the interference susceptibility of existing users; develop features to accept a certain level of interference from new entrants and capacity to minimize interference towards new entrants. Continuous technology upgrades to improve Tx/Rx performance and related spectrum utilization.
- **Frequency and time coordination capabilities**: Assess the needs of all users of a given spectrum band and enable situational awareness. All users may not need the entire spectrum range all the time.
- **Interference reporting mechanisms:** Ability for both incumbents and new entrants to report interference (beyond harm-claim thresholds) to aggressor so that aggressor systems can take appropriate actions.

Spectrum Sharing Examples

Sharing Situation	Share by Geographic Separation	Share by Time Separation	Centralized/ Database Managed	Aggregate Interference	Incumbent Sensing	Note
TV White Space	X		X			
CBRS	X	X	X	X	X	
6 GHz AFC	X		X			
AMBIT (3.45 GHz Service)	X	X		X		Operators coordinate directly with DoD
AWS						Operators coordinate directly with government
5 GHz DFS	X				X	

- Incumbent Responsibilities for Future Shared Systems:
  - Coordinate with the secondary users in a fair and reasonable manner to help maximize shared use while reducing the risk of harmful interference to the incumbent.
  - Provide feedback to the secondary users on the interference environment encountered in practice.
  - Revisit technical assumptions as the sharing environment evolves to either implement more conservative sharing assumptions if harmful interference is shown to occur in practice, or conversely, move to more liberal assumptions if harmful interference rarely or never occurs.
  - In an informing incumbent environment, avoid reserving spectrum resources when not needed, and relinquish resources expeditiously when no longer needed. For example, minimize reservations in geography, frequency, and time to only those that are truly needed to meet mission objectives.

New Sharing Frameworks

- **Dynamic Sharing using Active Antennas**: active antennas and related technologies, such as beamforming and massive MIMO, can be used to transmit signals in directions that are desired, while reducing emissions in other directions, such as towards incumbents.
- **Multi-tiered access**: CBRS implemented a 3-tiered access mechanism which has since not been used. There are appealing aspects to this method, such as making more spectrum available for lower tier users when higher tier users have not deployed in a spectrum band and preventing of spectrum warehousing by higher tier users. Can result in improved spectrum utilization.
- **Hybrid Sharing**: Proposed recently by Ofcom: sharing between incumbents, licensed and unlicensed users either on an outdoor-indoor basis or on urban-rural basis. Practicality under investigation, but may be useful depending on incumbent and new entrant use cases.

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Characteristics of Incumbent Services

Spectrum sharing opportunities with incumbent services depend upon multiple fundamental criteria (and combinations thereof):

- Whether the services are ubiquitous or limited in geography.
- Whether the services are intermittent or continuous, including the level of susceptibility to interference from other users of the spectrum; (this may include an analysis of impact to operations of any class of users from interference).
- Whether the services always need the entire spectrum range.
- National security considerations, including the level of transparency possible between concurrent or shared uses of the spectrum.
- Technology/service sunset/evolution, including repacking possibilities and incentive mechanisms to enable transition of obsolete equipment towards a more efficient utilization of spectrum. Continuous technology upgrades by incumbents to maximize spectrum utility should be encouraged.

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Selecting potential bands for sharing

There are several factors that need to be considered in the process of identification of bands that may be suitable for sharing between incumbent services and wireless communications:

- Band characteristics (lower vs. upper part of the 7.125 - 24 GHz band): the lower part, 7.125 - 15 GHz, is more desirable for wireless communications.
- Amount of spectrum likely available: while carrier aggregation across the entire spectrum band is theoretically possible, it increases complexity and cost, especially impacting user equipment.
- Incumbents in potential wireless communications deployment bands and adjacent bands:
  - Current and future spatial, directional (UL/DL) and temporal usage.
  - Corresponding power levels, in-band and out-of-band emission regulations and protection requirements.
- Special protection requirements of certain incumbent services, e.g., passive services, special federal operations, etc.
- Lead time for any clearance requirements: some services may require a long time to migrate to another frequency range.
- Usage by neighboring countries: important for coordination at borders.

Global harmonization: important for economies of scale

Recommendations: (1) Required Data

Various types of data are necessary to make spectrum sharing a successful effort:

- FCC and NTIA should work together to perform a detailed quantitative assessment for 7.125 - 24 GHz that is similar to the one that was done in 2016 for select bands up to 3.5 GHz. A more recent example of such data is included in NTIA's comments on 12 GHz, which provides details of unclassified federal usage in 12.7 - 13.25 GHz.
- Public information about actual spectrum usage (not just allocations) should be collected in an online website, e.g., 'Spectrum Wiki" which should be kept updated.
- Information on spectrum occupancy for federal users similar to what is being requested by the FCC for non-federal users: a process by which classified information can be shared may be necessary to implement this. Non-federal usage data should include both terrestrial and non-terrestrial usage.
- Additional data from past spectrum sharing techniques and lessons learned, e.g., building on NTIA's CBRS assessment with measurements.

Recommendations: (2) Potential Bands for Sharing

- The working group's preliminary list of potential spectrum ranges suitable for sharing, based on the limited information available at this time are listed below. All of the these frequency ranges will require extensive analysis to determine spectrum sharing methodology, new entrant applications and operational parameters that will protect co-channel and adjacent channel incumbents from harmful interference.
  - 7.125 – 8.5 GHz, for sharing with federal fixed, fixed satellite and mobile satellite services.
  - 10.7 – 13.25 GHz for sharing with non-federal satellite (there is an NPRM on 12.7 – 13.25 GHz and FNPRM in 12.2 – 12.7 GHz).
  - 14.0 - 14.2 GHz for sharing with space research.
  - 17.8 – 18.6 GHz and 18.8 – 20.2 for sharing with federal satellite. Additional analysis need to be done with regard to commercial satellite use of this part of the spectrum.

- Target amount of spectrum required for terrestrial wireless communications is approximately 2 GHz, preferably in the 7.125 - 15 GHz range. Potential ways that this need can be met:
  - **Contiguous s**pectrum that is **partly exclusive** for wireless communications and **partly shared** with incumbents.
  - **Non-contiguous** spectrum that is **partly exclusive** for wireless communications and **partly shared** with incumbents.
  - **Contiguous** spectrum that is **fully shared** among incumbents and wireless communications services.
  - **Non-contiguous** spectrum that is **fully shared** among incumbents and wireless communications services.

Recommendations: (3) Future Work

There are a significant number of activities that a future TAC may want to pursue as a follow-up to this effort:

- Assess spectrum needs of the country with a holistic view – scientific, federal and commercial, terrestrial and non-terrestrial, fixed and mobile. Assess sustainability and energy efficiency issues as new bands are added.
- Evaluate emerging spectrum sharing techniques, for example, using active antenna arrays in addition to evolving spectrum sharing techniques used in CBRS and AMBIT bands to move towards dynamic sharing.
- Implement a specific project to investigate possible practical implementations of spectrum sharing techniques with collaboration between relevant federal and commercial entities, including sharing of real-time or near real-time data that may be necessary for such solutions. The required information will include current allocations, actual usage of spectrum, protection criteria for services in the band as well as for sensitive (e.g., passive, scientific or military) services in adjacent bands.
- Develop a real-time database to assess spectrum utilization with sensors and measurement entities; this database may be supplemented with crowdsourced data. This is required for federal and non-federal bands.

Thank You

FCC Technological Advisory Council Agenda – August 17, 2023

10am – 10:30am	Introduction and Opening Remarks •Welcome Message (TAC Chair) •Opening Remarks by OET Chief •DFO/Deputy DFO Remarks •Member Introduction/Roll Call
10:30am – 11:15am	Emerging Technologies WG Presentation
11:15am – 12:00pm	Advanced Spectrum Sharing WG Presentation
12:00pm – 1pm	Lunch Break
1pm – 1:45pm	AI/ML WG Presentation
1:45pm – 2:30pm	6G WG Presentation
2:30pm – 2:45pm	Closing Remarks
2:45pm	Adjourned

Federal Communications Commission Technological Advisory Council Meeting

(Lunch Break)

August 17, 2023

FCC Technological Advisory Council Agenda – August 17, 2023

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FCC TAC

Artificial Intelligence, Machine Learning, and Computing Working Group - AIWG

AIWG WG Chairs: Lisa Guess, Cradlepoint/Ericsson
Adam Drobot, OpenTechWorks, Inc.

Safe Uses of AI SWG Chairs: Mark Bayliss, Visual Link
Nomi Bergman, Advance

FCC Liaisons: Chrysanthos Chrysanthou, Kambiz Rahnavardy, Patrick Sun,
Sean Yun, Michael Ha, Martin Doczkat

Date: August 17th , 2023

Agenda

Artificial Intelligence, Machine Learning, and Computing - AIWG

- Working Group
  - Members
  - Charter and Topic Areas
  - SME Speakers
- Overview and Observations
  - State of AI/ML
  - Operational Aspects of AI/ML and Computing and Data Curation
  - A Lifecycle View of AI/ML Use Cases in Telecommunications
- Recommendations
- Suggestions for 2024
- Appendices

A. AI & ML Hype Curves 2019-2023	E. FCC Strategic Plan
B. Creating AI & ML Models	F Selected Portions of US Code Involving the FCC
C. Data Glossary for AI &ML Applications	H. AIWG Recommendations from 2022
D. SME Speakers	G. Sample Use Case Details

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AIWG Members

Name	Organization	Name	Organization
Mark Bayliss	Visual Link	Nageen Himayat	Intel
Nomi Bergman	Advance/Newhouse	Greg Lapin	ARRL
Dean Brenner	TAC Chair	Jose Mejia	RapidSoS
Cagatay Buyukkoc	Deutsche Telecom	Amit Mukhopadhyay	Nokia Bell Labs
Krishna Chintalapudi	Microsoft	Jack Nasielski	Qualcomm
Martin Cooper	Dyna LLC	Mike Nawrocki	ATIS
Andrew Clegg	WIE, Google	Jon Peha	CMU Metro21
Adam Drobot	OpenTechWorks	Balaji Raghothaman	Keysight
Brian Daly	AT&T	Andy Scott	NCTA
Monisha Ghosh	Notre Dame	Mariam Sorond	VmWare
James Goel	Qualcomm	Michelle Thompson	ORI
Lisa Guess	Ericsson (Cradlepoint)	Tom Van Meter	Juniper
Jason Livingood	Comcast Corporation		

Charter and Topic Areas

For 2023 there were five items in the Artificial Intelligence, Machine Learning, and Computing Working Group (AIWG) Charter as a continuation of work done in 2022.

1. Expand pilot project proposal(s) from the 2020 TAC session to provide details and associated quality metrics that will allow the Commission to explore, extract the value, and gauge the success of implementing AI/ML techniques.

2. Explore the use of AI/ML methods and techniques to improve the utilization and administration of spectrum (licensed, unlicensed, and shared) by addressing the fundamental aspects of propagation, interference, signal processing, and protocols.

Charter and Topic Areas

For 2023 there were five items in the Artificial Intelligence, Machine Learning, and Computing Working Group (AIWG) Charter as a continuation of work done in 2022. (continued)

3. 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 software-ized.

4. Consider the implications of AI/ML adoption by content providers and the impact on consumers, focusing on understanding causes of and approaches to dealing with addictive behaviors.

Charter and Topic Areas

For 2023 there were five items in the Artificial Intelligence, Machine Learning, and Computing Working Group (AIWG) Charter as a continuation of work done in 2022. (continued)

5. Formulate a better understanding of uses of AI/ML that may result in modification of human behavior, to develop sound policies that encourage positive outcomes (e.g., public health measures, and other benefits) and mitigate against negative outcomes.

Charter and Topic Areas

The AIWG has taken the five items in the Charter and organized them as four broad Topics.

Subject	Area Covered	Responsibility
Topic 1	AI/ML Pilot Projects for the FCC	AI/ML Working Group
Topic-2	Safe Uses of AI (Impacts on Consumers, the Network, and the FCC – Security, Privacy, Trust, Assurance)	Safe Uses of AI Sub – Working Group
Topic-3	Use of AI/ML and Computing for Spectrum Sharing	AI/ML Working Group
Topic-4	Use of AI/ML in Telecommunication Networks (present and future)	AI/ML Working Group

SME Speakers

	Speaker	Org	Subject	Date
1.	Tao Zhang	NIST	6G and AI/ML	June 21
2.	Venki Ramaswamy	Mitre	6G and AI/ML	July 12
3.	Martin Zoltick Magali Feys	RothwellFigg AContrario	AI Legislation Status US AI Legislative Status EU	July 19
4.	Ravit Dotan	Move AI Ethics	Making Data Technologies Safe	July 20
5.	Harish Viswanathan	Nokia Bell Labs	AI Native 6G	July 26
6.	Hubert Etienne	Meta	AI Ethics	July 27
7.	Daniel Rohrer	NVIDIA	AI Security	August 3

Overview and Observations

State of Artificial Intelligence and Machine Learning

The last year saw considerable advances in AI and ML

- Continued evolution of Computing Infrastructure for AI/ML including Cloud Services, Edge AI, specialized Inference Engines, and Compute Accelerators
- Recognized impact of large data sets on model performance
- Emergence of Generating AI
- Greater Public and Legislative attention focussed on AI/ML

Overall, AI & ML is still on a learning curve with both spectacular successes and significant challenges seen over a wide range of applications.

A useful source: https://aiindex.stanford.edu/report/

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Overview and Observations

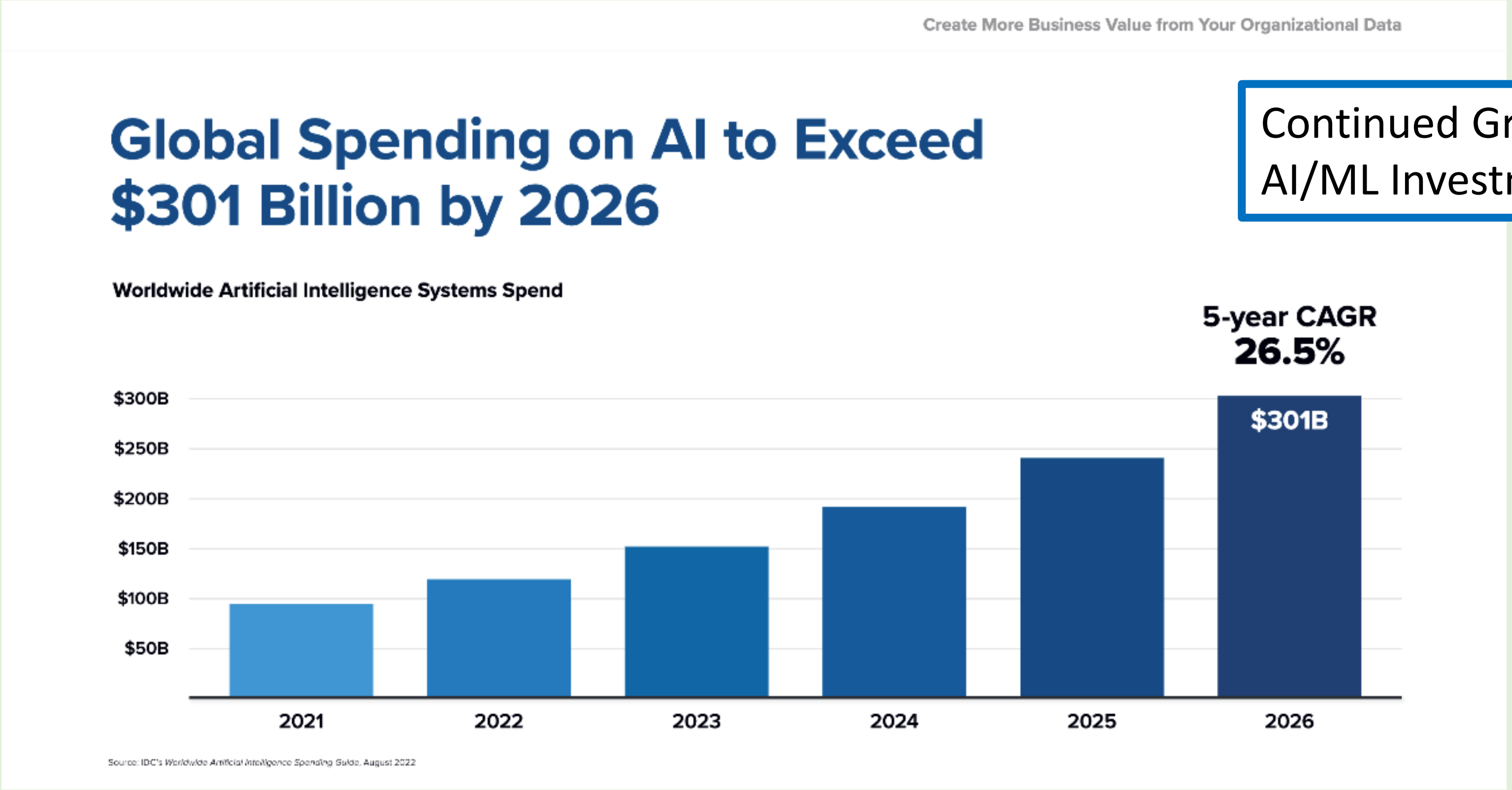
State of Artificial Intelligence and Machine Learning

In 2023 Generative AI is dominating discussions on AI and has reached the Peak of Inflated Expectations, together with foundation models, which have become bigger and exhibit behaviors that display human-level performance on a variety of complex comprehension tasks. The hype surrounding these models, often in news and media, generally focuses on cherry-picked examples of output rather than a realistic assessment of their strengths and weaknesses. There is still a large gap between the expected potential impact and actual usage,

Sources: IDC and https://hbr.org/2023/06/the-ai-hype-cycle-is-distracting-companies

Overview and Observations
Global Spending on Artificial Intelligence

State of Artificial Intelligence and Machine Learning



Continued Grown in AI/ML Investments

Source: https://pages.dataiku.com/report-idc-2023

Overview and Observations
Federal Investments

State of Artificial Intelligence and Machine Learning

https://www.ai.gov/naiio/

Coordination of Us Federal Investments

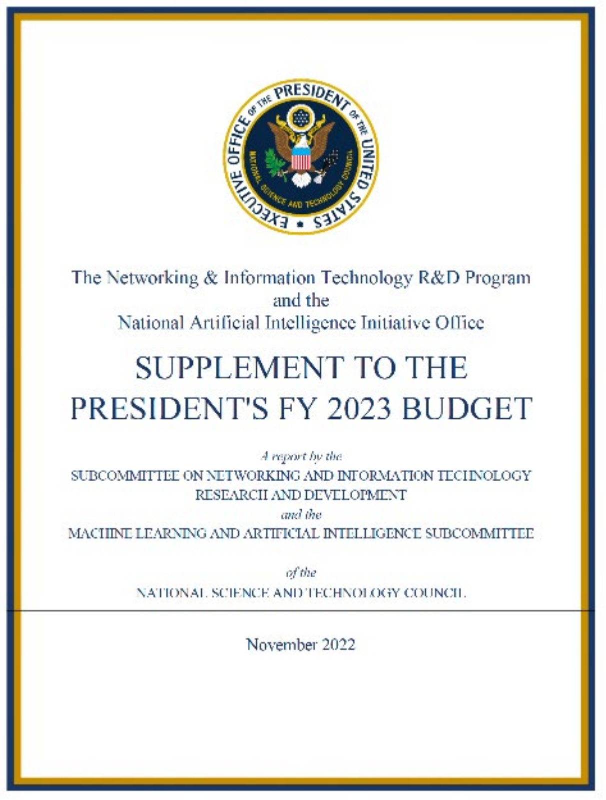
NITRD

https://www.nitrd.gov/coordination-areas/wsrd/

A Major Area for Federal Initiatives

Overview and Observations
Federal Investments

State of Artificial Intelligence and Machine Learning


The Networking & Information Technology R&D Program
and the
National Artificial Intelligence Initiative Office

SUPPLEMENT TO THE
PRESIDENT'S FY 2023 BUDGET

A report by the
SUBCOMMITTEE ON NETWORKING AND INFORMATION TECHNOLOGY
RESEARCH AND DEVELOPMENT
and the
MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE SUBCOMMITTEE

of the
NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

November 2022

Table 2.1-4. NITRD Agency Budgets for AWN R&D, FYs 2021–2023

FY	Agencies							TOTALS
	DARPA	DoD/Navy	DOE/NNSA	DOT/FRA	NIST	NSF	NTIA	
2021	27.0	12.3	0.8	0.0	9.0	130.9	10.3	190.2
2021-S	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.6
2022	26.5	12.8	1.6	1.0	8.7	130.2	11.3	192.1
2022-S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2023	39.4	16.7	2.0	0.0	18.8	166.3	11.1	254.3

Notes for Table 2.1-4:
- Figures break out those portions of NITRD member agencies' R&D investments in the ACNS PCA (formerly LSN) that are primarily dedicated to advanced wireless networks.
- Fiscal years with "-S" after them denote supplemental funding.
- Amounts are in U.S. dollars in millions.
- DOE/NNSA and DOT/FRA are new this fiscal year.
- AWN R&D investments are typically coordinated through NITRD's WSRD IWG.
- Totals might not sum exactly as a result of rounding.

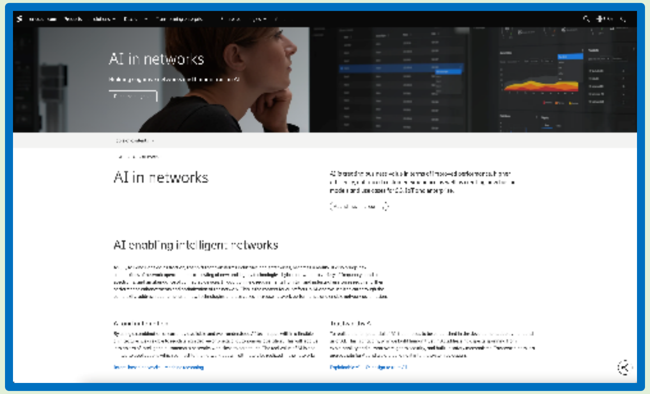
AWN: Advanced Wireless Research

Total US Federal Annual Investment > $3B

Source: https://www.ai.gov/naiio/

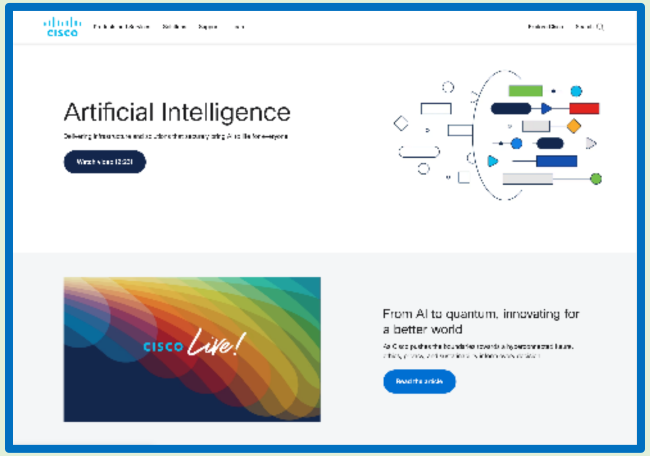
A Major Area for Federal Investments

Overview and Observations
Initiatives by many leading Network Equipment Providers (Examples)

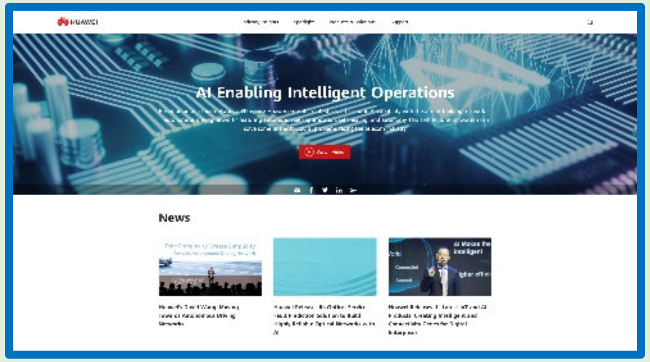


https://www.ericsson.com/en/ai

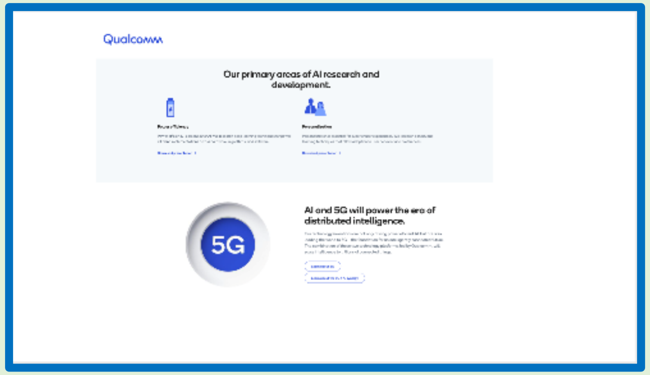
https://www.bell-labs.com/research-innovation/what-is-6g/6g-technologies/ai-native-air-interface#gref



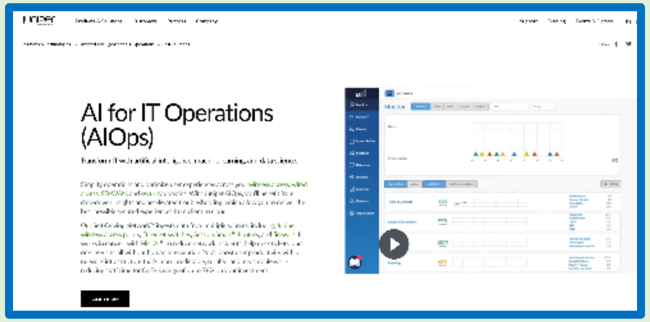
https://www.cisco.com/site/us/en/solutions/artificial-intelligence/index.html



https://carrier.huawei.com/~/media/cnbgv2/download/products/wireless-network/ai-in-network-en.pdf



https://www.qualcomm.com/research/artificial-intelligence



https://www.juniper.net/us/en/solutions/artificial-intelligence-for-it-operations-aiops.html

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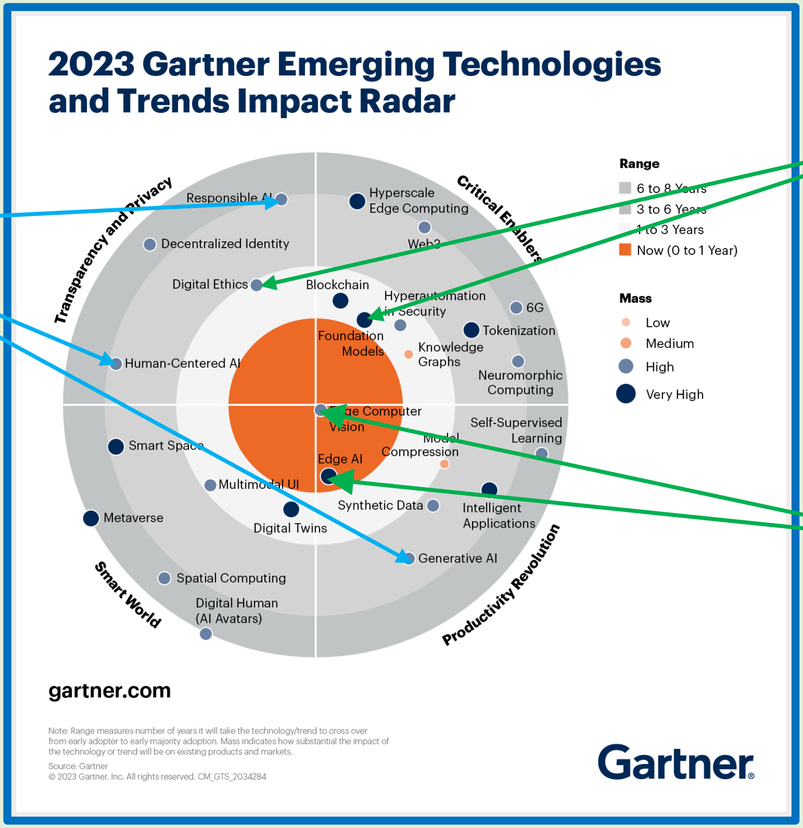
Overview and Observations

State of Artificial Intelligence and Machine Learning

3 to 6 Years

The accompanying Artificial Intelligence and Machine Learning Hype Curves Appear in Appendix A



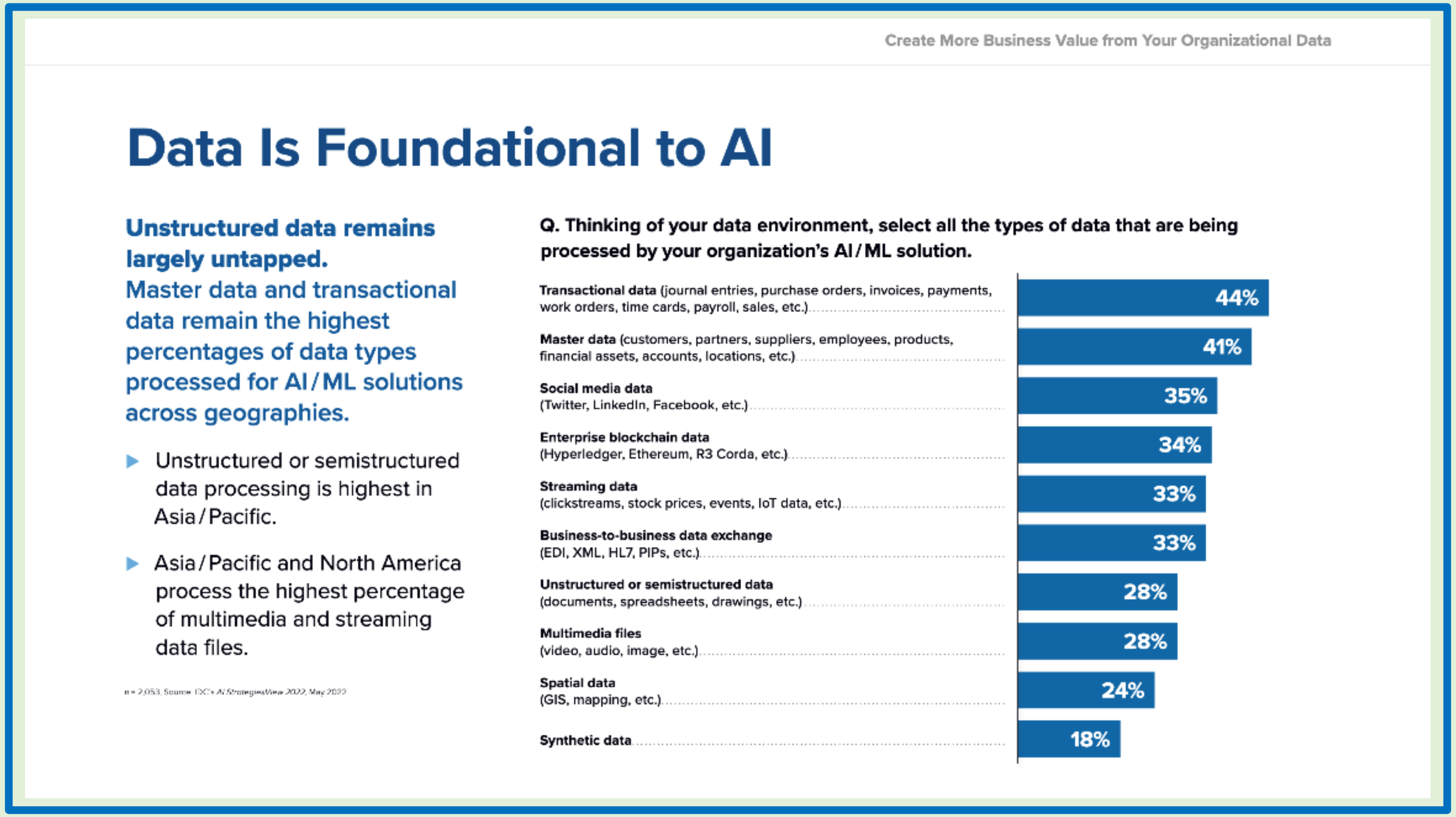
1 to 3 Years

Existing Or Near Term

Heightened Expectations of Future Progress and Impact

Overview and Observations

State of Artificial Intelligence and Machine Learning



Source: https://pages.dataiku.com/report-idc-2023

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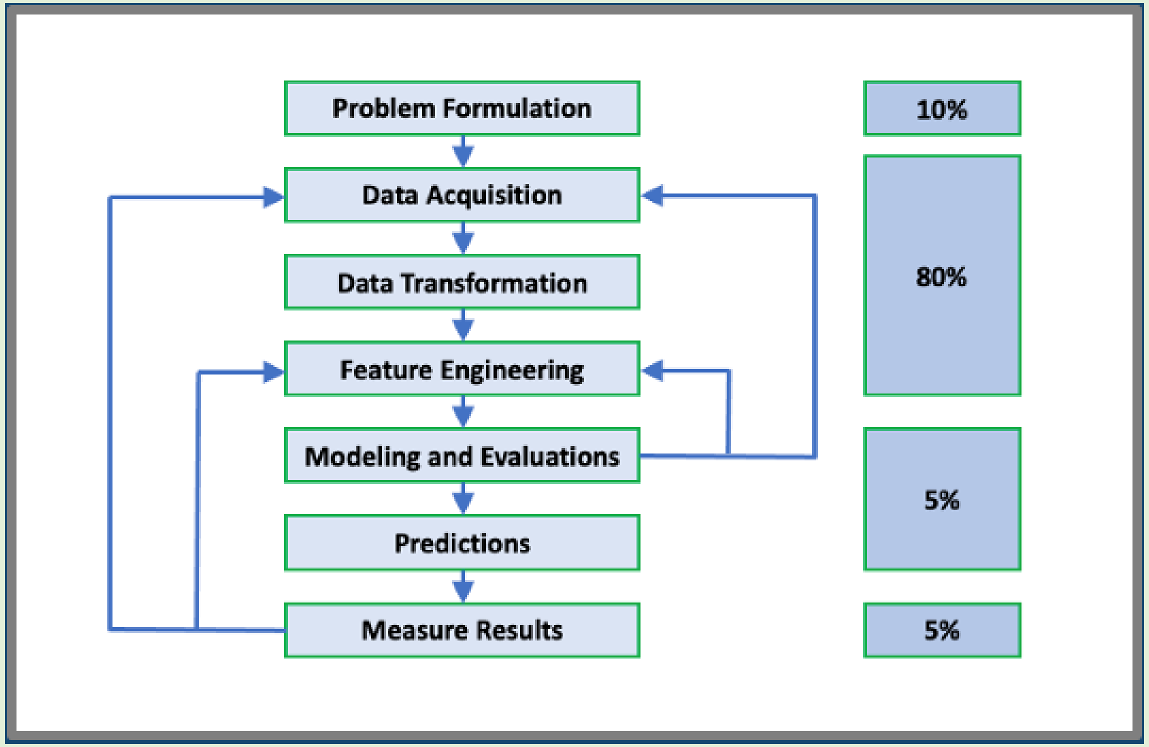
Findings

- ➢A Few Factoids as a guide
  - ➢ Over 90% of Data Stored Digitally was created in the last two years
  - ➢Between 2% and 4% of that Data was used
  - ➢Less than 0.1% of that data was analyzed
  - ➢Between 25million and 50 million people around the world were involved in collecting and curating data.

➢ The experts we heard from stressed that the art of picking the "right data" and the "right model" play a significant role solving a specific problem, but the overwhelming effort usually goes into the collection and curation of the data itself.

From 2022 FCC TAC Final Briefing

The AI/ML Solution Cycle



Overview and Observations

State of Artificial Intelligence and Machine Learning

Considerations for Data

1. AI/ML Models Require Use Case Specific Data
   - Models must be sufficiently contained that they are scalable and can achieve required levels of performance (speed, levels of false positive and negatives, and limit unpredictable behaviors)
   - The data required must match the dimensionality of the model in providing a high level of coverage for learning and training.
2. Data for AI/ML Models often comes from many sources and is collected using a variety of techniques (it is crucial that data fom different sources can be co-registered and fused) The sources may include:
   - Device Instrumentation (Use case specific measurements and campaigns)
   - Prevailing Conditions (Often from third party sources)
   - Characterization and prevenance information
   - Historical data
   - Synthetic data from Simulation/Emulation
   - ……………….

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Overview and Observations

State of Artificial Intelligence and Machine Learning

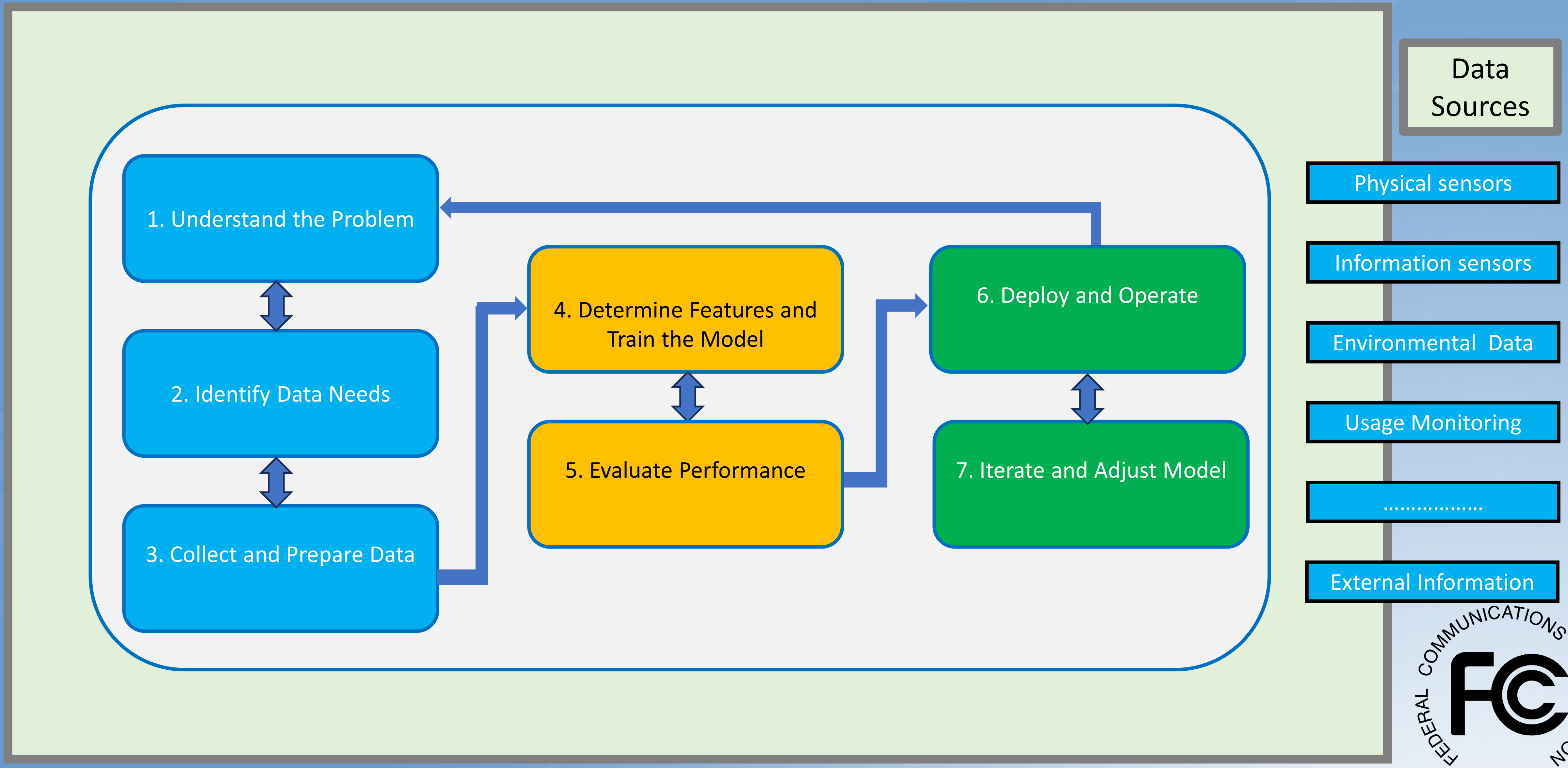
Considerations for Data (continued)

3. Data Governance and Best Practices
    - Lifecycle Management and Curation
    - Retention and oversight policies
    - Mechanisms for Data Sharing across all modalities when appropriate (using security and privacy technologies to protect proprietary competitive, and sensitive information)
    - Policy filters on data collection (relevance, value, and period of retention)

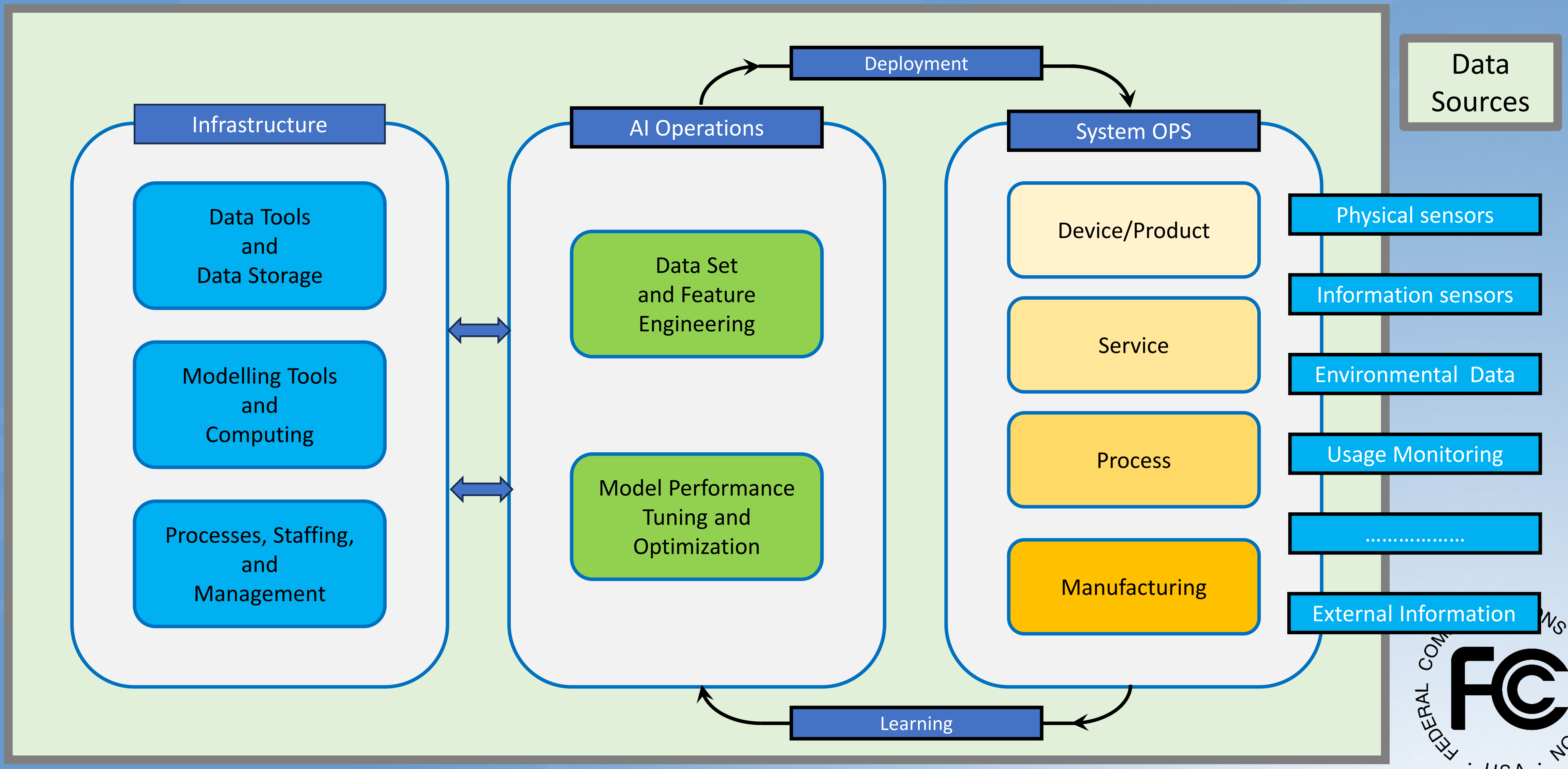
4. Data Catalogs making Data available for multiple uses – getting away from single use project centric data approach. This eases the burden on individual projects and encourages sharing within and across organizations. Clean data sets to support activities from research to operations.

5. Encouraging open sharing of Models and Data

Creating AI and ML Models



AI and ML in Operation



Network and Technology Life Cycle

- Network Generations Lifecycle View – Focus on the Next Generation AI – Native Network
  - Technology Research & Development
  - Operational and Management Practices
  - Network Lifecycle Phases
    - Design
    - Development
    - Deployment
    - Operation
    - Maintenance and Upgrades
    - Retirement

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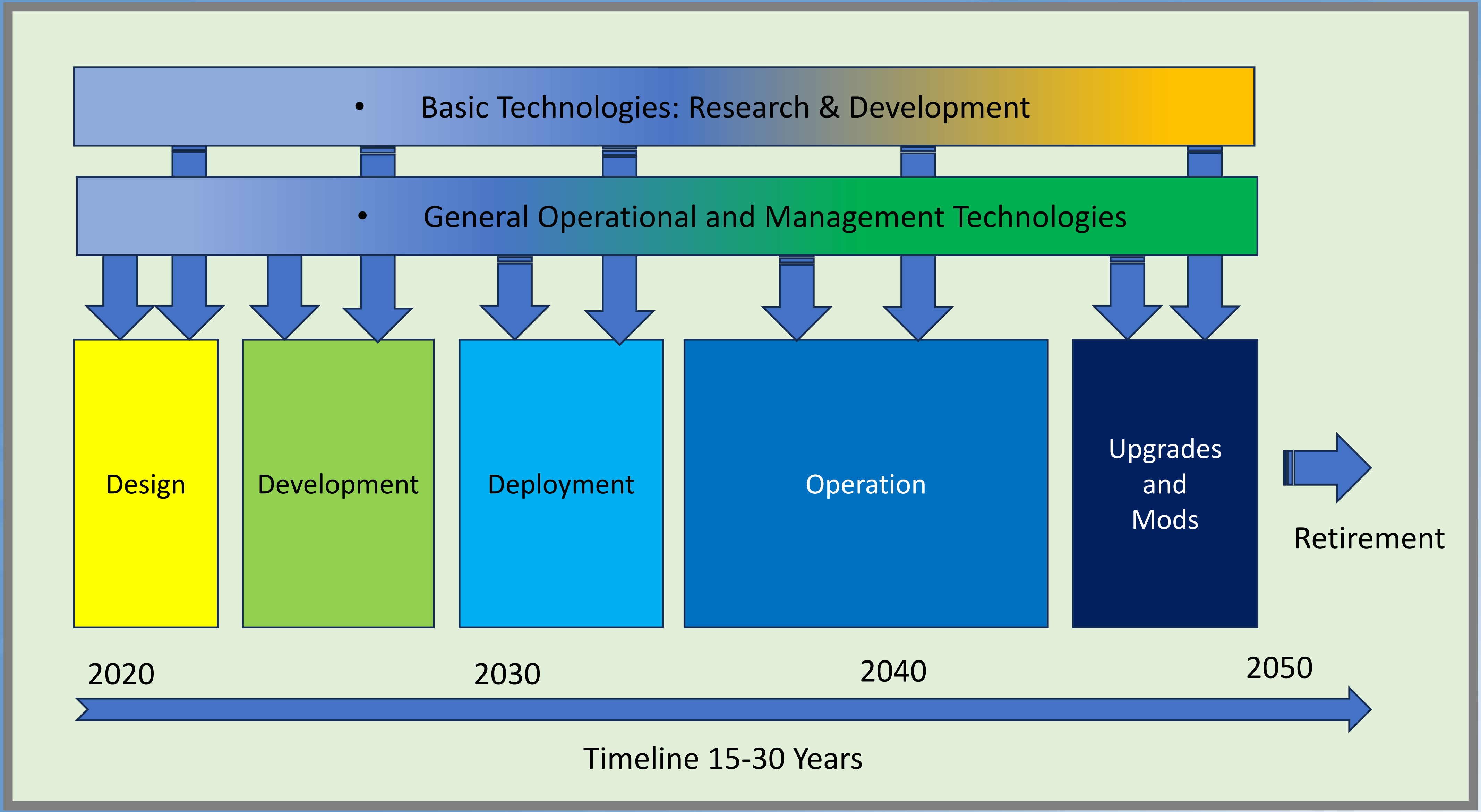
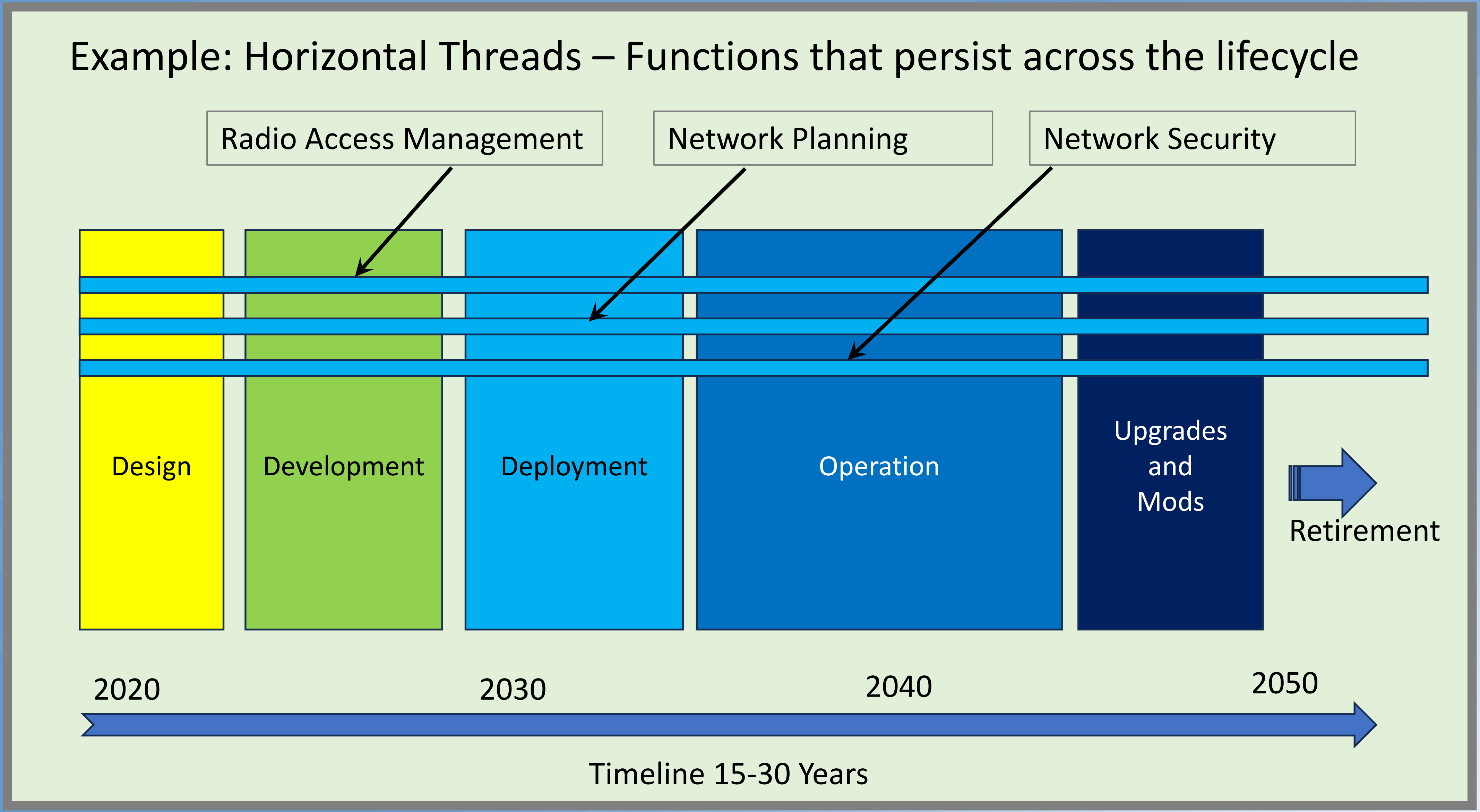
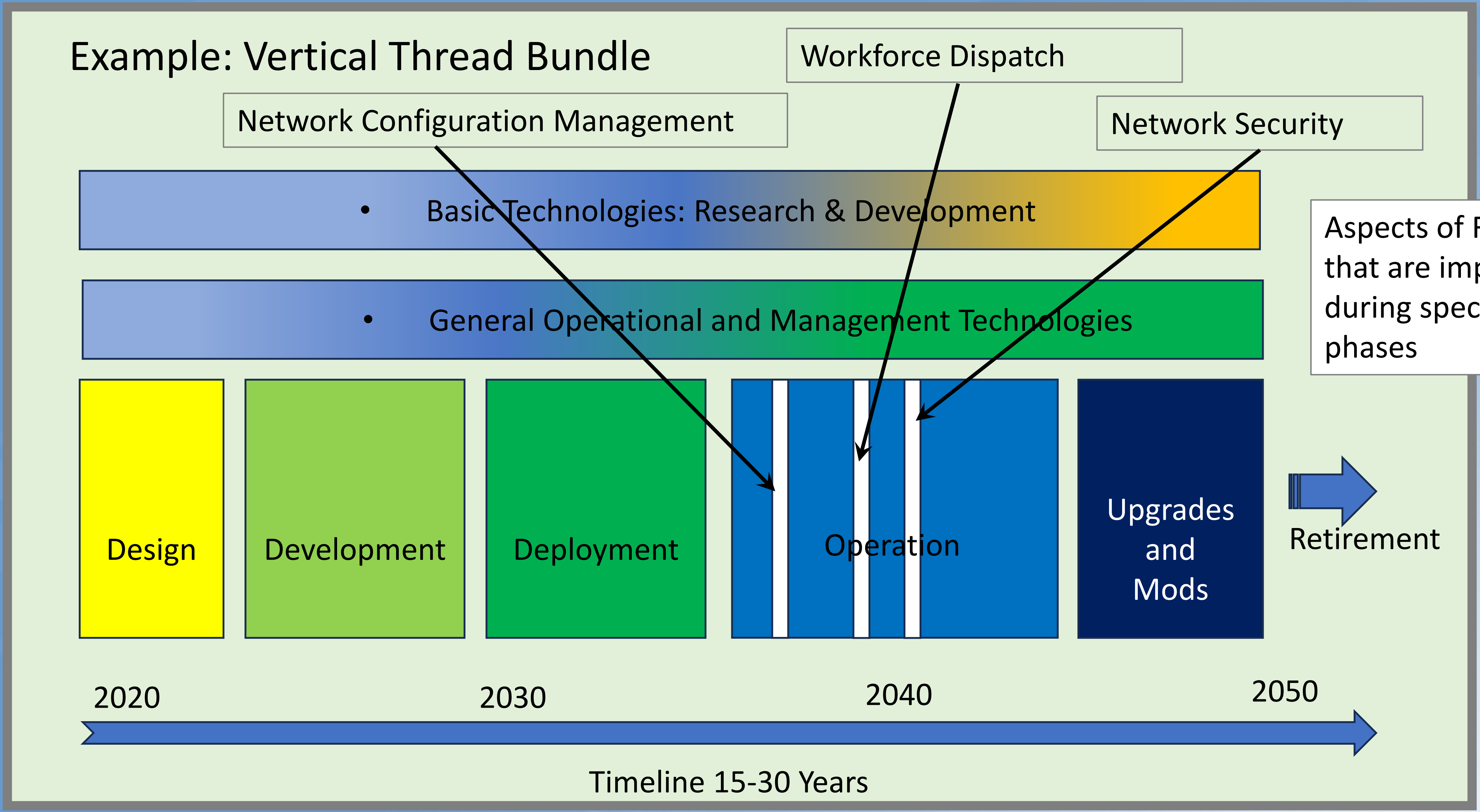
Network and Technology Life Cycle



Network and Technology Life Cycle



Network and Technology Life Cycle



Topic 4: Use of AI/ML in Telecommunication Networks

Example : Technology Research & Development (AI/ML Use Cases)

Aspect	
Phenomenology	Electromagnetic environment, Propagation, Spectrum use, Identity of emission sources, Interference, Prediction of traffic patterns.
Intrinsic Requirements	Testability and Verifiability, Availability, Evolutility, Reliability, Resilience, Trust, Security, Privacy, Assurance, ……
Physical and Software Components	Component Design (Amplifiers, Antennas, Filters/Masks, ……), Compensation techniques (Linearization ….), Radio design, Signal Processing, Protocol Design, Air Interface Design (AI Native …..)
System Design and Architecture	System Optimization, System Planning, Complex and Robust Control Systems, Optimization of Heterogenous Systems, MIMO Antenna Control, Frequency assignments, power, down angles, etc., …..
Network Management	Spectrum assignment, Beam Forming Antennas and Control Systems, Realtime Resource Assignment and Optimization, Admission Management, Automated Dynamic Spectrum Sharing, …..

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Topic 4: Use of AI/ML in Telecommunication Networks

Example - Operational and Management Practices (AI/ML Use Cases)

Aspect	
Configuration Management	Realtime testing and reporting, Configuration Optimization, Automation of Configuration Settings, Policy Compliance, …..
Monitoring and Troubleshooting	Root cause identification [Correlations, Diagnostics, Prognostics Predictive Maintenance, Intelligent automated testing (built in testing), Mitigation,….], AI Ops, Devops, etc…..Network Security and Assurance (Threat detection and mitigation, recovery, …….)
Workforce Management	Marshalling yard management, Crew and Vehicle assignment, Dispatch, Support and chase crew routing, Training, ……..
Asset Tracking	Asset inventory, condition, utilization, failure analysis, …….
Customer Facing Operations	Intelligent customer interaction interfaces, Customer care management, Experience personalization, ……

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Topic 4: Use of AI/ML in Telecommunication Networks

Example - Network Lifecycle – Design (AI/ML Use Cases)

Aspect	
System Level Network Design	Characterizing EM Environment at a local level and a systems level, Projecting Traffic/usage patterns, Network Operations Centers, Site specific building and equipment enclosure design, Integration Approaches, Design Documentation, ….
Component and Functional Design	Radio Design (Transmitters, Receivers, …..), Amplifiers, Filters, Antennas, Signal Processing Chain, Packaging, Mechanical components, software architecture and design,
Implementation Design	Site Surveys, Code Compliance, Site Engineering, Coexistence with legacy systems, Infrastructure Support (Power, Processing, Storage, ….), Capacity Planning, Backhaul requirements, Network Disaggregation, ….

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Topic 4: Use of AI/ML in Telecommunication Networks

Example - Network Lifecycle – Operation (AI/ML Use Cases)

Aspect	
Operational Support Systems and Network Management	Enforcement of regulatory policies, Establishing backup processes and capacity, Dealing with large events Security and trust framework management including preventive action,……….
Network Control Systems	Network Control, Mobility management, RAN Operation, Interaction with supporting infrastructure (power, storage, compute), Network restoration, Bandwidth Queues and edge cache management(leveraging AI for optimization),…
Customer Care	CPE Management, Subscriber management, Customer Billing, Customer Assistance, Customer Contact, Customer Experience, Retail Outlet Management, Helpline,……
Workforce Management	Workforce training and continuous education, Workforce deployment and dispatch, Fleet management support. Continuous learning from customer installation engagements……..

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Overview and Observations

Summary of Key Observations:

The exploration of AI/ML Methods is pervasive for Network Functions and Network Support Systems across the Network Lifecycle.

- Automation of Control Function
- Network Management
- Network Planning
- Emergency Response and Network Recovery
- Network Security

- Compliance
- Supply Chain Management
- Optimization of Asset Utilization

- Customer Facing Functions and Services

Historically, Telecommunications has been and is a lead sector in the introduction of AI/ML in operations

Recommendation

Recommendations - Approach

Issues Addressed

1. Pilot Projects for the FCC
2. Safe Uses of AI and ML
3. Future Evolution of Spectrum Sharing
4. Use of AI/ML in Telecommunication Networks

Considerations

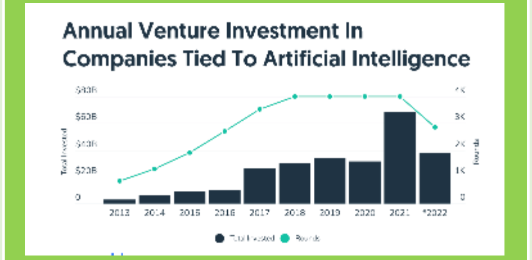
1. The FCC's Strategic Priorities
2. Industry Trends
3. Technology Maturity
4. Timeliness
5. Impact

The FCC
Service Providers
Consumers
Industry
The Public Sector

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



Inputs

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

Nature of Recommendations

- Data – A Critical Role for the FCC
- Build Capacity – Budgets and Resources
- Information Services – Driving Innovation and Leadership in Telecommunications
- Tools and Facilities – Moving beyond the Project!
- Balanced and Safe Use of AI/ML - A Foundation for the Future!

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Recommendations

1. **Data for AI/ML – A Critical Role for the FCC**

   Recommendation:

- The FCC should take an active and lead role, in coordinating the national agenda to provide data and data sets important to Telecommunications. The focus should be on critical problems that will advance Artificial Intelligence, Machine Learning, and other Analytical approaches that further the FCC's strategic goals and the same time the needs of Network Operators, Equipment Suppliers, Public Organizations , Consumers, and the Research Community. Examples of areas important for Telecommunications include data needed to improve models for propagation, interference, and spectrum use, that can lead to better management of spectrum. They also include methods for improved management of networks, network planning, and to support innovation of new services enabled by AI/ML.

- The actions that the FCC undertakes should include budgets and allocation of resources for curating and looking after critical data. In doing so the FCC should consider partnership opportunities with Industry, Academia, and other Government Organizations.

Recommendations

2. Organizational Capabilities and Capacity for AI/ML - Necessary Budgets and Resources

Recommendation

- FCC should make the necessary investments and create an internal AI-focused organization, staffed with experts spanning all facets of AI. The expertise should include the technical areas of AI and machine learning, the commercial, public and private use cases of AI, as well as the ethical, legal, security and privacy aspects of AI. The organization should have sufficient budget and resources to accomplish meaningful directives, as well as sufficient standing to genuinely influence outcomes in FCC and beyond.

Recommendations

3. AI native FCC Information Services – Driving Innovation and Leading in Telecommunications

Recommendation

- The FCC is an important source of information for the Telecommunications Industry and for Consumers. We urge the FCC to conduct a review of its information products and its mandates to create a long-range plan that provides its stakeholders with the best information services for a data driven world. This includes user interfaces and analytical capabilities that reflects the advantages of AI/ML based technologies.
- The plan should include the building of data catalogs that make it easier for stakeholders to ingest and utilize FCC supplied data in their routine activities and as a reliable source for their AI/ML operations. Without creating an undue burden, we urge the FCC to consider data mechanisms for the collection and dissemination of data that would advance best practices across the industry. The objective is to take advantage of AI/ML technologies to provide efficiencies and benefits for operators and consumers. This should include "Data" that is part of FCC proceedings.

Recommendations

4. Tools and Facilities For Capitalizing on AI – Moving beyond point projects!

Recommendations

• Use AI/ML tools to investigate systemic issues. Focus beyond just individual issues to broader scope organization-wide issues. Track single-session activities across all internal boundaries, using AI/ML to investigate internal processes. Use AI/ML pattern recognition to create dynamic feedback loops to pinpoint optimal paths along multiple parallel tracks in different administrative domains. Use AI/ML to see the broader picture hidden by all the details within individual sub-organizations.

• Use AI/ML to identify inaccurate inputs/data—for search, for content, for review. Process extremely large data sets with the goal of confirming accuracy, so that bad data is not used/cited in other areas of the organization.

• Use AI/ML to evaluate simulation/emulation systems to predict areas of concern. Allow "what if" scenarios to be explored. AI/ML analysis could broaden the scope of visibility for identifying the law of unintended consequences in the simulation.

Recommendations

5. Safe Uses of AI and ML in Telecommunications Networks and Network Services – The Foundation for Optimism in the Future!

Recommendation

We would encourage the FCC to explore the frameworks proposed by organizations that are dedicated to the safe use of AI/ML. Principal among these, as an example, is the EU AI Act. It is likely to have a pervasive impact, possibly as significant as GDPR. An important positive aspect of the EU AI act is the use of a risk-based framework, the questionable aspect is the overtly bureaucratic approach to enforcement. We recommend that the FCC should continue in conjunction with other relevant government agencies to convene a series of meetings and workshops on the topic to gather a broad view of the issues. The objective is to develop a balanced approach that mitigates the risks of AI/ML and at the same time harvests the benefits!

The WG felt that it did not have sufficient knowledge or expertise to make a primary and detailed determination of the issues concerning: (1) Affecting Human Behaviors; and (2) Addiction, and hence the way they should be approached

Suggestions for 2024

Suggestions for 2024

Suggestions for 2024 TAC

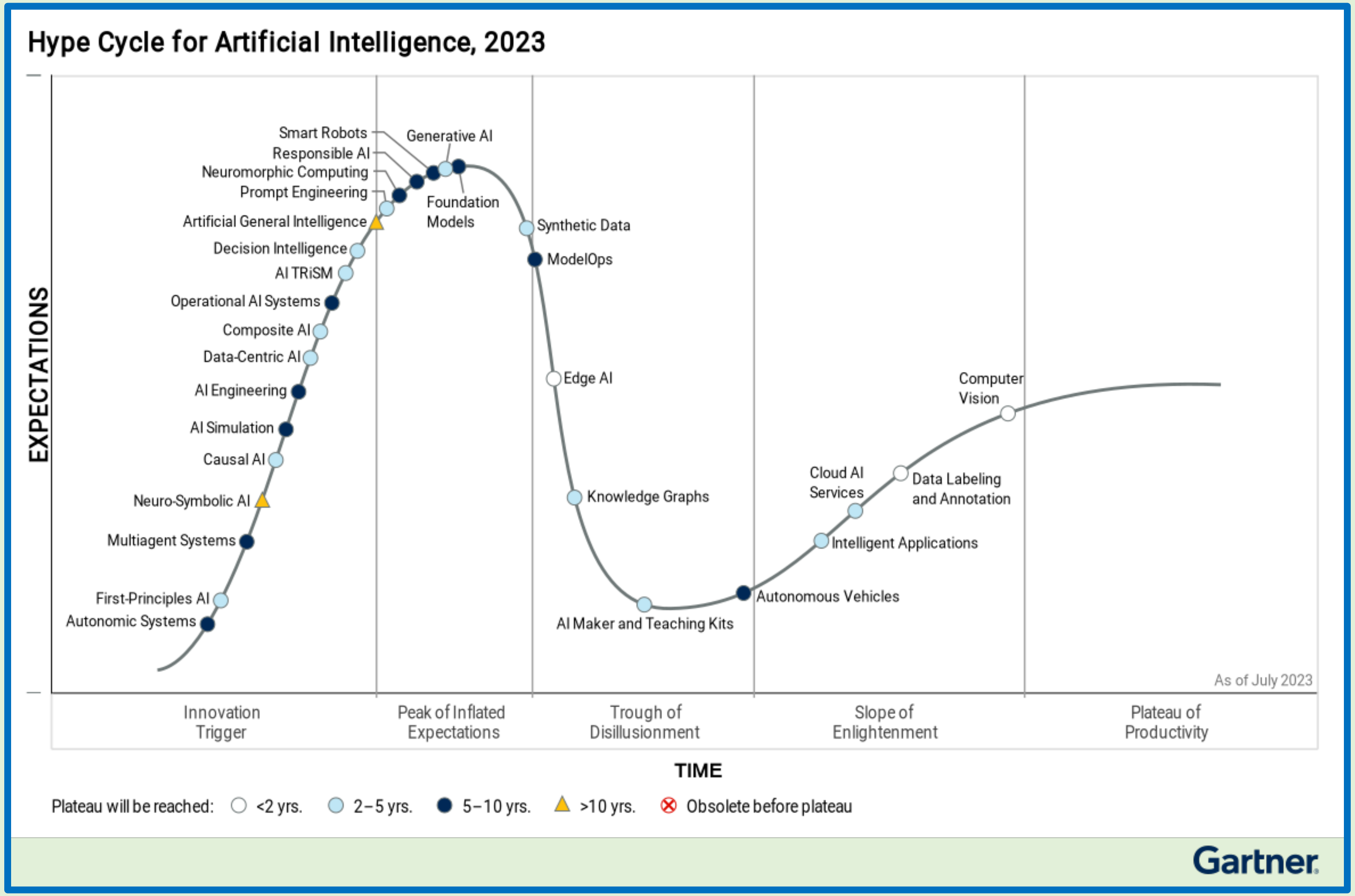
- AI/ML models of Spectrum usage - patterns to be made publicly available (Data specifics: at level of parameters, campaigns, reuse, ….)
- AI/ML Security (Cybersecurity, Privacy, Trust and Assurance)
- Categorization of AI/ML Risks in Networks use as well as in Services and Content (Balance between Protection and Benefits)
- Paths to Discovery and Maturity for AI/ML capabilities: Utilized properly AI/ML will benefit the Telecommunications world tremendously. New and undiscovered uses would need to be investigated and developed if the US is to be at the forefront of this technology.
- Approaches to testing and certification for AI/ML and Softwarization of the Network

Appendix A

Artificial Intelligence and Machine Learning Hype Curves

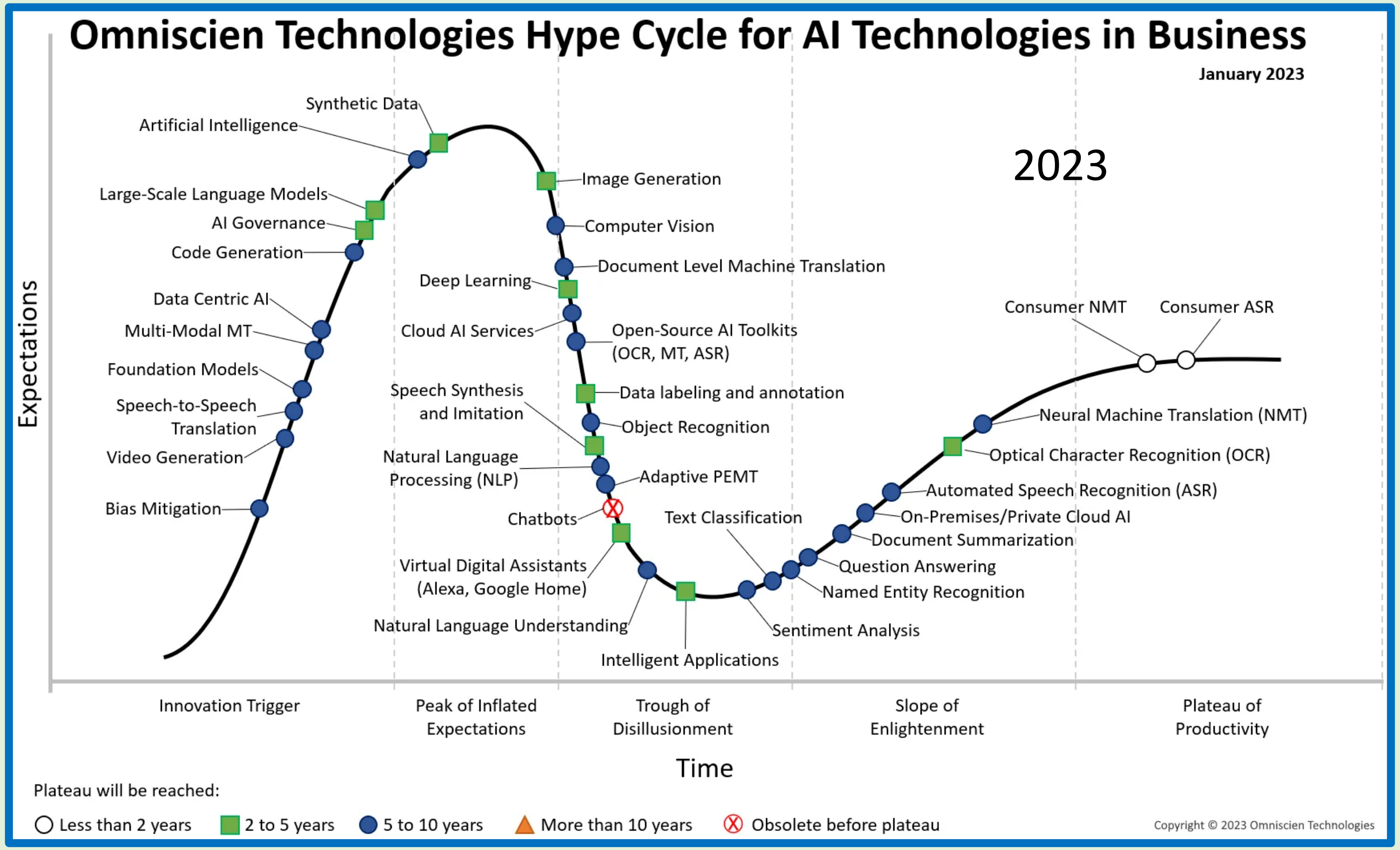
2019-2023

Overview and Observations



Overview and Observations

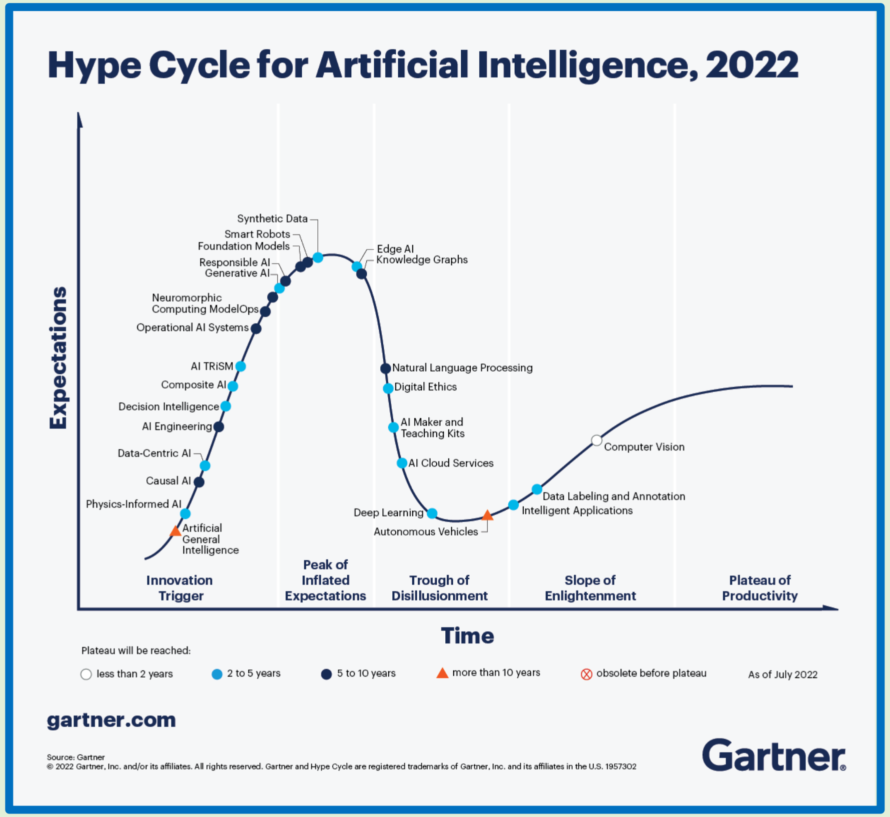
State of Artificial Intelligence and Machine Learning

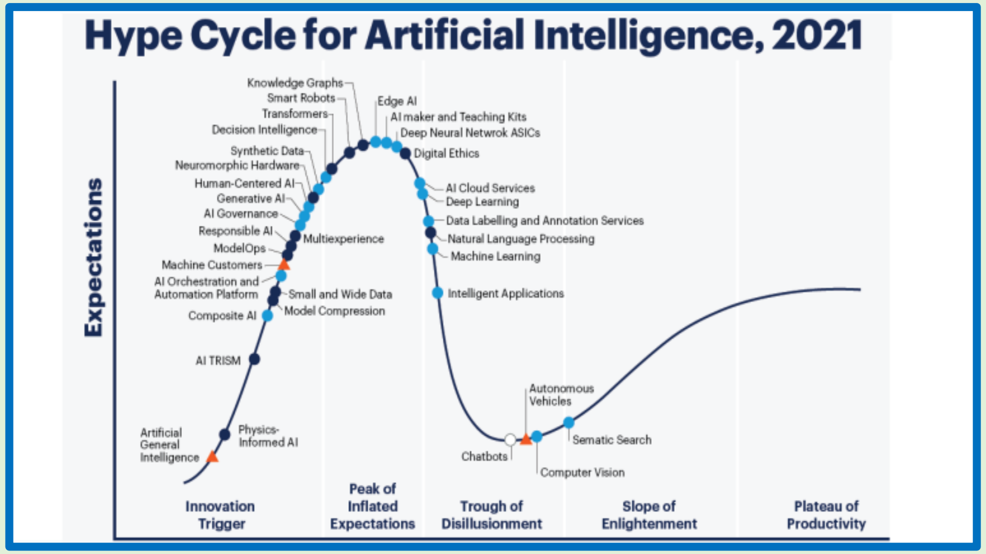


Source: https://omniscien.com/blog/hype-cycle-for-ai-technologies-in-business/

Overview and Observations

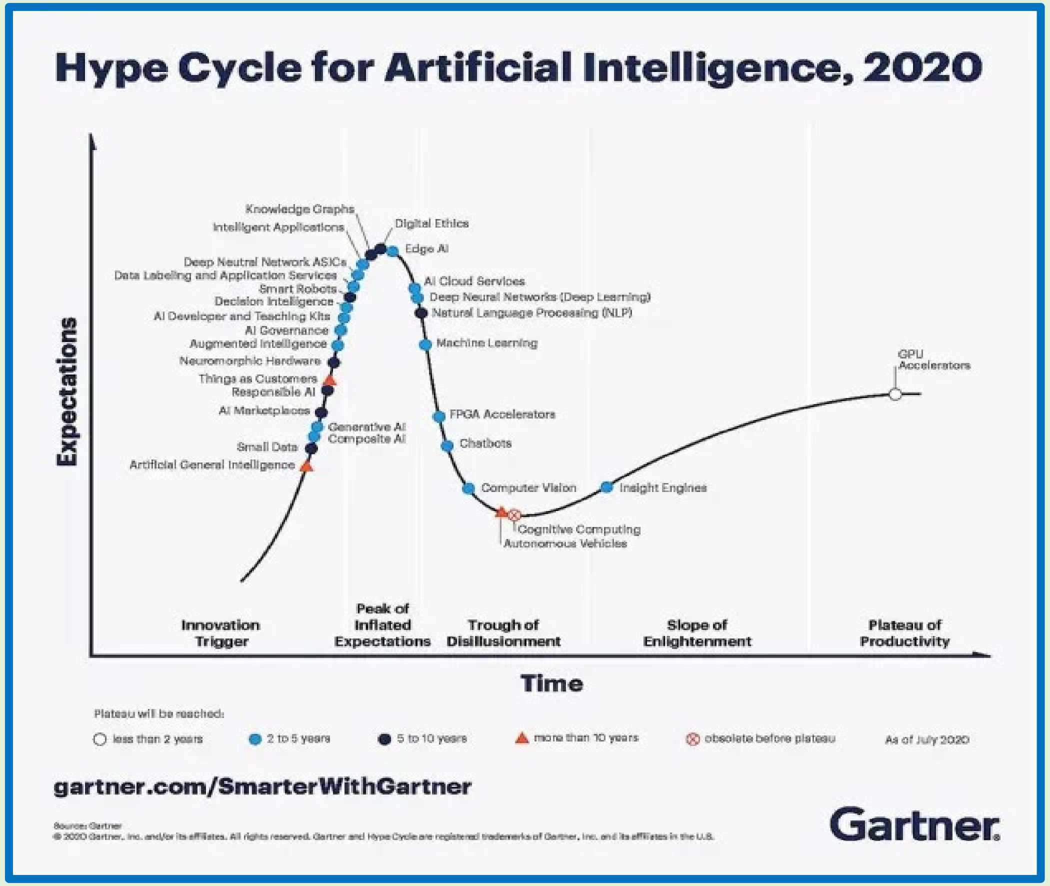
State of Artificial Intelligence and Machine Learning

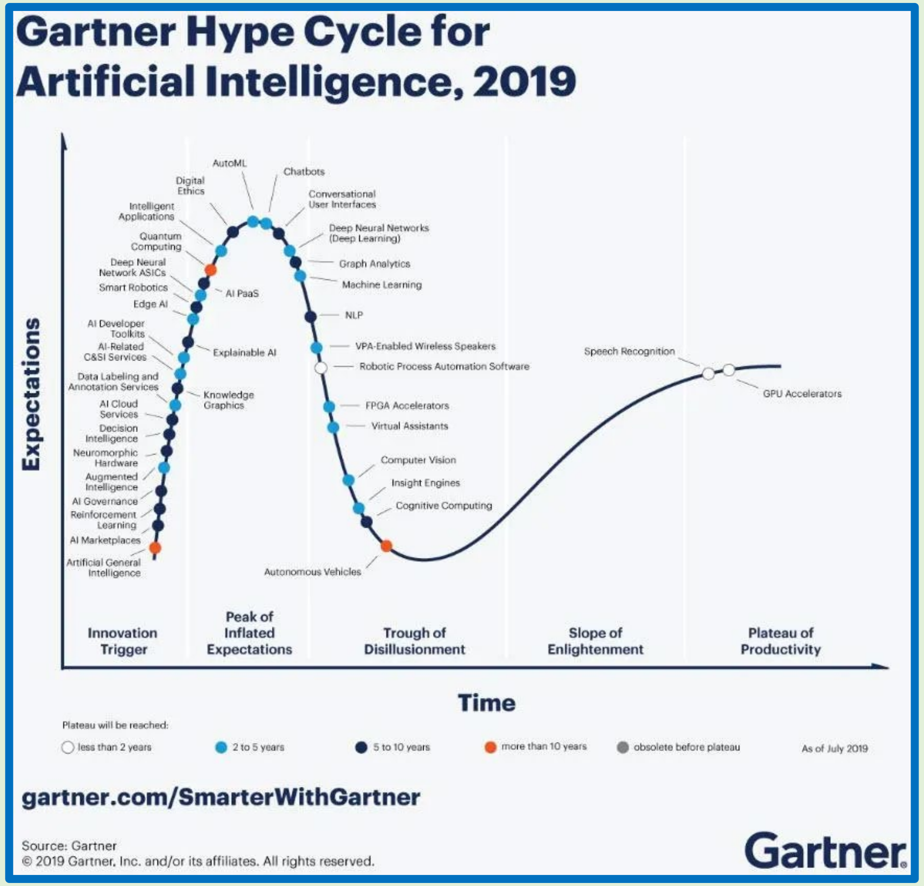




Overview and Observations

State of Artificial Intelligence and Machine Learning





Appendix B

Creating Artificial Intelligence and Machine Learning Models

Creating AI and ML Models

Understand the Problem

Step 1

- Identify the Problem and Success Criteria
- Identify Requirements – KPIs and intrinsic attributes
- Perform tradeoffs on approaches and decompositions that are scalable and "tractable"

Identify Data Needs

Step 2

- Data needed to support approach – internal, external, and provenance
- Sources of data and methods of acquisition
- Identify uses of data to be shared across projects

Collect and Prepare Data

Step 3

- Data from Campaigns and external sources Collect and Label
- Verify and validate data - Characterize
- Create Data fusion Products as needed
- Construct Catalogs for Curation and Sharing

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Creating AI and ML Models

Is your machine learning project a go or no-go?

Use this chart to gauge the feasibility of your AI project from a business, data and implementation standpoint.

Business feasibility	Data feasibility	Implementation feasibility
Is there a clear problem definition?	Do you have the required data that measures what you care about?	Do you have the required technology and skills?
Is the organization willing to invest and change?	Is there a sufficient quantity of data needed to train systems and do you have access to that data?	Can you execute the model as required in a timely manner?
Is there sufficient ROI or impact?	Is the data of sufficient quality?	Does it make sense to use the model where you plan to use it?

TechTarget

Creating AI and ML Models

Data considerations for machine learning projects

Data comes from a variety of sources, formats, conditions and locations.

Sources of training data	Data structure types	Data locations
Images	Structured data	On-premises databases
Videos	Queryable with a well-defined schema	Data warehouses
Emails	Unstructured data	Data Lakes
Documents, PDFs	No well-defined schema, not queryable	Cloud sources
Quantitative data from databases	Semi-structured data	Edge devices
Spreadsheets	Limited structure and queryability	Hybrid
Text content		Sensors/IoT
Voice and audio		

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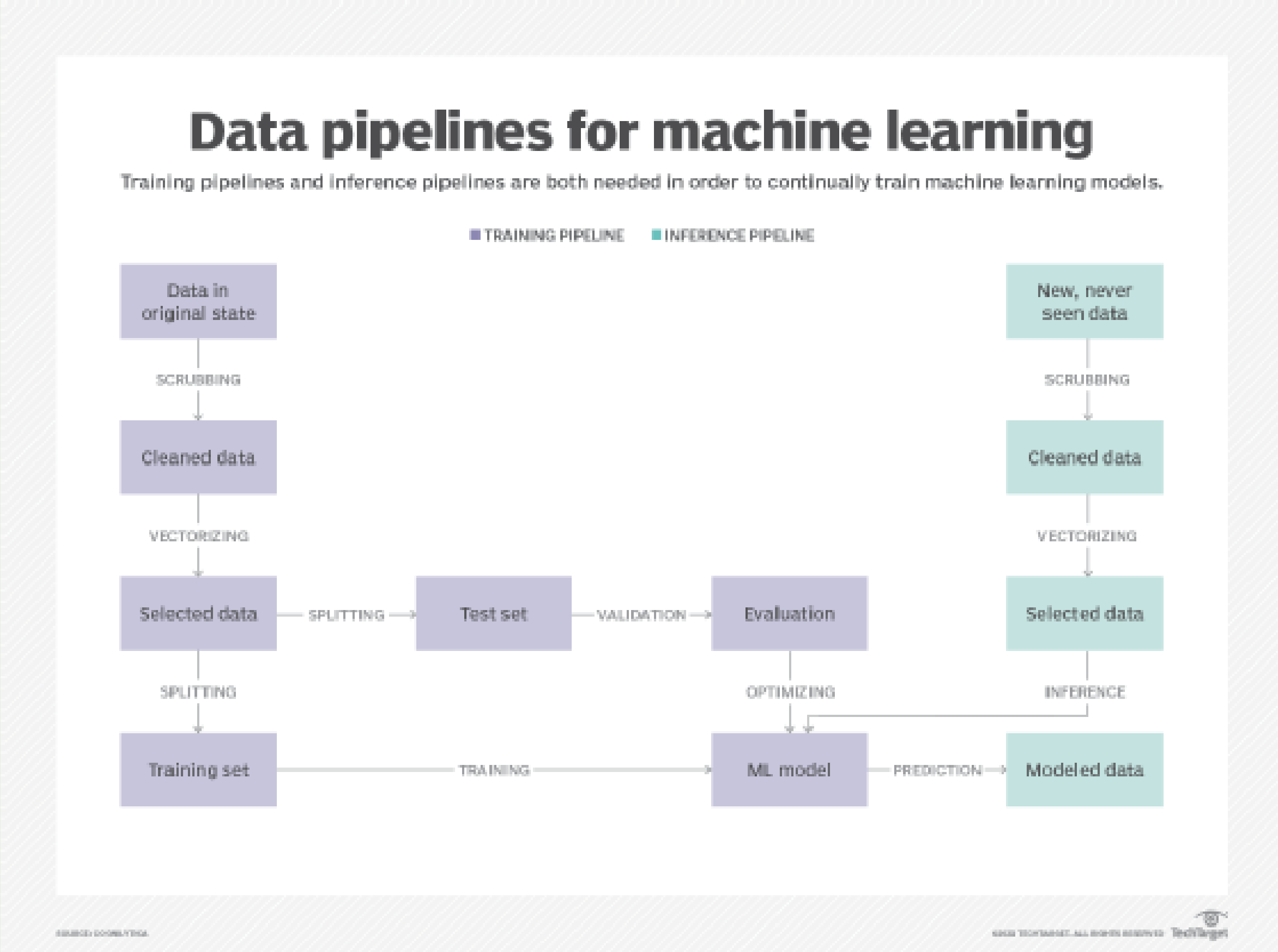
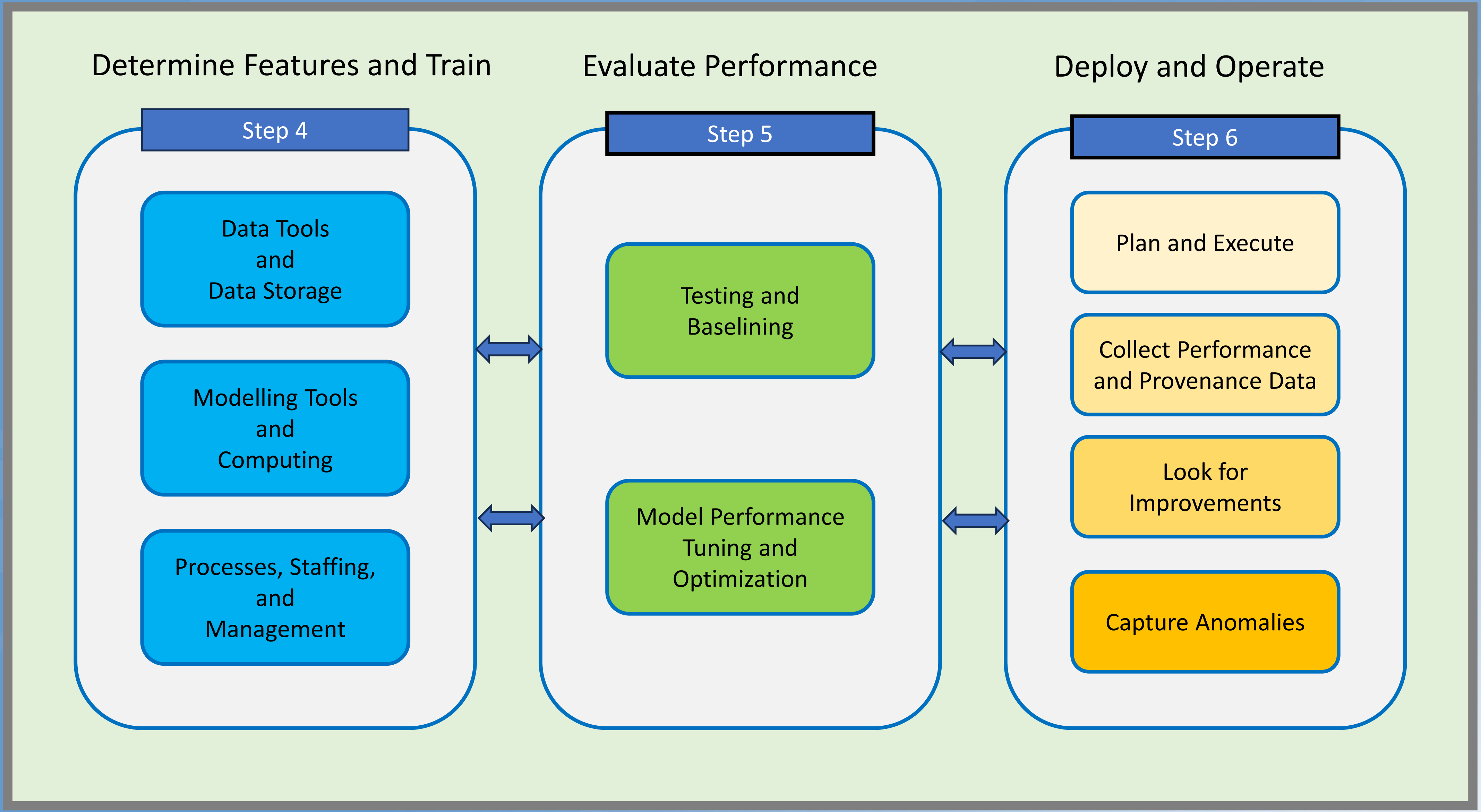
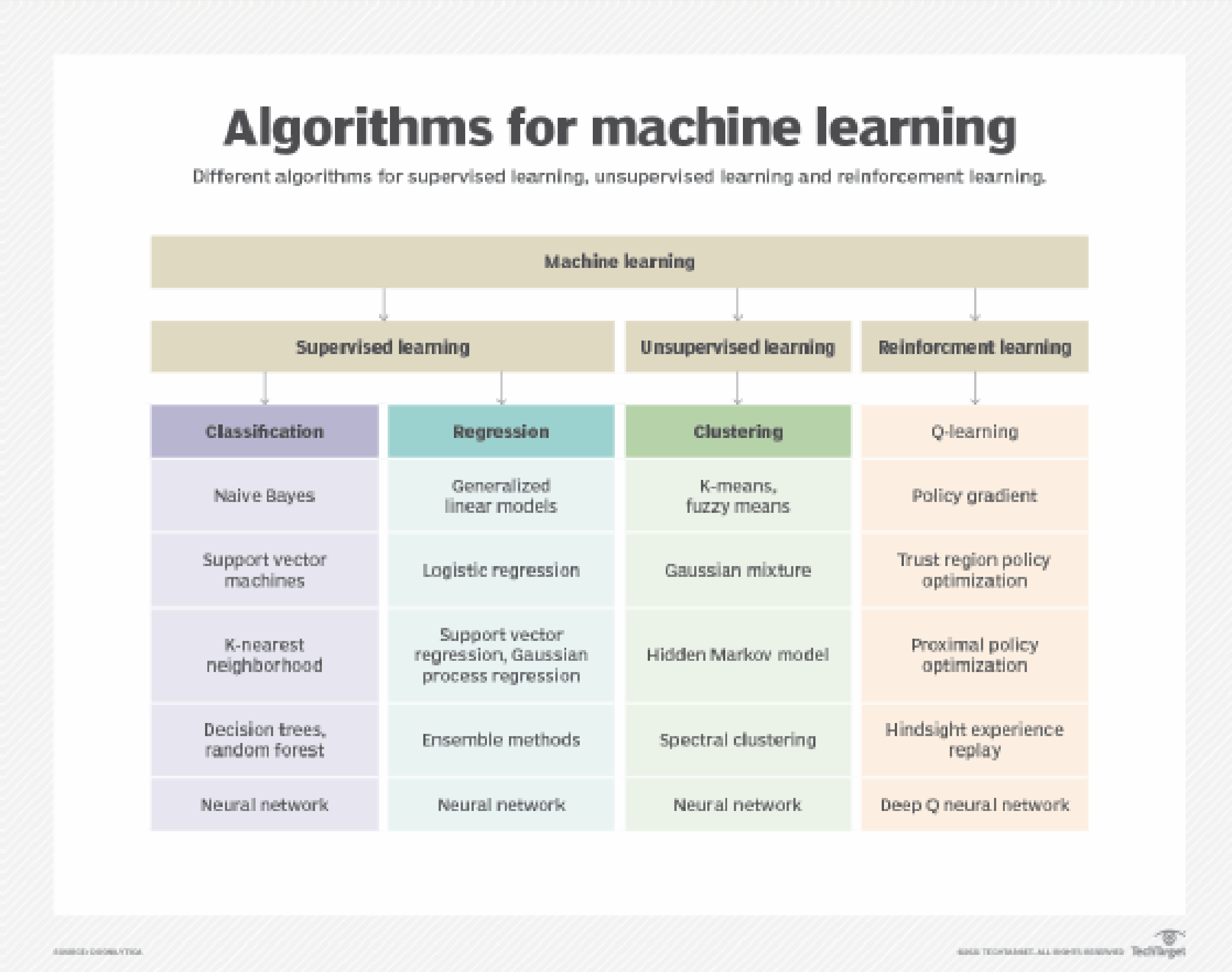


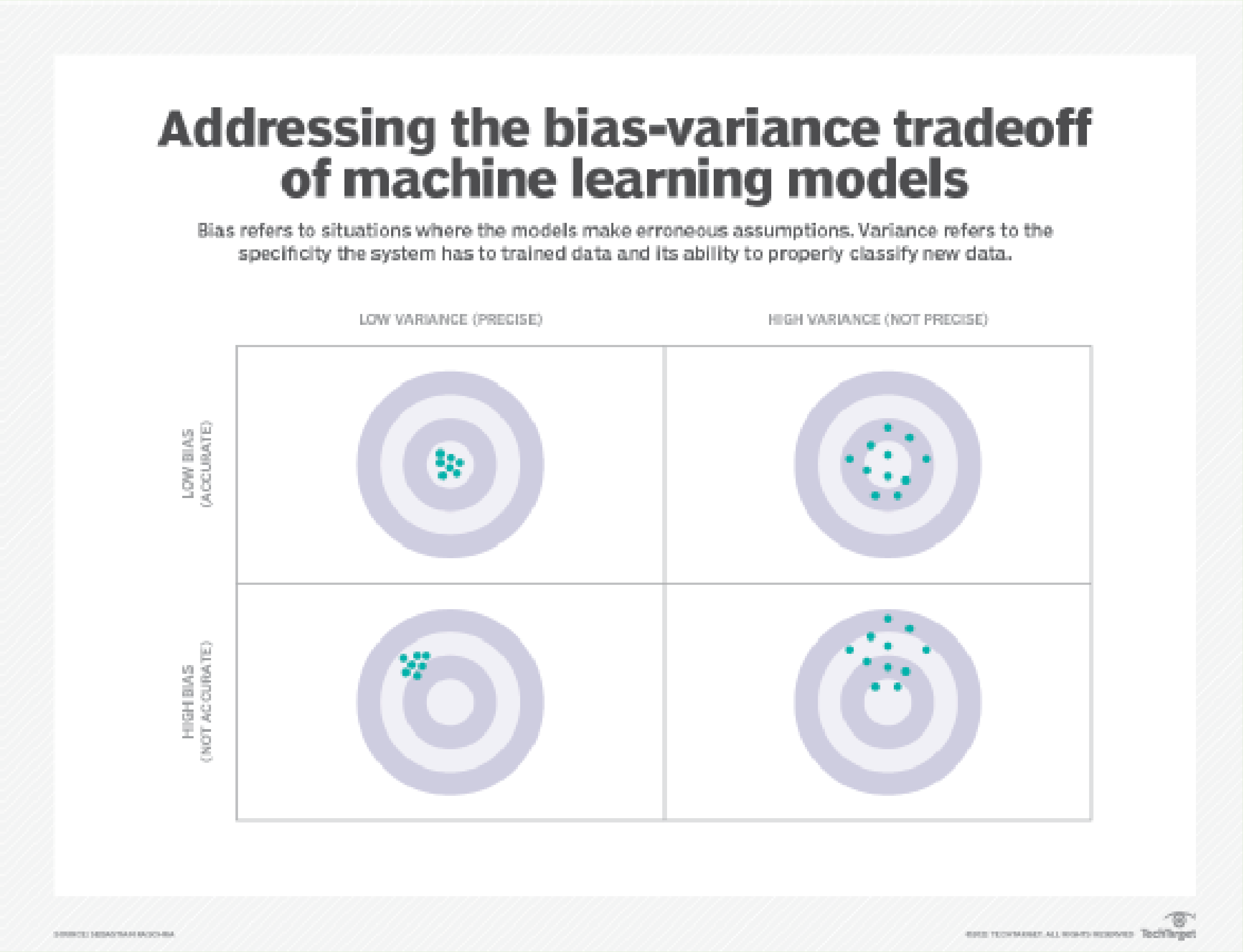
Creating AI and ML Models



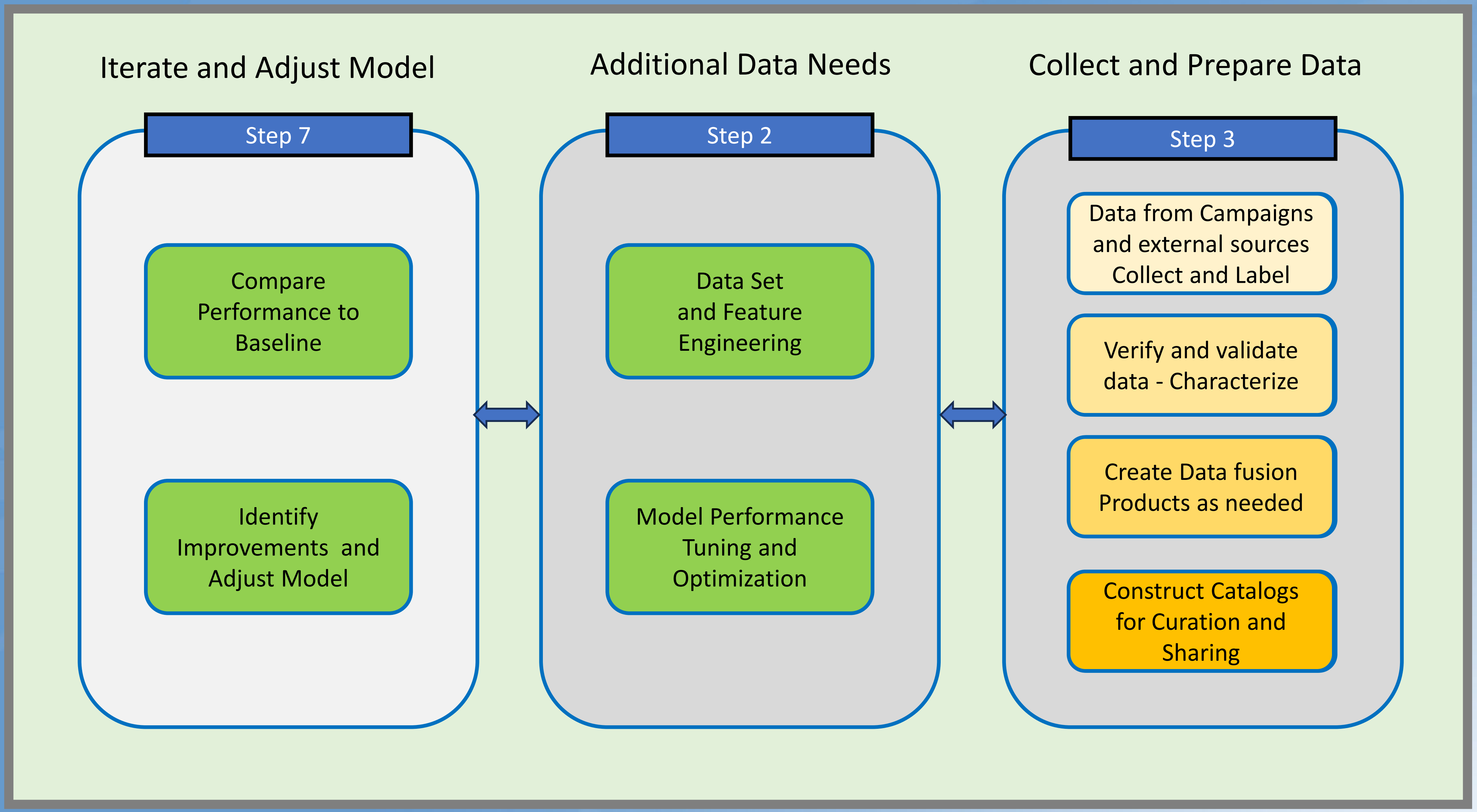
Creating AI and ML Models



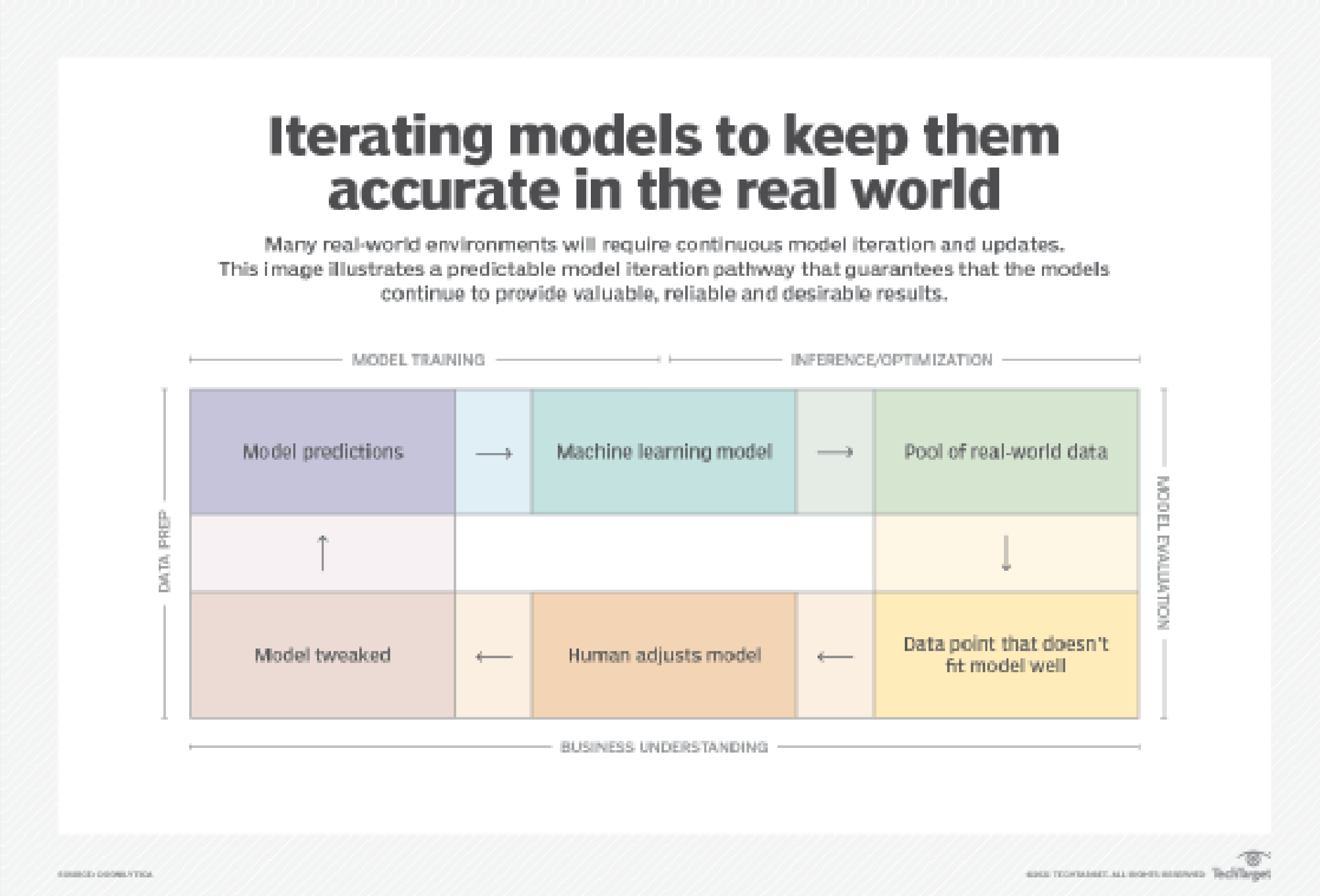
Creating AI and ML Models



Creating AI and ML Models



Creating AI and ML Models

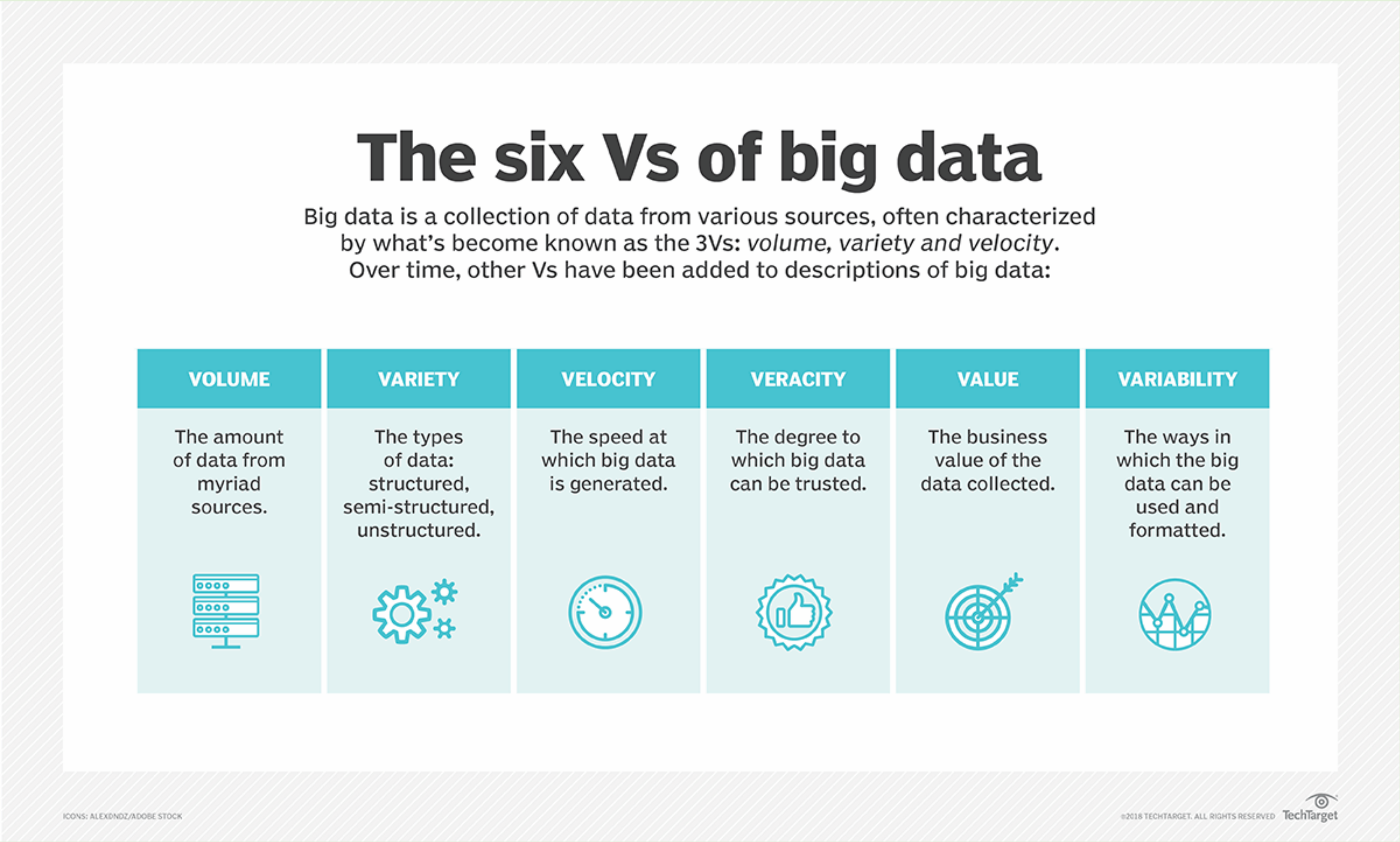


Source: TechTarget

Appendix D

Data Glossary for AI/ML and Big Data

Data Glossary AI & ML Applications



Source: TechTarget

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Data Glossary AI & ML Applications

1. **Algorithm**: A procedure or formula for solving a problem based on conducting a sequence of specified actions. In the context of big data, algorithm refers to a mathematical formula embedded in software to perform an analysis on a set of data.

2. **Artificial intelligence**: The simulation of human intelligence processes by machines, especially computer systems. These machines can perceive the environment and take corresponding required actions and even learn from those actions.

3. **Cloud computing**: A general term for anything that involves delivering hosted services over the internet. For big data practitioners, cloud computing is important because their roles involve accessing and interfacing with software and/or data hosted and running on remote servers.

4. **Data lake:** A storage repository that holds a vast amount of raw data in its native format until it's required. Every data element within a data lake is assigned a unique identifier and set of extended metadata tags. When a business question arises, users can access the data lake to retrieve any relevant, supporting data.

5. **Data science**: The field of applying advanced analytics techniques and scientific principles to extract valuable information from data. Data science typically involves the use of statistics, data visualization and mining, computer programming, machine learning and database engineering to solve complex problems.

Source: TechTarget

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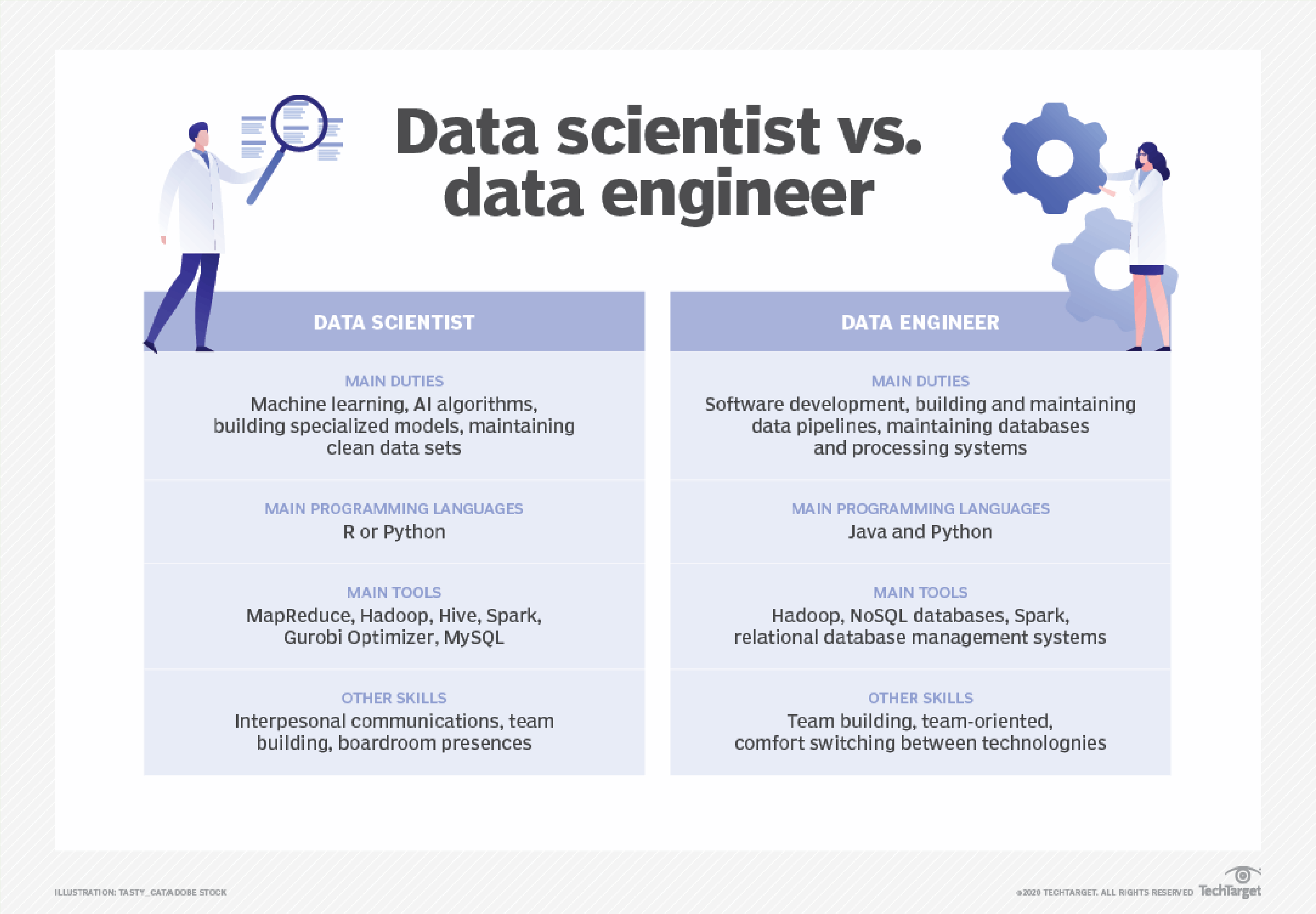
Data Glossary AI & ML Applications



Data scientist vs. data engineer

DATA SCIENTIST	DATA ENGINEER
MAIN DUTIES Machine learning, AI algorithms, building specialized models, maintaining clean data sets	MAIN DUTIES Software development, building and maintaining data pipelines, maintaining databases and processing systems
MAIN PROGRAMMING LANGUAGES R or Python	MAIN PROGRAMMING LANGUAGES Java and Python
MAIN TOOLS MapReduce, Hadoop, Hive, Spark, Gurobi Optimizer, MySQL	MAIN TOOLS Hadoop, NoSQL databases, Spark, relational database management systems
OTHER SKILLS Interpesonal communications, team building, boardroom presences	OTHER SKILLS Team building, team-oriented, comfort switching between technolognies

ILLUSTRATION: TASTY_CAT/ADOBE STOCK

Source: TechTarget

Data Glossary AI & ML Applications

6.**Database management system (DBMS)**: System software that serves as an interface between databases and end users or application programs, ensuring that data is consistently organized and remains easily accessible. DBMSes make it possible for end users to create, protect, read, update and delete data in a database.

7.**Data set:** A collection of related, discrete items of data that may be accessed individually or collectively, or managed as a single, holistic entity. Data sets are generally organized into some formal structure, often in a tabular format.

8.**Hadoop**: An open-source distributed processing framework that manages data processing and storage for big data applications. It provides a reliable means for managing pools of big data and supporting related analytics applications.

9.**Hadoop distributed file system (HDFS)**: The primary data storage system used by Hadoop HDFS employs a NameNode and DataNode architecture to implement a distributed file system that provides high-performance access to data across highly scalable Hadoop clusters.

10.**Machine learning**: A type of artificial intelligence that improves software applications' ability to predict accurate outcomes without being explicitly programmed to do so. Common use cases for machine learning include recommendation engines, fraud and malware threat detection, business process automation and predictive maintenance.

Source: TechTarget

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Data Glossary AI & ML Applications

11. **MapReduce:** Specific tools that support distributed computing on large data sets. These form core components of the Apache Hadoop software framework.

12. **Natural language processing (NLP):** A computer program's ability to understand both written and spoken human language. A component of artificial intelligence, NLP has existed for over five decades and has roots in the field of linguistics.

13. **NoSQL:** An approach to database design that can accommodate a wide variety of data models, including key-value, document, columnar and graph formats. NoSQL, which stands for "not only SQL," is an alternative to traditional relational databases in which data is placed in tables and data schemas carefully designed before the database is built. NoSQL databases are especially useful for working with large sets of distributed data.

14. **Object-based image analysis:** The analysis of digital images using data from individual pixels. It combines spectral, textural and contextual information to identify thematic classes in an image.

15. **Programming language:** Used by developers and data scientists to perform big data manipulation and analysis. R, Python, and Scala are the three major languages for data science and data mining.

Source: TechTarget

Data Glossary AI & ML Applications

16. **Pattern recognition:** The ability to detect arrangements of characteristics or data that provide information about a given system or data set. Patterns could manifest as recurring sequences of data that can be used to predict trends, specific configurations of features in images that identify objects, frequent combinations of words and phrases or clusters of activities on a network that could indicate a cyber attack.

17. **Python:** An interpreted, object-oriented programming language that's gained popularity for big data professionals due to its readability and clarity of syntax. Python is relatively easy to learn and highly portable, as its statements can be interpreted in several operating systems.

18. **Qualifications and learning resources for big data careers**: Students exploring a career in big data, and even established professionals seeking to augment their existing experience, have a host of options and resources at their disposal to advance their ambitions and grow their big data skills. These include university degrees at both undergraduate and graduate levels as well as online certifications and learning modules.

19. **R programming language:** An open source scripting programming language used for predictive analytics and data visualization. R includes functions that support both linear and nonlinear modeling, classical statistics, classifications and clustering.

20. **Relational databases:** A collection of information that organizes data points with defined relationships for easy access. Data structures (including data tables, indexes and views) remain separate from the physical storage. This enables administrators to edit the physical data storage without affecting the logical data structure.

Source: TechTarget

Data Glossary AI & ML Applications

15.Scala: A software programming language that blends object-oriented methods with functional programming capabilities. This allows it to support a more concise programming style which reduces the amount of code that developers need to write. Another benefit is that Scala features, which operate well in smaller programs, also scale up effectively when introduced into more complex environments.

16.Soft skills: Today's most successful big data professionals are those who can harmonize their academic qualifications, innate intellectual abilities and real-world experience with a diverse range of other softer skills. These soft skills include tenacity, problem-solving abilities, curiosity, effective communication, presentation and interpersonal skills, and well-rounded business understanding and acumen.

23.Statistical computing: The collection and interpretation of data aimed at uncovering patterns and trends. It may be used in scenarios such as gathering research interpretations, statistical modeling or designing surveys and studies, and advanced business intelligence. R is a programming language that's highly compatible with statistical computing.

24.Structured data: Structured data is data that has been organized into a formatted repository, typically a database, so that its elements can be made addressable for more effective processing and analysis.

25.Unstructured data: Everything that can't be organized in the manner of structured data. Unstructured data includes emails and social media posts, blogs, and messages, transcripts of audio recordings of people's speech, images and video files, and machine data, such as log files from websites, servers, networks and applications.

Source: TechTarget

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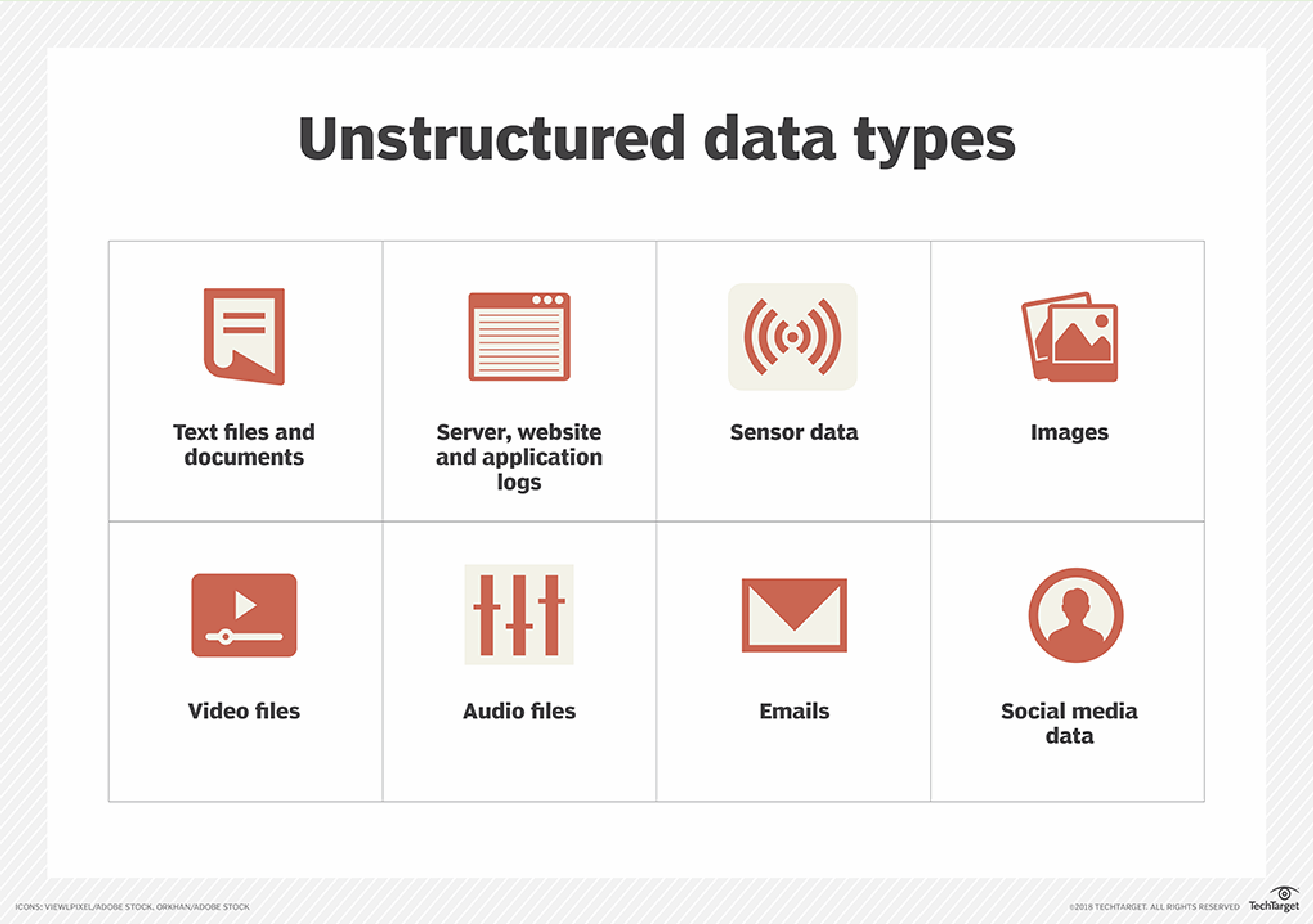
Data Glossary AI & ML Applications



Source: TechTarget

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Appendix D

SME Speakers

SME Speakers

Tao Zhang

Talk Title: "Artificial Intelligence and 6G"

Abstract: A data-driven world powered by AI is emerging, where networks, connected systems, and things act based on dynamically available data and learn from the data to improve their performance and functionality. In this talk, I will discuss potential roles of AI in 6G and beyond systems, including challenges, architectural considerations, and potential directions.

Biography: Dr. Tao Zhang leads the Transformational Networks and Services Group in the Communications Technology Lab at NIST. The group has been innovating and advancing technology and standards in areas including edge (fog) computing, edge and network AI, automated driving and teleoperation, 6G networks, information-centric networking, cloud computing, and wireless localization.

Before joining NIST, Dr. Zhang was the CTO / Chief Scientist for the Smart Connected Vehicles business unit at Cisco Systems, and a Chief Scientist and Director of Research at Telcordia Technologies (formerly Bell Communications Research) where he led breakthrough research on 3G/4G wireless networks and vehicular networks. He has cofounded two industry consortia—the Open Fog Consortium and the Connected Vehicle Trade Association—and served as a founding Board Director for them. More recently, he helped the industry establish the Teleoperation Consortium and has been serving on its Advisory Board.

Dr. Zhang was elevated to IEEE Fellow (class 2011) for his contributions to wireless and infrastructure networking protocols for applications. He holds about 60 US patents and coauthored two books ("Vehicle Safety Communications: Protocols, Security, and Privacy" and "IP-Based Next Generation Wireless Networks"), several book chapters, and over 100 peer-reviewed papers. He served as the CIO and a Board Governor of the IEEE Communications Society and as a Distinguished Lecturer of the IEEE Vehicular Technology Society. He cofounded several international conferences and served on leadership roles for many conferences and journals.

https://www.nist.gov/people/tao-zhang
https://www.linkedin.com/in/tao-zhang-ph-d-ieee-fellow-b5a6942/

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SME Speakers

Venki Ramaswamy

Talk Title: "How can Artificial Intelligence make NextG a reality?"

Abstract: Timely and affordable access to spectrum is needed for realizing unprecedented capabilities in next generation wireless networks. However, the spectrum in low and mid bands is extremely scarce and is occupied by incumbents that cannot (or should not) be relocated. In this talk, we will argue that intelligent sharing is the only practical way to ease the spectrum shortage. We will provide a summary of available spectrum sharing frameworks and highlight some of the shortcomings of current approaches. We will also describe through two use-cases, how AL/ML techniques when applied on an open RAN based network could significantly improve spectrum utilization and ease mobile industry's spectrum shortage. At the end of my talk, I would like to point out some challenges associated with widespread adoption of these approaches.

Biography: Dr. Venkatesh Ramaswamy is Chief Technologist at MITRE Labs in Bedford, Massachusetts where he currently leads technical innovation and R&D activities in 5G/xG technologies. He has more than 20 years of experience in the telecommunications industry and has held technical leadership positions at top technology companies, startups, and research labs. Currently he serves as one of the active industry members of the ATIS/Next G Alliance Research Council working on the development of a comprehensive North American 6G strategy. He is also an industry researcher at the NSF Edge AI Institute looking at synergies between networking and AI. He has published more than 50 peer-reviewed publications and patents, served as a TPC member for various conferences, and participated in several technical panels. He received his PhD in Electrical Engineering in 2007.

https://www.linkedin.com/in/venkatesh-ramaswamy-5b581121/

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SME Speakers

Martin Zoltick

Biography: Martin ("Marty") Zoltick is a shareholder with Rothwell, Figg, Ernst & Manbeck, P.C. in Washington, DC. He has been practicing in the field of technology law for more than 30 years. Marty has prosecuted hundreds of U.S. and international patent applications, served as lead trial counsel in major IP disputes in U.S. Federal District Courts and in inter Partes review (IPR) proceedings before the Patent Trial and Appeal Board (PTAB), negotiated hundreds of transactional matters involving IP rights, and provided strategic counseling and opinions to clients on patent, trademark, copyright, and trade secret strategies, due diligence, and portfolio development, valuation, and acquisition. As a Certified Information Privacy Professional in the United States (CIPP/US), Marty helps clients understand and navigate the rapidly evolving area of privacy and data protection law, including assisting in preparing for and implementing best practices for compliance with data privacy regulations and in handling data breach incidents. Marty has a degree in computer science and, prior to attending law school, worked for several years as a software developer and engineer at leading technology development companies. Ever since this beginning, he has been interested in the intersection of law and technology and has observed and influenced the evolution of both. As a result, he has an exceptional level of hands-on knowledge of a broad range of technologies and fields, including operating systems, networking and telecommunications, data analytics and big data, artificial intelligence (AI) and machine learning (ML). His formal training and industry experience enable him to handle complex software-related legal matters successfully in a cost-effective and efficient manner.

https://www.rothwellfigg.com/professionals-martin-zoltick
https://www.linkedin.com/in/martin-zoltick-9128145/

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SME Speakers

Magali Feys

Biography: Magali holds various degrees and specializes in all aspects of intellectual property, information technology, data protection and health law. She also deals with issues such as e-commerce, consumer protection and unfair market practices. Her practice focuses on developing and crafting IP, data protection and innovation strategies for a wide array of companies throughout their growth cycle, ranging from technology start-ups to large organizations in both the private and public sector. She has gained legislative experience by co-developing draft legislation for various governments. In addition, she has extensive experience in dispute resolution both before civil, criminal, or administrative authorities, courts and/or tribunals.

Magali is a volunteer scientific collaborator at the University of Ghent, department of MetaMedica, where she is conducting her PhD research on the secondary use of health data for further scientific research. She is also involved in a number of European H2020 projects on the secondary use of medical data as well as on informed consent and draws up a framework for various hospitals on the secondary use of personal data in line with the applicable provisions of health law, data protection law and privacy. As a guest lecturer, Magali gives a number of courses on "Data protection in health care", as part of Prof. Tom Goffin's Health Law course at the University Hospital. She also gives a number of lectures on Data and Ethics, as part of Prof. Dr. Mahsa Shabani's course at the University of Ghent, as well as on the topic of "Data protection applied to new technologies", as part of Prof. Dr. Fabienne Brison's course at the Vrije Universiteit Brussel.

Furthermore, Magali co-drafted a memorandum for the European Data Protection Board ("EDPB") entitled: "Data Embassy Principles". These principles provide a concrete solution for the exchange of personal data between EU member states and third countries, addressing the concerns raised in the so-called "Schrems II"-judgment of the European Court of Justice. The EDPD adopted these principles in "Use Case 2: lawful international data transfer", as set out in its December 2020 and June 2021 guidelines. Magali is a much sought-after speaker at various national and international conferences and webinars and the author of numerous national and international (legal) publications on data protection.

https://www.acontrario.law/people/magali-feys
https://www.linkedin.com/in/magali-feys-75bb645/recent-activity/articles/

SME Speakers

Harish Viswanathan

Talk Title: “AI Native 6G.”

Abstract: With advances in devices, sensing, display and other technologies, it is expected that the demand for immersive experiences that seamlessly blend the digital and physical worlds will become significant by the end of the decade. To enable this new revolution in human experience at scale, the upcoming 6G networks need to deliver unprecedented capacity, low latency, energy efficiency, and cognitive capabilities to efficiently manage vast radio resources. It is widely expected that artificial intelligence technology will play a major role in enabling these 6G capabilities so much so that 6G will be ‘AI-Native’. We begin with our view of what AI-Native means and describe the key elements of applications, ML framework, standardization and hardware acceleration that have to come together to realize AI-native 6G. We highlight the current state of research in AI application to physical layer, MAC layer and network automation. We then describe what ML Operations framework is and its importance, and then some new standardization issues that arise. Finally, we describe new hardware acceleration techniques that will be essential for comprehensive use of AI in wireless.

Biography: Dr. Harish Viswanathan is Head of Radio Systems Research Lab in Nokia Bell Labs. He received the B. Tech. degree from the Department of Electrical Engineering, Indian Institute of Technology, Chennai, India and the M.S. and Ph.D. degrees from the School of Electrical Engineering, Cornell University, Ithaca, NY. Since joining Bell Labs in October 1997, he has worked extensively on wireless research ranging from physical layer to network architecture and protocols including multiple antenna technology for cellular wireless networks, multi-hop relays, network optimization, network architecture, and IoT communications. He has published extensively with over 100 publications. From 2007 to 2015, Harish was in the Corp CTO organization, where as a CTO Partner he advised the Corporate CTO on Technology Strategy through in-depth analysis of emerging technology and market needs. He is a Fellow of the IEEE and a Bell Labs Fellow.

https://www.bell-labs.com/about/researcher-profiles/harishviswanathan/#gref
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SME Speakers

Ravit Dotan

Biography: Ravit Dotan, Ph.D. is an award-winning tech ethicist specializing in data-heavy technologies such as AI. She works as an advisor, speaker, writer, and researcher in both the private and academic sectors. In the private sector, she helps investors and tech companies develop socially responsible approaches to data-heavy technologies. In academia, she is the Co-Founder and Director of the Collaborative AI Responsibility (CAIR) Lab at the University of Pittsburgh, where she leads research on socially responsible AI governance. She earned her Ph.D. in Philosophy from UC Berkeley and has received multiple awards for her work, including being recognized as one of the 100 women in AI Ethics for 2023 by Women in AI Ethics and receiving a 2022 "Distinguished Paper" Award from FAccT, the top AI ethics conference. Recently, her work has been featured in publications such as the New York Times and TechCrunch.

Discussion: The use and misuse of AI. State legislations and regulations (over 32 passed or in process. Approach in EU AI Act.

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SME Speakers

Hubert Etienne

Talk Title: "AI Ethics and Safe Uses of AI"

Biography: Dr. Etienne is a researcher and professor of AI ethics. He teaches AI ethics at Sciences Po and ESCP Europe, as well as data economics at HEC Paris. He created Computational philosophy, a new approach of philosophy for data analysis, which he used to conduct research on content moderation at Facebook AI Research, especially on misinformation management. He previously served as the Global Generative AI ethics lead at Meta.

Discussion: AI Ethics and approaches to responsible use. (Social impacts)

https://www.linkedin.com/in/hubert-etienne/
https://www.hubert-etienne.com/bio

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SME Speakers

Daniel Rohrer

Talk Title: “Software and AI Product Security”

Abstract: Data is increasingly being generated at remote edge locations out of reach from traditional data center solutions. To take advantage of these sources of data, companies adopt edge computing by moving computing power and storage closer to where the data is collected. This decreases bandwidth costs and latency when streaming data back to a data center or cloud. Edge computing delivers applications to customers and employees in a more cost-effective way. While there are many benefits to deploying applications at the edge, edge devices create potential entry points for cybersecurity threats not seen in a traditional data center model, such as DDoS attacks or endpoint malware.
As critical infrastructure such as healthcare, robotic manufacturing, utilities, and telecommunications increasingly incorporate AI-capable devices, edge security becomes a serious concern for society. Edge AI systems are vulnerable. They contain valuable IP and private user data that can be stolen, commandeered for other applications such as bitcoin mining and DDoS attacks, or used to manipulate critical infrastructure. Operators of edge computing have a responsibility to secure endpoints, networks, and data. As a leader in AI computing, NVIDIA is bringing expertise to the forefront and helping customers understand how to protect valuable AI models and applications when deploying at the edge.
To understand the new approach to edge security, it’s important to compare it to the traditional security models that have been implemented in the data center. https://developer.nvidia.com/blog/edge-computing-considerations-for-security-architects/

Biography: Daniel is VP of Software Product Security at NVIDIA, having started as an intern over 22 years ago. Over his career, he has held a variety of technical and leadership roles, ranging from 3D software, to managing 3D and kernel development, to creating the NVIDIA GPU software chip development organization. Daniel has taken his integrated knowledge of everything NVIDIA to hone security practices through the delivery of advanced technical solutions, reliable processes, and strategic investments to deliver the most trustworthy solutions. He has a Master’s in Computer Graphics from the University of North Carolina, Chapel Hill.

https://developer.nvidia.com/blog/author/drohrer/
https://www.linkedin.com/in/graphicstogo/

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Appendix E

FCC Strategic Plan

Background US Code – The Purpose of the FCC

Strategic Goal 1: Pursue a "100 Percent" Broadband Policy

The COVID-19 pandemic put a spotlight on the serious broadband gaps that exist across the country, including in rural infrastructure, affordability for low-income Americans, and at-home access for students. This continuing digital divide means millions of Americans do not have meaningful access to essential infrastructure for 21st century success. In response to the challenges that many Americans face, the agency should advance access to communications that are essential for Americans to work remotely, learn remotely, receive healthcare, and engage in commerce. To this end, the FCC will pursue policies to help bring affordable, reliable, high-speed broadband to 100 percent of the country.

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Background US Code – The Purpose of the FCC

Strategic Goal 2: Promote Diversity, Equity, Inclusion and Accessibility

The FCC will seek to gain a deeper understanding of how the agency's rules, policies, and programs may promote or inhibit advances in diversity, equity, inclusion, and accessibility. The FCC will pursue focused action and investments to eliminate historical, systemic, and structural barriers that perpetuate disadvantaged or underserved individuals and communities. In so doing, the FCC will work to ensure equitable and inclusive access and facilitate the ability of underserved individuals and communities to leverage and benefit from the wide range of opportunities made possible by digital technologies, media, communication services, and next-generation networks. In addition, the FCC recognizes that it is more effective when its workforce reflects the experience, judgement, and input of individuals from many different backgrounds. Advancing equity is core to the agency's management and policymaking processes and will benefit all Americans.

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Background US Code – The Purpose of the FCC

Strategic Goal 3: Empower Consumers

Consumers who are well informed about their rights and what they’re buying are more confident and more likely to participate in the digital economy. The FCC will tackle new challenges to consumer rights and opportunities stemming from digital transitions. The FCC also will pursue effective enforcement and new approaches to protect consumers from unwanted and intrusive communications, phone-based scams, telephone privacy issues, and other trends that affect consumers. The FCC will work to enhance competition and pursue policies that protect the competitive process to improve consumer choice and access to information. The FCC will work to foster a regulatory landscape that fosters media competition, diversity, and localism. The FCC also must work to ensure the availability of quality, functionally equivalent communications services for persons with disabilities.

Background US Code – The Purpose of the FCC

Strategic Goal 4: Enhance Public Safety and National Security

There is no task at the FCC that is more important than keeping the American people safe. The FCC will pursue policies to promote the availability of secure, reliable, interoperable, redundant, and rapidly restorable critical communications infrastructure and services. The FCC also will promote the public's access to reliable 911, emergency alerting, and first responder communications. The FCC will work to ensure the continued availability of timely emergency alerts. The FCC will work in coordination with Federal and state, local, Tribal, and territorial government partners and industry stakeholders to support disaster response and to ensure the nation's defense and homeland security.

Background US Code – The Purpose of the FCC

Strategic Goal 5: Advance America's Global Competitiveness

The FCC will take action to promote investment and advance the development and deployment of new communications technologies, such as 5G, that will allow the nation to remain a global leader in an increasingly competitive, international marketplace. The FCC will identify incentives and policies to close security gaps and accelerate trustworthy innovation. The FCC will work with its federal partners to advocate for US interests abroad.

Background US Code – The Purpose of the FCC

Strategic Goal 6: Foster Operational Excellence

The FCC should be a model for excellence in government by effectively managing its resources, maintaining a commitment to transparent and responsive processes that encourage public involvement and decision-making that best serves the public interest, and encouraging a culture of collaboration both internally and across government agencies.

Appendix F

Selected Portions of US Code Involving the FCC

Background US Code – The Purpose of the FCC

§ 151. Purposes of chapter; Federal Communications Commission created.

For the purpose of regulating interstate and foreign commerce in communication by wire and radio so as to make available, so far as possible, to all the people of the United States, without discrimination on the basis of race, color, religion, national origin, or sex, a rapid, efficient, Nation-wide, and world-wide wire and radio communication service with adequate facilities at reasonable charges, for the purpose of the national defense, for the purpose of promoting safety of life and property through the use of wire and radio communications, and for the purpose of securing a more effective execution of this policy by centralizing authority heretofore granted by law to several agencies and by granting additional authority with respect to interstate and foreign commerce in wire and radio communication, there is created a commission to be known as the "Federal Communications Commission", which shall be constituted as hereinafter provided, and which shall execute and enforce the provisions of this chapter.

(JUNE 19, 1934, CH. 652, title I, § 1, 48 STAT. 1064; MAY 20, 1937, CH. 229, § 1, 50 STAT. 189; PUB. L. 104–104, TITLE I, § 104, Feb. 8, 1996, 110 STAT. 86.)
CITE AS: 47 USC 151

Background US Code - New Technologies and Services

§ 157. New technologies and services

(a) It shall be the policy of the United States to encourage the provision of new technologies and services to the public. Any person or party (other than the Commission) who opposes a new technology or service proposed to be permitted under this chapter shall have the burden to demonstrate that such proposal is inconsistent with the public interest.

(b) The Commission shall determine whether any new technology or service proposed in a petition or application is in the public interest within one year after such petition or application is filed. If the Commission initiates its own proceeding for a new technology or service, such proceeding shall be completed within 12 months after it is initiated.

(JUNE 19, 1934, CH. 652, title I, § 7, as added PUB. L. 98–214, § 12, Dec. 8, 1983, 97 STAT. 1471; amended PUB. L. 103–414, TITLE III, § 304(A)(1), Oct. 25, 1994, 108 STAT. 4296.)
CITE AS: 47 USC 157

Background US Code - Competition

§ 160. Competition in provision of telecommunications service.

(a) Regulatory flexibility. Notwithstanding SECTION 332(C)(1)(A) OF THIS TITLE, the Commission shall forbear from applying any regulation or any provision of this chapter to a telecommunications carrier or telecommunications service, or class of telecommunications carriers or telecommunications services, in any or some of its or their geographic markets, if the Commission determines that—

(1) enforcement of such regulation or provision is not necessary to ensure that the charges, practices, classifications, or regulations by, for, or in connection with that telecommunications carrier or telecommunications service are just and reasonable and are not unjustly or unreasonably discriminatory;

(2) enforcement of such regulation or provision is not necessary for the protection of consumers; and

(3) forbearance from applying such provision or regulation is consistent with the public interest.

(b) Competitive effect to be weighed. In making the determination under subsection (a)(3), the Commission shall consider whether forbearance from enforcing the provision or regulation will promote competitive market conditions, including the extent to which such forbearance will enhance competition among providers of telecommunications services. If the Commission determines that such forbearance will promote competition among providers of telecommunications services, that determination may be the basis for a Commission finding that forbearance is in the public interest.

Background US Code – Competition (continued)

c) Petition for forbearance. Any telecommunications carrier, or class of telecommunications carriers, may submit a petition to the Commission requesting that the Commission exercise the authority granted under this section with respect to that carrier or those carriers, or any service offered by that carrier or carriers. Any such petition shall be deemed granted if the Commission does not deny the petition for failure to meet the requirements for forbearance under subsection (a) within one year after the Commission receives it, unless the one-year period is extended by the Commission. The Commission may extend the initial one-year period by an additional 90 days if the Commission finds that an extension is necessary to meet the requirements of subsection (a). The Commission may grant or deny a petition in whole or in part and shall explain its decision in writing.

(d) Limitation. Except as provided in SECTION 251(F) OF THIS TITLE, the Commission may not forbear from applying the requirements of section 251(c) or 271 of this title under subsection (a) of this section until it determines that those requirements have been fully implemented.

(e) State enforcement after Commission forbearance. A State commission may not continue to apply or enforce any provision of this chapter that the Commission has determined to forbear from applying under subsection (a).

(JUNE 19, 1934, CH. 652, title I, § 10, as added PUB. L. 104–104, TITLE IV, § 401, Feb. 8, 1996, 110 STAT. 128.)
CITE AS: 47 USC 160

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Background US Code – Research

§ 162. Additional research authorities of the FCC

In order to carry out the purposes of this chapter, the Commission may –

(1) undertake research and development work in connection with any matter in relation to which the Commission has jurisdiction; and
(2) promote the carrying out of such research and development by others, or otherwise to arrange for such research and development to be carried out by others.

(JUNE 19, 1934, CH. 652, title I, § 12, as added PUB. L. 111–358, TITLE VIII, § 803, Jan. 4, 2011, 124 STAT. 4043.)
CITE AS: 47 USC 162

Background US Code – Market Place Report

§ 163. Communications marketplace report.

(a) In general. In the last quarter of every even-numbered year, the Commission shall publish on its website and submit to the Committee on Energy and Commerce of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate a report on the state of the communications marketplace.

(b) Contents. Each report required by subsection (a) shall –

(1) assess the state of competition in the communications marketplace, including competition to deliver voice, video, audio, and data services among providers of telecommunications, providers of commercial mobile service (as defined in SECTION 332 OF THIS TITLE), multichannel video programming distributors (as defined in SECTION 522 OF THIS TITLE), broadcast stations, providers of satellite communications, Internet service providers, and other providers of communications services;

(2) assess the state of deployment of communications capabilities, including advanced telecommunications capability (as defined in SECTION 1302 OF THIS TITLE), regardless of the technology used for such deployment;

(3) assess whether laws, regulations, regulatory practices (whether those of the Federal Government, States, political subdivisions of States, Indian tribes or tribal organizations (as such terms are defined in SECTION 5304 OF TITLE 25), or foreign governments), or demonstrated marketplace practices pose a barrier to competitive entry into the communications marketplace or to the competitive expansion of existing providers of communications services;

(4) describe the agenda of the Commission for the next 2-year period for addressing the challenges and opportunities in the communications marketplace that were identified through the assessments under paragraphs (1) through (3); and

(5) describe the actions that the Commission has taken in pursuit of the agenda described pursuant to paragraph (4) in the previous report submitted under this section.

Background US Code – Market Place Report (Continued)

(c) Extension. If the President designates a Commissioner as Chairman of the Commission during the last quarter of an even-numbered year, the portion of the report required by subsection (b)(4) may be published on the website of the Commission and submitted to the Committee on Energy and Commerce of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate as an addendum during the first quarter of the following odd-numbered year.

(d) Special requirements.

(1) Assessing competition. In assessing the state of competition under subsection (b)(1), the Commission shall consider all forms of competition, including the effect of intermodal competition, facilities-based competition, and competition from new and emergent communications services, including the provision of span and communications using the Internet.

(2) Assessing deployment. In assessing the state of deployment under subsection (b)(2), the Commission shall compile a list of geographical areas that are not served by any provider of advanced telecommunications capability.

(3) Considering small businesses. In assessing the state of competition under subsection (b)(1) and regulatory barriers under subsection (b)(3), the Commission shall consider market entry barriers for entrepreneurs and other small businesses in the communications marketplace in accordance with the national policy under SECTION 257(B) OF THIS TITLE.

(JUNE 19, 1934, CH. 652, title I, § 13, as added PUB. L. 115–141, DIV. P, TITLE IV, § 401, Mar. 23, 2018, 132 STAT. 1087.)
CITE AS: 47 USC 163

Appendix G

Examples of Sample Use Cases

Topic 4: Use of AI/ML in Telecommunication Networks

For each aspect of the Network Lifecycle where does AI/ML play a role:

- Applications of AI/ML
  - Function
    - Improvements
    - New Functionality
- Benefits of AI/ML
- Level of Impact of AI/ML
- Timeliness/Maturity of AI/ML
- Evidence and Documentation

Once the list of Lifecycle use cases is constructed, we will be discussing these and other metrics to prioritize what is most important for the FCC

Growing Emphasis on Trustworthy AI in Networks

Use of AI/ML in Telecommunication Networks **Technology Research & Development (Use Cases)**

- **Intrinsic Requirements**
  - Testability and Verifiability
  - Availability and Reliability
  - **Trust, Security, Privacy, Assurance**

AI & Trust, Security, Privacy, Assurance, are key Priorities for 5G/6G Systems

Next G Alliance lists AI, Trust, Security, Privacy, as top technology priorities for Next G Systems

Source: https://www.nextgalliance.org/research-priorities/technology/

Natively Integrating AI/ML into Networks, Systems, and Devices

Achieving Trustworthy, Secure and Resilient Solutions for North America

O-RAN & CISA working on threat modeling and risk analysis of AI/ML in Open Networks

- **O-RAN Security Threat Modeling and Remediation Analysis 5.0, March 2023 (https://orandownloadsweb.azurewebsites.net/specifications)**
- **"Open Radio Access Network Security Considerations, https://www.cisa.gov/sites/default/files/publications/open-radio-access-network-security-considerations_508.pdf**

AI for Network Security Applications

Use of AI/ML in Telecommunication Networks

Operational and Management Practices (Use Cases)

Monitoring and Troubleshooting

- Threat detection and mitigation, recovery

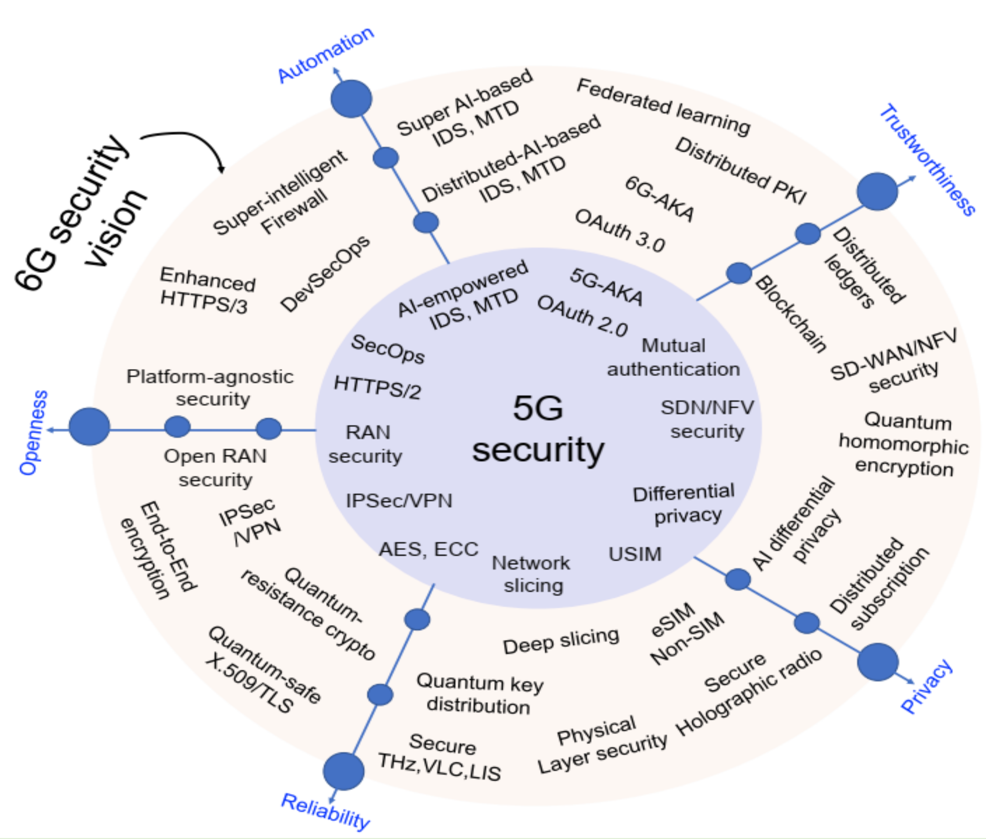
Network Lifecycle (Use Cases)

Deployment

Security threat analysis – anomaly detection

Technological Innovations under consideration for 6G security compared to the 5G security vision (V. Nguyen et. al. DOI:10.1109/COMST.2021.3108618)

(AI for Security Examples)



AI for Network Security Applications (References)

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3. R. Patil, R. Biradar, V. Ravi, P. Biradar, and U. Ghosh, “Network anomaly detection using PCA and BiGAN,” Internet Technology Letters, pp. 1–6, Sep. 2020 [BiGAN].
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5. Mohiuddin Ahmed, Abdun Naser Mahmood, and Jiankun Hu. 2016. A survey of network anomaly detection techniques. J. Netw. Comput. Appl. 60, C (January 2016), 19–31 [AD-survey]
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Data Sets

1. Iman Sharafaldin, Arash Habibi Lashkari, and Ali A. Ghorbani, “Toward Generating a New Intrusion Detection Dataset and Intrusion Traffic Characterization”, 4th International Conference on Information Systems Security and Privacy (ICISSP), Portugal, January 2018 [IDS-TR]
2. Yair Meidan, Michael Bohadana, Yael Mathov, Yisroel Mirsky, Asaf Shabtai, Dominik Breitenbacher, and Yuval Elovici. N-baiot—Network-based detection of IoT botnet attacks using deep autoencoders. IEEE Pervasive Computing, 17(3): 12–22, 2018. doi:10.1109/MPRV.2018.03367731 [NbaIoT].

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Safe Uses of AI/Trustworthy AI

Threats to AI in Networks

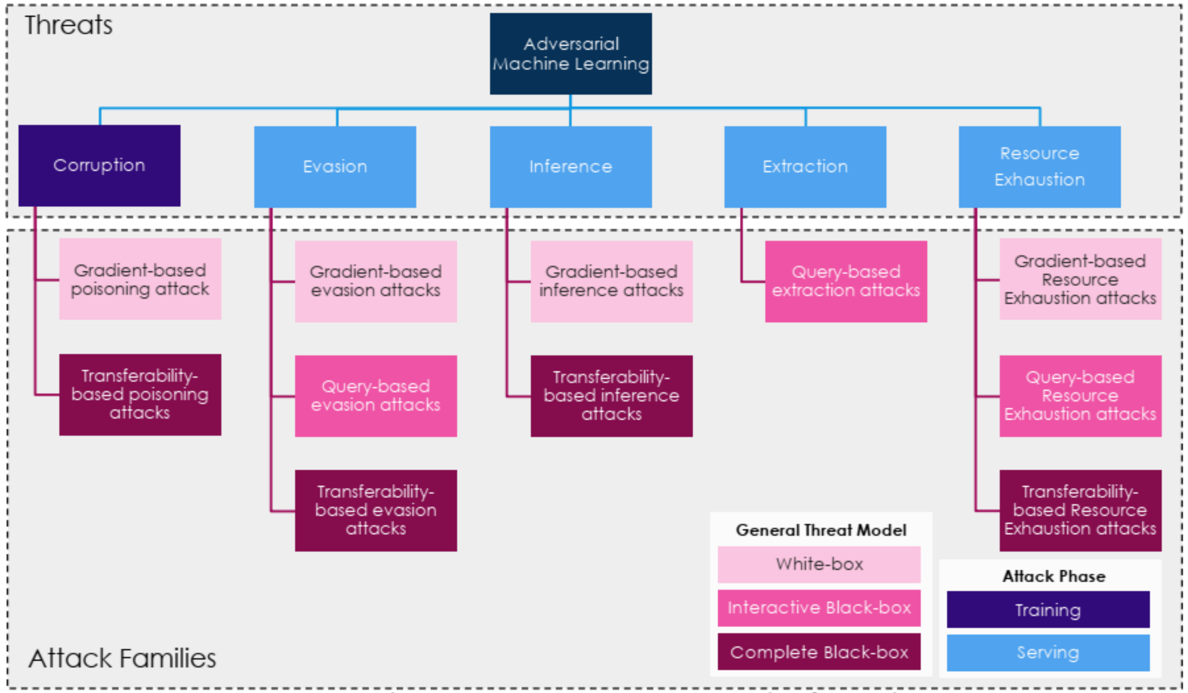

Fig. 5: The main AML attack families.

Source: Bitton, Ron, et al. "*Adversarial Machine Learning Threat Analysis in Open Radio Access Networks*." arXiv preprint arXiv:2201.06093 (2022)

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Safe Uses of AI/Trustworthy AI (References)

Adversarial ML in Networks

Adversarial Threats and Attacks

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Safe Uses of AI/Trustworthy AI (References)

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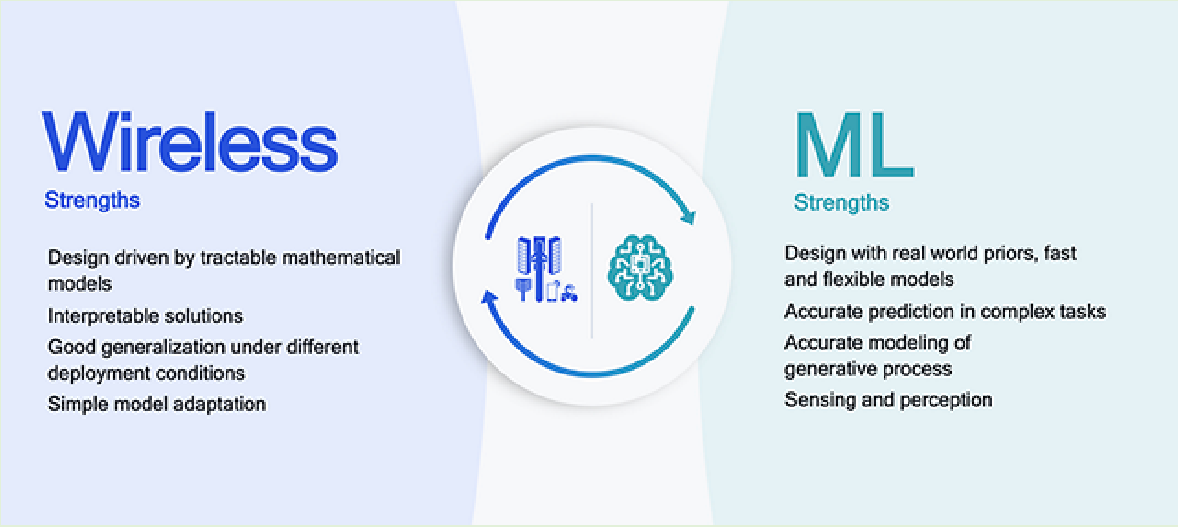
Topic 4: Use of AI/ML in Telecommunication Networks

Example: Technology Research & Development

Wireless Networks

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



Topic 4: Use of AI/ML in Telecommunication Networks

Example: Technology Research & Development

Wireless Networks

https://www.hindawi.com/journals/wcmc/2022/9901960/

“AI-Empowered Propagation Prediction and Optimization for Reconfigurable Wireless Networks”

Abstract

Vehicular ad-hoc network (VANET) is one of the most important components to realizing intelligent connected vehicles, which is a high-commercial-value vertical application of the fifth-generation (5G) mobile communication system and beyond communications. VANET requires both ultrareliable low latency and high-data rate communications. In order to evolve towards the reconfigurable wireless networks (RWNs), the 5G mobile communication system is expected to adapt the key parameters of its radio nodes rapidly. However, the current propagation prediction approaches are difficult to balance accuracy and efficiency, which makes the current network unable to perform autonomous optimization agilely. In order to break through this bottleneck, an accurate and efficient propagation prediction and optimization method empowered by artificial intelligence (AI) is proposed in this paper. Initially, a path loss model based on a multilayer perception neural network is established at 2.6 GHz for three base stations in an urban environment. Not like empirical models using environment types or deterministic models employing three-dimensional environment models, this AI-empowered model explores the environment feature by introducing interference clutters. This critical innovation makes the proposed model so accurate as ray tracing but much more efficient. Then, this validated model is utilized to realize a coverage prediction for 20 base stations only within 1 minute. Afterward, key parameters of these base stations, such as transmission power, elevation, and azimuth angles of antennas, are optimized using simulated annealing. This whole methodology paves the way for evolving the current 5G network to RWNs.

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Topic 4: Use of AI/ML in Telecommunication Networks

Example: Technology Research & Development

Wireless Networks

https://digitalcommons.usf.edu/cgi/viewcontent.cgi?article=10109&context=etdNetworks

Artificial Intelligence Towards the Wireless Channel Modeling Communications in 5G

Abstract

Channel prediction is a mathematical predicting of the natural propagation of the signal that helps the receiver to approximate the affected signal, which plays an important role in highly mobile or dynamic channels. The standard wireless communication channel modeling can be facilitated by either deterministic or stochastic channel methodologies. The deterministic approach is based on the electromagnetic theories and every single object in that environment has to be known in that propagation space and an example of this method is ray tracing. While the stochastic modeling method is based on measurements that in-volve statistical distributions of the channel parameters and an example of this approach is Floating Intrcept (FI) model. In other words, channel modeling uses mathematical parameters to obtain the effect of the channel medium. These effects cause the transmitted signal to be either destructive or constructive during the propagation. Where the main focus of this dissertation is how Artificial Intelligence will be used in channel modeling. Fifth-generation -5G- with massive MIMO, higher data rate, handover, and channel modeling become more and more complex with the new wireless generations than the traditional stochastic or deterministic approaches. Nowadays, traditional wireless communication channel modeling is considered an old fashion especially with new technologies era such as things that applies to MmWave. In this sense, researchers and academia looking forward to more effective methods that have less complexity and more accuracy. Emerging machine learning technology sup-plies a new direction to process big measurement data and traffic data toward the wireless channel. Thus, new novel strategies of channel learning are proposed to generate a model free of the wireless channel modeling by tacking these difficulties………….

Topic 4: Use of AI/ML in Telecommunication Networks

Example: Technology Research & Development

Wireless Networks

https://arxiv.org/abs/2004.13875

6G White Paper on Machine Learning in Wireless Communication Networks

Abstract

The focus of this white paper is on machine learning (ML) in wireless communications. 6G wireless communication networks will be the backbone of the digital transformation of societies by providing ubiquitous, reliable, and near-instant wireless connectivity for humans and machines. Recent advances in ML research has led enable a wide range of novel technologies such as self-driving vehicles and voice assistants. Such innovation is possible as a result of the availability of advanced ML models, large datasets, and high computational power. On the other hand, the ever-increasing demand for connectivity will require a lot of innovation in 6G wireless networks, and ML tools will play a major role in solving problems in the wireless domain. In this paper, we provide an overview of the vision of how ML will impact the wireless communication systems. We first give an overview of the ML methods that have the highest potential to be used in wireless networks. Then, we discuss the problems that can be solved by using ML in various layers of the network such as the physical layer, medium access layer, and application layer. Zero-touch optimization of wireless networks using ML is another interesting aspect that is discussed in this paper. Finally, at the end of each section, important research questions that the section aims to answer are presented.

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Topic 4: Use of AI/ML in Telecommunication Networks

Operations

Network Management

https://go.juniper.net/c/gap-case-study-en?x=fK8SL2&utm_medium=sem&utm_source=google&utm_campaign=AMER_ALL_Stein_Paid_Media&utm_content=Consideration-ENTWW-Generic&utm_term=ai-driven%20networkpc_647526695917

Gap Inc. Transforms In-Store Wi-Fi Experience with AI-Driven Networking

Technology has transformed retail, changing how shoppers interact with their favorite brands. To give customers and retail associates the best experience with in-store Wi-Fi, Gap Inc. found AI-driven networking to be a perfect fit.

Gap Inc. redesigned its in-store networks to enable new levels of retail innovation. The AI-driven Mist Platform provides stores with predictable, reliable, and measurable Wi-Fi.
A proof-of-concept test quickly turned into a deployment of the Mist WLAN in stores across North America. That's because Mist has given the Gap Inc. IT team unprecedented visibility into a user's Wi-Fi experience and consistently delivers the expected service levels. Marvis, a virtual network assistant, is at the heart of what makes Mist different. The IT operations team can interact intuitively with Marvis to gain proactive insights to deliver a better user experience and simplify network operations.
"Before Mist, we spent a lot more time troubleshooting," says Patel. "Now, we can slice and dice the data and see very clearly that we're having a problem at a specific store. "Mist shows eight key metrics so we can see whether wireless is good in the stores," Patel continues. "Mist is always measuring the baseline, and if there's a deviation, Mist helps our operation team identify the problem." ……….

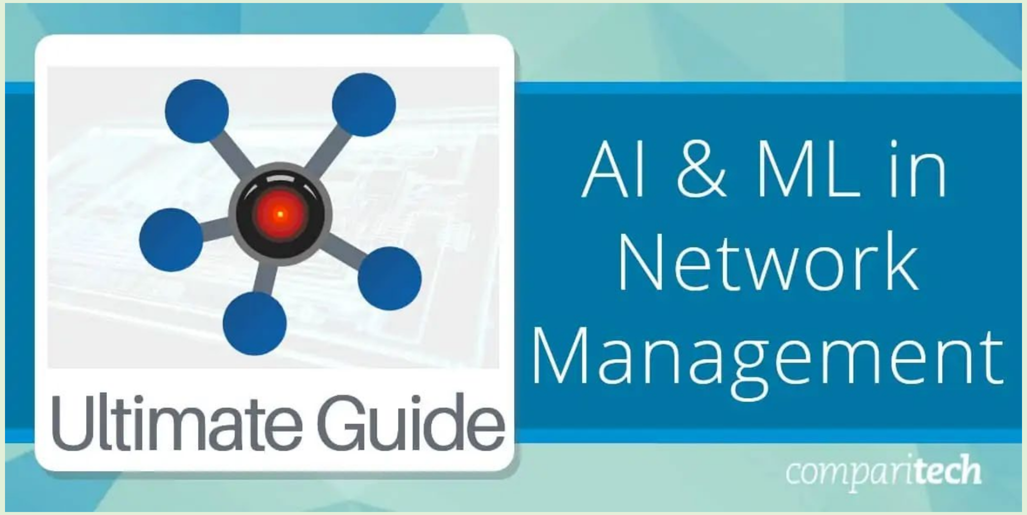
Topic 4: Use of AI/ML in Telecommunication Networks

Operations

Network Management

https://www.comparitech.com/net-admin/ai-ml-in-network-management/

AI & ML in Network Management



Topic 4: Use of AI/ML in Telecommunication Networks

Horizontal Thread: AI/ML in Network Security

Item 1. **Deployment - Retirement:** Security Threat Analysis—Anomaly detection.

Item 2. **Operations:** Security and Trust Framework management and components including preventive action.

Item 3. **Maintenance and Upgrades:** Prognostics and diagnostics for security.

Item 4. **Retirement:** Security implications of decommissioning systems.

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Topic 4: Use of AI/ML in Telecommunication Networks

Horizontal Thread: AI/ML in Network Security

Item 1. **Operations - Retirement.** Regardless of what lifecycle section security threat analysis lives, clearly AI/ML is in its sweet spot for security threat analysis, especially ML. Gathering data and looking at existing patterns and actions to detect similar activities throughout real time activities is what AI/ML does. The impact of being able to detect activities is huge. All important security players are using AI/ML to supplement their security.

Juniper Networks: https://www.juniper.net/documentation/us/en/software/jatp/jatp-operator/topics/topic-map/jatp-managing-incidents.html

StrongDM: https://www.strongdm.com/blog/anomaly-detection#:~:text=Anomaly%20detection%20is%20the%20process,baseline%2C%20and%20investigate%20inconsistent%20data.

StateTech: https://statetechmagazine.com/article/2023/01/state-and-local-agencies-can-identify-cyberthreats-through-anomaly-detection-perfcon

Topic 4: Use of AI/ML in Telecommunication Networks

Horizontal Thread: AI/ML in Network Security

Item 2. **Operations.** AI/ML has the same impact for preventive action. Analysis of configurations can easily highlight security vulnerabilities that might not be obvious. Checking the oeuvre of various actions provided by metadata can easily lead to finding hidden security vulnerabilities. For example, someone failing to configure secure NTP could lead to IPSec tunnels having incorrect timing because a bad actor could inject bad timing. Or a BGP speaker could inject routes and point good traffic to bad sites if they were not properly authenticated. The panoply of information regarding security concerns could infer bad configuration data with known security issues. This is a current, relevant topic and would benefit from AI/ML.

Vendor Agnostic:
https://www.cisa.gov/news-events/cybersecurity-advisories/aa22-137a
Palo Alto Networks:
https://www.paloaltonetworks.com/russia-ukraine-cyber-resources
Juniper Networks:
https://www.juniper.net/documentation/us/en/software/jatp/jatp-operator/topics/topic-map/jatp-managing-incidents.html

Topic 4: Use of AI/ML in Telecommunication Networks

Horizontal Thread: AI/ML in Network Security

Item 3. **Maintenance and Upgrades.** AI/ML seems a perfect fit for validating security. Many data points can be evaluated that based upon ML could indicate significant security concerns. Privilege escalation or lateral movement could be monitored via automated queries; too much "bad" data visibility could lead to identifying bad actors or nefarious activities. AI/ML could have a huge impact identifying low and slow incursions lost in the noise of the system, that regular logging could not detect. Many security firms are actively using AI/ML to implement security detection. Security companies have open AI/ML software engineers—so they can implement and maintain the ability to maintain and grow security while operations and their customer's networks grow.

Vendor Agnostic:
https://www.securityroundtable.org/dont-get-caught-in-the-hype-cut-out-the-bs-in-ai-and-ml/
Palo Alto Networks:
https://www.paloaltonetworks.com/apps/pan/public/downloadResource?pagePath=/content/pan/en_US/resources/articles/true-value-of-aiml-in-security-environments
Juniper Networks:
https://www.juniper.net/us/en/customers/ameritrust-case-study.html

Topic 4: Use of AI/ML in Telecommunication Networks

Horizontal Thread: AI/ML in Network Security

Item 4. **Retirement.** Security implications of decommissioning systems. AI/ML for system retirement would mostly be part of new functionality. It lends itself to validating that critical information for networking and security telecommunications equipment would wiped. Because its automated, it could ensure that nothing gets left off a checklist. For example, the checklist of things to check may change as time progresses. With an automated system, you only have to check one item. And as errors are found in decommissioning, the AI/ML system could provide hints/rectify the decommissioning process. Although small in terms of activities to check, the impact could be huge because critical security information left on a system could be used to crack into other systems (possibly) that could lead to massive data exfil or lawsuits—both of which have a lasting impact on other uses and an entity's reputation. Decommissioning systems is not broadly implemented at this time with AI/ML.

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Topic 4: Use of AI/ML in Telecommunication Networks

Horizontal Thread: AI/ML in Network Security

Item 4. (Continued) ITIL is a broadly understood standard in IT service management. Two of the guiding principles for ITIL are 1) Automation and Optimization and 2) Iterative progress with feedback—both of which lend themselves to AI/ML. As part of the several stages in ITIL, two lend themselves to security concerns. First is Service Strategy. As part of the Service Strategy to give a service portfolio, retired services need to be addressed. Because ITIL can be considered rigid in execution, having an AI/ML set of tasks can look at various data points and point auditors and others in the right direction when retiring services—especially for equipment related concerns, be it data base service or switches, firewalls, or routers. Second is service design. Part of service design is IT Security Management—which focuses on critical security and characteristics: Confidentiality, Integrity, Availability (all three of which, referred to as CIA, are critical aspects of NIST SP 800-53), Authenticity, and Non-repudiation. Based upon various automated queries, AI/ML could easily parse through the unbelievably large set of security controls in 800-53 for CIA concerns and relate them to provide valid checkpoints.

https://www.simplilearn.com/itil-key-concepts-and-summary-article

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Appendix H

AIWG Recommendations from 2022

Summaries and Recommendations – Cross Cutting Issues

Recommendations - Cross Cutting Issues

1. **Create an "AI/ML and Data Analytics" Task Force to address how the FCC can best incorporate AI based methods and techniques as part of its operations. The focus is data driven decision making for the FCC's internal needs, and those of industry and the public.**

   - 1.1 Building Capacity – incorporate staffing with expertise in AI/ML and AI/OPS, as well as access to resources within the FCC's planning cycle. Take advantage of other organizations and institutions within the telecommunications ecosystem, and team with other federal agencies that have similar interests or existing expertise.

   - 1.2 Role in Providing Data – conduct an inventory of data and information products that the FCC currently provides, identifying gaps in the needs for data to support strategic goals, plan to develop and deploy information systems that take advantage of AI/ML and DDAs to serve the FCC's strategic goals and support the FCC's mandates.

   - 1.3 Best Practices for the Industry – adopt best practices internally and provide the mechanisms and encouragement for other stakeholders within the Telecommunications ecosystem to do the same.

Be ready for an AI/ML World!

Summaries and Recommendations – Cross Cutting Issues

Recommendations - Cross Cutting Issues

2. Address the needs of the technical and operational communities for access to critical data sets that broadly support the exploration of AI/ML solutions within the FCC, within the industry, and the supporting research communities. This includes the formation or adoption of Forums where the needs can be identified, long and short-range plans developed, the required data collected, vetted and analyzed, provided, and curated.

- 2.1 Recognize that that Data Sets can be used for multiple purposes and that Data is more valuable if it is managed and provided across organizational lines. This requires budgeting, funding, and the pooling of funds, to support multiple objectives and may require new authority outside the FCC’s current purview.

- 2.2 Prioritize and sequence Data Set collection to address the most pressing issues, with balance between short term imperatives and the long term needs of the Nation’s Telecommunications Systems.

- 2.3 Specifically, allocate budget resources, develop a strategic plan, and execute a series of projects that makes such Data available to the stakeholders within the “Wireless” Ecosystem. (Dealing with issues such as spectrum usage, spectrum sharing, rules for radio equipment and operational radio parameters, etc,)

Eliminate a key bottleneck to progress and innovation!

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Summaries and Recommendations – Topic 1

Topic 1: AI/ML Pilot Projects for the FCC

1. **Lay the groundwork for fulfilling future demand for access to spectrum by exploring and advancing the technical and policy aspects of spectrum sharing. The focus is on a higher degree of dynamic automation, eliminating the friction for exploiting multi-use spectrum and satisfying the needs for higher bandwidths, lower latency, and more efficient utilization.**

    - 1.1 Spectrum Sharing Evolution – Develop a multiyear consortial plan for exploring and piloting a series of projects that will advance dynamic and highly automated spectrum sharing. Secure approval for funding the plan and subsequently launch a series of projects that address the foundational technical and policy issues. The projects should be guided by systems analysis to provide an overall end-end architecture and solution options. Individual projects should focus on resolving uncertainties and find solutions for key system components. It would be beneficial to include institutions with existing resources and know how as part of the consortium. It would also be important to create mechanisms for Industry participation – since the eventual responsibility for providing solutions will fall to industry.

Summaries and Recommendations – Topic 1

Topic 1: AI/ML Pilot Projects for the FCC

1. **Lay the groundwork for fulfilling future demand for access to spectrum by exploring and advancing the technical and policy aspects of spectrum sharing. The focus is on a higher degree of dynamic automation, eliminating the friction for exploiting multi-use spectrum and satisfying the needs for higher bandwidths, lower latency, and more efficient utilization - continued**

   - 1.2 Technical Aspects – The central hypothesis in this recommendation is that future spectrum sharing regimes will be based on Systems that use AI/ML and other techniques. The construct is to understand local conditions around a "Cell Site", while interacting sparingly with neighboring "Cells", to form an on-demand dynamic real-time Network with a high degree of automation. This is in fact developing the equivalent of "Digital Twins" for the Networks principal elements.

Summaries and Recommendations – Topic 1

Topic 1: AI/ML Pilot Projects for the FCC

1. **Lay the groundwork for fulfilling future demand for access to spectrum by exploring and advancing the technical and policy aspects of spectrum sharing. The focus is on a higher degree of dynamic automation, eliminating the friction for exploiting multi-use spectrum and satisfying the needs for higher bandwidths, lower latency, and more efficient utilization - continued**

   - 1.3 The key elements of such as System are modules for:
     - Sensing (Based on EM signals and other sources of Information)
     - A module for electromagnetic phenomenology (weather effects, frequency dependent effects, etc.)
     - A time varying model of the site specific electromagnetic “Cell Site” environment
     - A time varying propagation model around the “Cell Site” and parametrization of signals impinging on neighboring “Cells” as well as identification of conditions where propagation can affect more distant “Cells”
     - Time varying model of usage patterns around the cell
     - An admissions module
     - A module for assigning Network resources to the “Cell Site”

Summaries and Recommendations – Topic 1

Topic 1: AI/ML Pilot Projects for the FCC

2. **Conduct a pilot project around ”Wireless Data” collected by the FCC and data that may be available from other sources. The purpose is to lay the groundwork for categorizing and understanding the use of spectrum and to test how AI/ML methods and techniques may be used to provide relevant and valuable information to stakeholders in the “Wireless” ecosystem.**

    - 2.1 Experiment with analysis of the Data using AI/ML and conventional techniques to Characterize the Data and identify patterns, dominant parameters, and input conditions.
    - 2.2 Identify gaps in the Data that should inform the formulation of future collections
    - 2.3 Publish and make the data available

Summaries and Recommendations – Topic 2

Topic 2: Safe Uses of AI/ML and Software Algorithms

1. **Address the Concerns and Risks to Consumers, Ecosystem Players, and the FCC related to the use of Artificial Intelligence, Machine Learning, and other Data Driven Algorithms.**

    - 1.1 **Develop and Disseminate** an FCC Document that Quantifies the Concerns and Risks (Effectively a '**guidance and code of conduct**' **for use of AI/ML and Data Driven Algorithms**)
    - 1.2 **Convene an Industry and Stakeholder Expert Group** that can exchange data on operational issues/concerns, best practices/processes, metrics, and operational learnings to develop (voluntary) industry actions to mitigate concerns and risks. Use an ISAC-like structure (Information Sharing & Analysis) and leverage the NIST AI RMF.
    - 1.3 **Collaborate with other government agencies who have similar concerns and are undertaking proactive actions** on the safe use of AI in their field to share knowledge and best practices.

Summaries and Recommendations – Topic 2

Topic 2: Safe Uses of AI/ML and Software Algorithms

2. **Develop Policies and Practices that place the FCC ahead of the curve in recognizing the fundamental changes that the use of AI, ML, and Data Driven Algorithms has created and portends for the next generation of Network Architectures, Consumer and Societal use patterns, and Industry Business Models.**

- 2.1 **Assess the need for changes (e.g., new or extensions of existing regulation)** where AI/ML has the potential to substantially magnify undesirable behaviors and outcomes or can mitigate such outcomes (e.g., wiretap, robocall abuse).
- 2.2 **Monitor regulatory activities internationally** with focus on the EU (European Union) and consider adoption of best practices. Identify aspects of international regulations that may prove problematic in the context of US National interests.
- 2.3 **: Leverage the NIST AI Risk Management Framework (AI RMF) to develop industry profile(s)** that impart guidance and best practices on safe use of AI. Consider structuring an NOI around the profiles. Address how this effort takes advantage of FCC authority, capability, and that of the Expert Group (Recommendation 1.2)

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Summaries and Recommendations – Topic 2

Topic 2: Safe Uses of AI/ML and Software Algorithms

3. **Recognizing the central importance of Data and Software Quality in the implementation of AI, ML and Data-driven Algorithms, the FCC should undertake actions to develop robust processes and practices within the FCC and across the Telecommunications ecosystem. This is important for the adoption of AI/ML and the eventual quality and safety of Network Services.**

   - 3.1 Partner with industry to **identify relevant data sets from operating AI systems. Develop methods to securely share these data sets** into a broader data corpus to advance assessment of AI in operation and to facilitate curation of improved training data sets.

   - 3.2 **Promote** the development and adoption of an **Integrated Software, AI, ML, and Data Maturity Model for Telecommunications.** This could be based on an extension of CMMI or alternate software quality standards and practices.

Summaries and Recommendations – Topic 3

Topic 3: Spectrum Sharing Evolution

1. **Prepare the groundwork for Dynamic Spectrum Sharing with a high degree of automation. Take advantage of evolving technologies (for AI/ML, and Radio Architectures, and devices that open up new spectrum) and practices that have a high probability of reaching maturity in time for the deliberations used to define the next generation of wireless systems.**

   - 1.1 Establish a long-term partnership to sustain the effort by teaming with consortia that involve the research community and industry, federal organizations and laboratories, industry associations, and where appropriate FFRDCs.
   - 1.2 Exploration of Technology – include a comprehensive view of technical issues and economics (better models for propagation, avoidance of interference, co-existence of communications and sensing, energy efficiency, area coverage, …….)
   - 1.3 Exploration of Policy Options – as part of the plans, include effort to eliminate as much uncertainty as possible for the rules that would govern advanced spectrum sharing schemes and the time-lines for availability of spectrum to be shared. Include consideration for spectrum sharing with Federal users. Consider the ability and incentives for licensed spectrum holders to share their unused spectrum with third parties.

   Be creative with spectrum resources!

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Summaries and Recommendations – Topic 4

Topic 4: Use of AI/ML in Telecommunication Networks

1. **Prepare for the evolution in Network requirements driven by the advances in technology and by significant changes in Telecommunications Network usage patterns. AI/ML, DDAs, and Data/Information Networks have a significant impact of how networks are built and designed and an even more significant impact on usage patterns.**

   - 1.1 The FCC should develop roadmaps and models to understand how the changes are likely to impact the technology and economic issues that affect the Nations Networks, and how the US can establish and maintain a competitive economic position in Telecommunications. Computing, Storage, Data, and Software (AI/ML and DDAs) are all advancing dramatically in capability and are the ingredients, that along with specific physical devices define the potential capabilities of Future Networks. The overall trend is a disaggregated, distributed, heterogenous, software driven Telecommunications Network that is increasingly more complex and requires techniques such as AI/ML to be managed efficiently and effectively.

   - 1.2 The FCC should establish the appropriate Forums to understand how the wide use of AI/ML and DDAs in user applications will affect the demand for Network Services. This should involve non-traditional constituencies for the FCC.

Summaries and Recommendations – Topic 4

Topic 4: Use of AI/ML in Telecommunication Networks

2. Conduct a comprehensive study to understand how the growing complexity of the Nations Networks, with the inclusion of AI/ML techniques and Sofwarization, can be managed. The objective is to maintain interoperability and the same time contain risks to the Network while providing equitable access, a high degree of automation, flexibility in the Network's composition, and ability to meet the requirements of emerging services and applications.

- 2.1 Control of the Network – As a priority address technology and policies approaches that limit exposures of Network control systems to risks. The focus should be on practices that contain the "blast radius" of malfunctions attributable to implementations of AI/ML and DDA's in software and hardware (embedded systems)

- 2.2 Management and Support of the Network – Address the technical, economic, and policy aspects of how Telecommunications Networks interact with other infrastructures, so they are capable of supporting the evolving requirements of applications that depend on AI/ML. At the same time identify the dependencies of the Network on these infrastructures and how these dependencies fit within the FCC's mandates.

Summaries and Recommendations – Topic 4

Topic 4: Use of AI/ML in Telecommunication Networks

3. It is important for the FCC to be an active participants in the emerging bodies (standards and open-source) responsible for the software, physical infrastructure, and practices, that supports today's Networks. The pervasive use of AI/ML and DDAs across the layers of the OSI model that defines today's Networks implies a need for competency in the accompanying technology and practices. An increasingly large fraction of the Networks consists of generic computing and data storage equipment, and software. Ultimately this affects how well our Networks function and how well they contribute to economic activity.

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FCC Technological Advisory Council Agenda – August 17, 2023

10am – 10:30am	Introduction and Opening Remarks •Welcome Message (TAC Chair) •Opening Remarks by OET Chief •DFO/Deputy DFO Remarks •Member Introduction/Roll Call
10:30am – 11:15am	Emerging Technologies WG Presentation
11:15am – 12:00pm	Advanced Spectrum Sharing WG Presentation
12:00pm – 1pm	Lunch Break
1pm – 1:45pm	AI/ML WG Presentation
1:45pm – 2:30pm	6G WG Presentation
2:30pm – 2:45pm	Closing Remarks
2:45pm	Adjourned

FCC TAC 6G Working Group

Co-Chairs: Brian Daly, AT&T

Abhimanyu (Manu) Gosain, Institute for Wireless Internet of Things, Northeastern University

FCC Liaisons: Martin Doczkat, Kamran Etemad, Nicholas Oros, Sean Yun, Michael Ha

Date: August 17, 2023

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Outline for FCC TAC Formal Readout August 17, 2023

- WG participants
- Charter
- Focus Areas for 2023
  - The Road to 6G: National and Global Landscape for 6G
  - New Spectrum Needs for 6G
  - Security Needs for 6G
  - Potential Solutions for the Digital Divide in Education in Emerging 6G
- Recommendations/Advisements Summary

2023 6G Working Group Team Members

Bayliss,Mark	Visual Link Internet		**Mukhopadhyay, Amit**	Nokia
Brenner, Dean	Consultant		**Nawrocki, Michael**	ATIS
Chandra, Ranveer	Microsoft		**Nichols, Roger**	Keysight
Clegg, Andrew	Wireless Innovation Forum		**Peha, Jon**	CMU
Cooper,Martin	Dyna,LLC		**Schulzrinne, Henning**	Columbia U
Drobot, Adam	Open Techworks		**Thakker, Rikin**	WIA
Forester,Jeffrey	Intel		**Sorond, Mariam**	VMWare
Gammel, Peter	GlobalFoundries		**Bali, Ramneek**	Charter
Ghosh, Monisha	Notre Dame		**Welsh, Patrick**	Verizon
Kuoppamaki,Karri	T-Mobile		**Tooley, Matt**	NCTA
Lapin, Greg	ARRL		**Khayrallah, Ali**	Ericsson
Manner, Jennifer	Echostar		**Damnjanovic,Aleksandar**	Qualcomm
Markwalter, Brian	CTA		**Buyukkoc, Cagatay**	Deutsche Telekom
Mansergh, Dan	Apple		**Gyurek, Russ**	Cisco
Merrill,Lynn	NTCA			

6G WG - 2023 Charter

- Provide information on the **development and deployment of 6G technology**, make recommendations and provide technology insights on new developments that need our attention, from the need for more **spectrum to the vulnerabilities of supply chain to the changing dynamics of global standards development**.

- How does **Open RAN/vRAN** continue to benefit 6G technology development and the ecosystem?

- What are the efforts to ensure an **adequate level of security is provided in Open RAN/vRAN architecture** and what are the cost/benefit tradeoffs to consider?

- What are the opportunities for using **mmW/terahertz bands for fronthaul/backhaul** in support of dense deployment of 6G systems given the capacity capabilities and corresponding bandwidth demands anticipated for 6G systems?

- How is 6G technology envisioned to enhance or be utilized in **autonomous driving, edge computing, emergency alerting, and smart city technology** deployments?

- How can **6G help bridge the digital divide** by bringing down the costs of delivering broadband particularly to rural and urban underserved areas?

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Focus Areas & Deliverable for 2023 6G Working Group

- Working group deliverable is a white paper covering:
  - The Road to 6G: National and Global Landscape for 6G
  - New Spectrum Needs for 6G
  - Security Needs for 6G
  - Potential Solutions for the Digital Divide in Education in Emerging 6G

Working Group White Paper Executive Summary

- Presents key national and global developments as Industry, Government, Academia and various standardization efforts chart a path towards 6G
- Key recommendations and considerations for the FCC across areas of 6G spectrum needs, security, and the digital divide
- Identifies key initiatives such as ITU-R/ITU-T IMT-2030 and WRC 2023 and WRC 2027 that will identify key input criteria: usage requirements, spectrum needs and technology development areas that will eventually define 6G and serve as input to 3GPP
- Identifies spectrum needs from low, mid to high bands including unlicensed and non terrestrial use
- Identify the security landscape and increased attack surface for 6G networks as ICT and mobile communications converge along with increased use of AI/ML in networks
- Address the digital divide topic and its impact on education with recommendations on spectrum access, siting and backhaul as well as cost of delivery to close the access gap with 6G technology

The Road to 6G: National and Global Landscape for 6G

National and Global Landscape for 6G

- CHIPS and Science Act has several parts that benefit wireless research .
  - Includes the Technology, Innovation and Partnerships (TIP) directorate under NSF, which has wireless research among its priorities
  - Public Wireless Supply Chain Innovation Fund, with the focus to "drive wireless innovation, foster competition, and strengthen supply chain resilience
- 6G has a prominent role in semiconductor-oriented activities.
  - White House PCAST report on revitalizing the US semiconductor ecosystem recognizes that mobile phones (26 percent), information and communications infrastructure (24 percent) make up half of the total demand
- Importance of 6G has been recognized as critical technology by the US and other governments, in light of the increasingly tense geopolitical situation

Government Actions on 6G

- April 2023, the National Security Council (NSC) and NSF organized a workshop on 6G
- NSC issued the document “Principles for 6G: OPEN & RESILIENT BY DESIGN” with 6 principles addressing these topics:
  1. Trusted Technology and Protective of National Security
  2. Open and Interoperable Innovation
  3. Secure, Resilient, and Protective of Privacy
  4. Affordable, Environmentally Sustainable, and Globally Connected
  5. Spectrum, Novel Materials, Manufacturing
  6. Standards & International Collaborations
- US government is renewing its attention to standards
  - Issued the national standards strategy for critical and emerging technology in May 2023, with Communication and Networking Technologies featured first among 8 focus areas
  - Notes that the US has lagged in participation in ITU, but expects a change with the election of the US candidate as secretary-general
  - Identifies an action to work with the private sector to educate and train a new standards workforce

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Trans-Atlantic Actions

- US and EU launched the Trade and Technology Council (TTC) in 2021
    - Objective "to promote U.S. and EU competitiveness and prosperity and the spread of democratic, market-oriented values by increasing transatlantic trade and investment in products and services of emerging technology, strengthening our technological and industrial leadership, boosting innovation, and protecting and promoting critical and emerging technologies and infrastructure
    - Working Group 4 focuses on information and communications technology and services, security and competitiveness
- 6G expert workshop was held under TTC auspices in April 2023, and included 3 panels:
    1. Introduction and scene setter;
    2. Use case categories and technology visions; and
    3. Key enablers
    - Workshop recommendations on mechanisms for transatlantic collaboration on 6G were provided to the fourth TTC meeting in Sweden 30-31 May 2023

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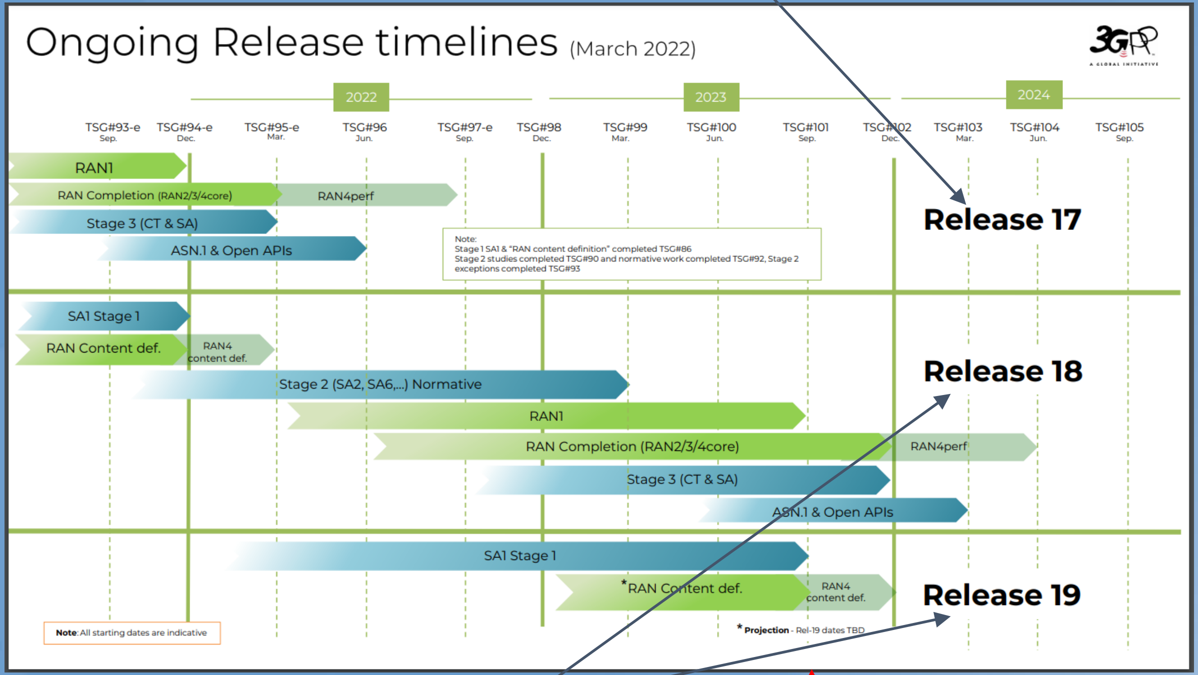
Additional Actions

- A B7 meeting was held in Tokyo in April 2023, and issued its recommendations to the G7 political leaders
  - Under the digital transformation goals, 6G is highlighted as an emerging critical technology, and there was a recommendation to promote research collaboration among the G7 members' initiatives
- National Security Council held a Roundtable to Advance Cooperation on Research and Development in 5G and 6G on June 1 2023 with attendees from academia, industry and government from the U.S. and India
  - Follow-up to the U.S.-India initiative on Critical and Emerging Technology (iCET) announced in May 2022 to elevate and expand strategic technology partnership between the governments, businesses, and academic institutions of India and the U.S.
- Followed up by a joint statement emphasizing collaborations on 5G/6G and Open RAN led by the NextG Alliance and the Bharat 6G Alliance

3GPP - 5G to 6G Path

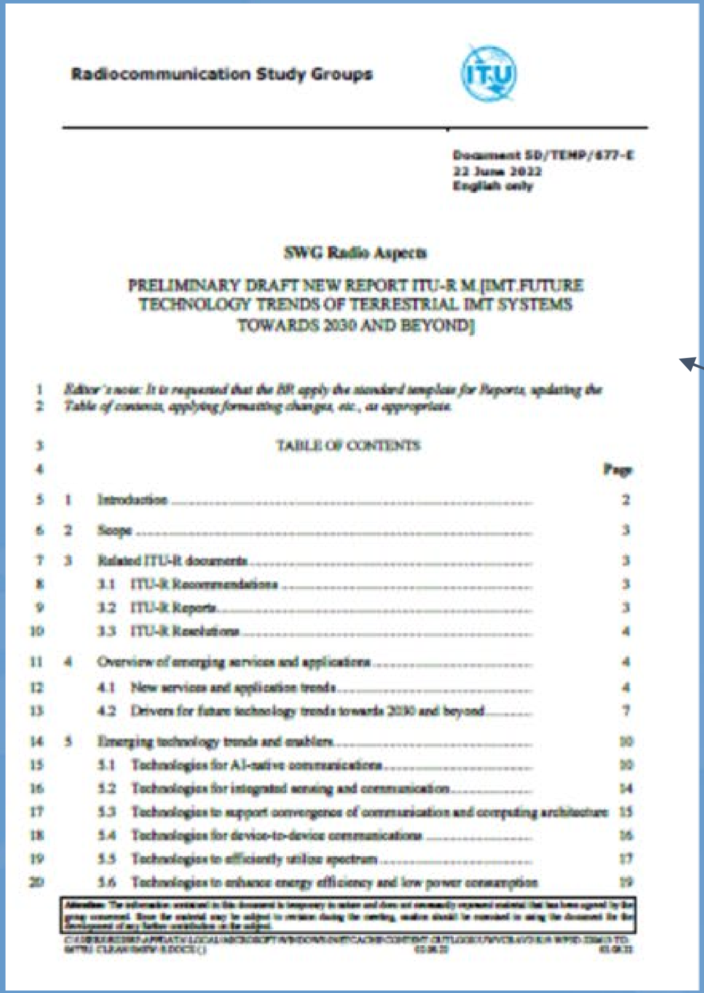


Today

- Release 17 completed June 2022 (with exceptions completed in September)
- Primary aim of Rel-17 is to improve 5GS performance, support new use cases and verticals, and provide ubiquitous connectivity in different deployment conditions and scenarios
- 3GPP release 18 represents a major evolution of the 5G System and due to this the 3GPP has decided to brand it as the first release of 5G Advanced.
- Rel-18 will include major enhancements in the areas of artificial intelligence (AI) and extended reality that will enable highly intelligent network solutions that can support a wider variety of use cases
- Rel-19 is starting to look at advanced services such as Integrated Sensing & Communications, localized mobile metaverse services, service robots, and ambient powered IoT

Today's Deployments are based on R15 & 16
Deployments are typically ~24 months after a 3GPP release completion

ITU-R IMT towards 2030 and beyond



Radiocommunication Study Groups

Document 5D/TEMP/677-E
22 June 2022
English only

SWG Radio Aspects

PRELIMINARY DRAFT NEW REPORT ITU-R M.[IMT.FUTURE TECHNOLOGY TRENDS OF TERRESTRIAL IMT SYSTEMS TOWARDS 2030 AND BEYOND]

Editor's note: It is requested that the BR apply the standard template for Reports, updating the Table of contents, applying formatting changes, etc., as appropriate.

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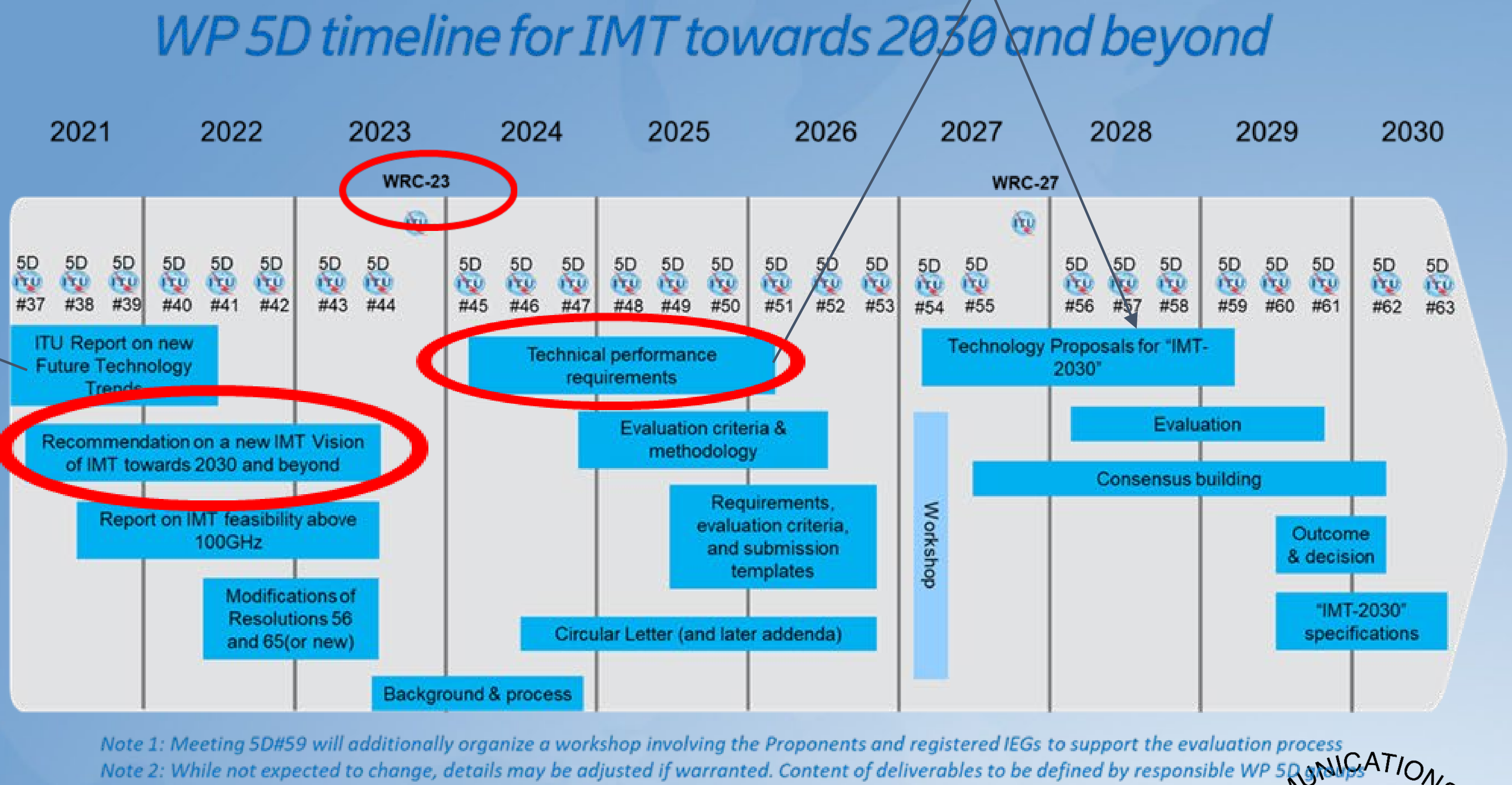

ITU-R Draft IMT-2030 Framework

- ITU-R reached an agreement on the draft IMT-2030 framework, sent for adoption by the Study Group 5 (SG5) of ITU-R
  - The next meeting is scheduled for September 25-26.

- International Telecommunication Union (ITU) plans to finish the initial IMT-2030 (6G) standardization process “no later than the year 2030”, consistent with 3GPP Release 20 & 21

- Consider spectrum in higher frequency ranges above 92 GHz as a complement to the use of lower frequency bands.
  - More specifically, bands around 100 GHz, 140-160 GHz, 220-240 GHz, and around 300 GHz could potentially be candidates

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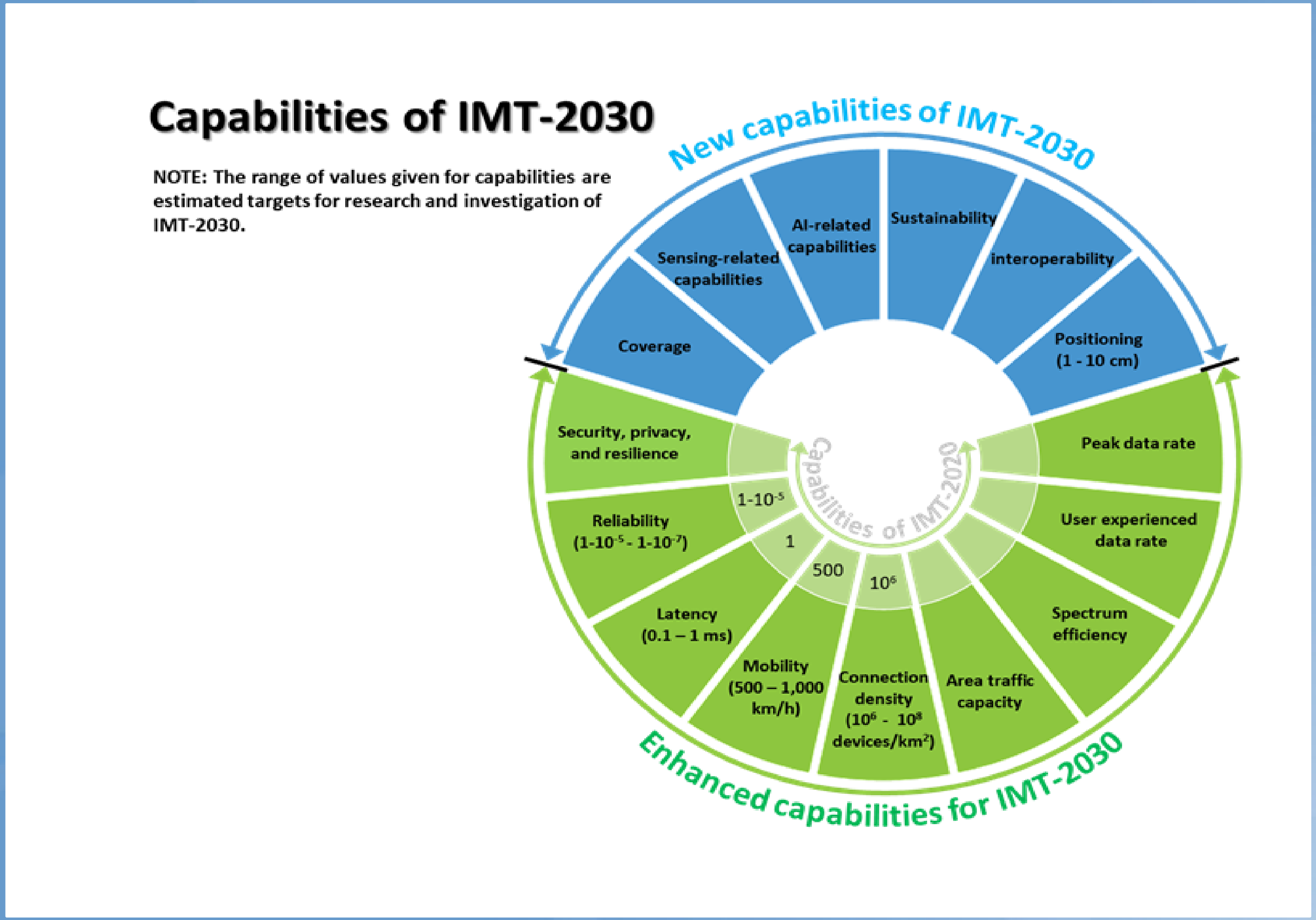
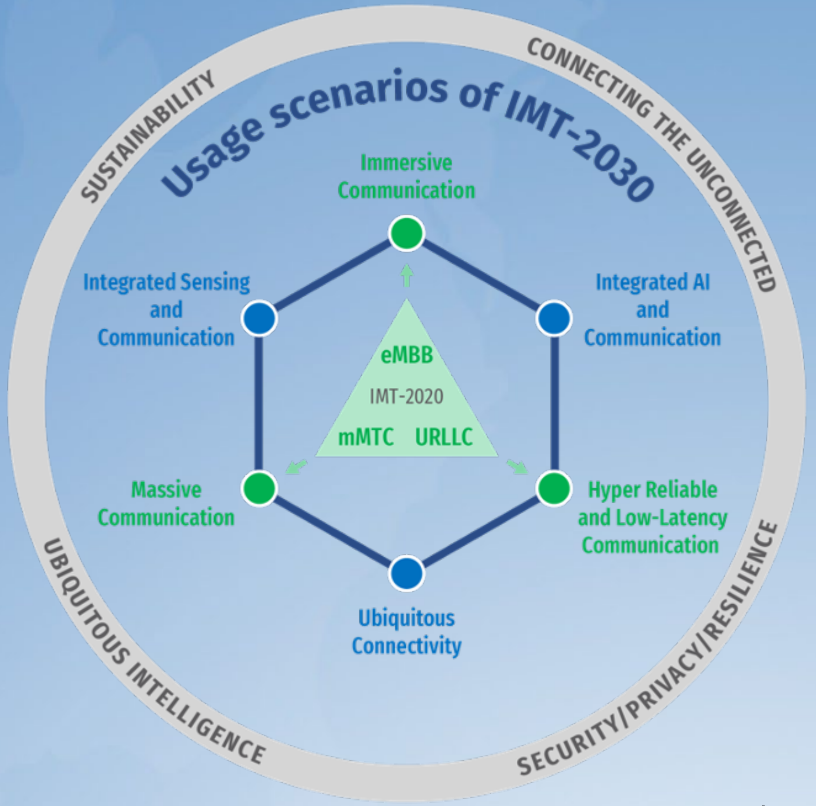
ITU-R Draft IMT-2030 Framework – Capabilities & Use Cases





New Spectrum Needs for 6G

Drivers of Demand for Spectrum Allocation

Long-term demand for increased spectrum allocation to terrestrial and non-terrestrial IMT stems from:

1. Increasing demand from existing use-cases; and
2. Novel use cases enabled by next-generation (6G) technologies

Increasing Demand From Existing Use-Cases			
North America: ***Source EMR June'23***	**2021→2022 (Increase)**	**2028 (fcst)**	**2021-2028 CAGR**
Consumption per Smartphone	13GB→20GB (+54%)	58GB	24%
Total Mobile Data Consumption	4.6EB→6.7EB (+46%)	21EB	21%

Novel Use Cases: 6G Context (2030 & Beyond)

- XR technologies including multi-sensory extended reality (e.g. haptic hologram)
- Cooperative robotics
- Distributed and integrated communications & sensing

A sample of quantitative analyses suggests a requirement of 2GHz for terrestrial and NTN spectrum in the next decade

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Summary of New Spectrum Bands Under Research and Consideration

- Terrestrial Component of 6G: (global perspective): 4.4-4.8GHz; 6-15GHz; 15-24GHz; and >110 GHz
  - 7-15GHz and 15-24GHz:
    - Existing FCC Considerations include:
      1. 10.0-10.5GHz (in WRC-23 Agenda Item 1.2); and
      2. The FCC has ruled out 12.2-12.7GHz but has 12.7-13.25GHz for consideration under NPRM (FCC-23-36)
    - Almost universal agreement from industry and academia that regulators must address the increasing demand of IMT by opening more spectrum from 7-15 GHz (the range from 15-24GHz is deemed less favorable due to radio-technology state of the art (cost))
    - Many entities are investing in channel analysis and modeling and advanced radio systems using bandwidths of up to 500MHz to support this
  - >110GHz:
    - Most demanding applications envisioned for 6G imply necessary bandwidths of >10GHz and thus the exploration of frequencies above 110GHz
    - This presents significant pressure on the state of the art for all related wireless technologies
- Non-Terrestrial Component of 6G:
  - Spectrum bands are under consideration today for use by integrated non-terrestrial networks (NTN) for 6G range from 900Mhz to upwards of 80 GHz.
  - Because of propagation characteristics, a variety of different bands will be required to meet the diverse 6G user cases.

Perspectives from major non-USA governing bodies

- Among the topics to be covered at the 2023 World Radio Conference (WRC-23) in Dubai in November-December 2023 will be the agenda for WRC-27
  - WRC-27 preliminary agenda covers proposed spectrum to be considered for use by 6G
  - Administrations around the globe are preparing country and regional positions on these topics
  - It is important that WRC-27 be enabled, through this agenda work, to consider the identification and allocation of sufficient spectrum for terrestrial and NTN 6G or it will be difficult to have the required spectrum available at the end of the decade
- Bands under consideration in the preliminary agenda:
  - Terrestrial 6G spectrum:
    - 1300-1325 MHz
    - 694-960 MHz
    - Other under consideration: 4.4-4.8 GHz, 6 GHz, 7-24 GHz.
  - NTN 6G spectrum:
    - 43.5-45.5 GHz
    - 71-76 GHz and 81-86 GHz
    - Other under consideration 2-7 GHz for mobile satellite services

Summary of considerations beyond adding spectrum for terrestrial IMT

- Elements which all contribute to arguments for better use of existing spectrum:
  1. challenges of re-allocation or re-farming;
  2. the wide variation in real-time occupation of licensed spectrum over geography and over time (low utilization); and
  3. the state of the art of spatial multiplexing
- Flexible Access to Unused Spectrum
  - require or incentivize licensees to cede use of spectrum when it is not in use or is under-utilized. (This can also be one avenue to address one facet of the rural digital divide.)
- Spectrum Sharing among different services (e.g., federal radiolocation and commercial mobile or satellite communication), and among same services (e.g., terrestrial and non-terrestrial, including satellite)
- Increased Cell Density
  - Consider the advantages and disadvantages of increased cell-density.
- Spatial Multiplexing Technologies
  - Higher-order MIMO and beam-forming have become ubiquitous in C-band 5G systems. This approach to increase bps/Hz/km2 ensures spatial allocation of a user's signal (RF flux density) is constrained to the user's physical location.

Spectrum Needs Recommendations

- Build a longer-term spectrum pipeline (add specific areas to consider for NTN and ICT)
  - 5G Americas states that the FCC has an inadequate 5-15 year pipeline for spectrum-allocation change considerations.
  - Such a pipeline would be similar to that which yielded the significant changes in spectrum for cellular communications over the past decade.
  - Large-scale long-term changes in radio spectrum usage, analogous to the advent of broadcast radio and TV, are again upon us and increasing demand is inevitable
- Explore licensing/sub-let schemes
  - This has been implemented in other nations.
  - The relative level of success should be analyzed to determine appropriateness and approaches for the USA.
  - This could allow for localized/short-term changes to address both under-capacity and under-served areas.
- Consider further streamlining the site location regulatory process since it is likely there will be many more sites for 6G.

Spectrum Needs Recommendations - continued

- Increased Cell Density:
  - Consider the advantages and disadvantages of increased cell-density.
  - There can be significant gains in spatial spectral efficiency (bps/Hz/km2) by decreasing the "cell size."
  - On the other hand, site acquisition, backhaul, inter-cell interference, increased power consumption, and the resulting operational complications can become limiting factors.
- Consider initiatives to spur greater geographic-area spectral efficiency (bps/Hz/km2).
  - This has been investigated by the TAC in the past and ruled out due to technical complexities of defining and measuring the associated figures of merit among other issues.
  - However, the rapid expansion of wireless use and of allocated spectrum since those investigations, as well as the expansion and rapid growth of altitude-based spectrum use (e.g. NTN), justifies exploring this idea in this newer context.

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Spectrum - Associated Caveats and Risk Areas

- Sustainability risks must be considered:
  - Increased cell density carries the risks of increasing power consumption and of negative impact on the physical environment.
  - Higher frequencies mean lower energy-efficiency of radio power amplifiers. Most of the energy consumed in mobile networks is dissipated as waste-heat in power amplifiers so moving to higher spectrum always carries this risk.
  - Increased use of NTN continues to crowd orbit resources.
- Complex and non-representative performance metrics
  - The complexity of topics like spectral efficiency and adequate backhaul are such that investigations will require methods of normalizing and averaging by and within use case, geographic areas, spectrum band and bandwidth, population density, time of day, time of year, and long-term changes in these areas.

Security Needs for 6G

Security must be a top 6G priority from the outset

- As 6G is specified and designed over the coming years, just as with 5G and prior generations of wireless, it is crucial that security be a top priority from the outset.
- Requires collaboration and ongoing work by many commercial and governmental stakeholders in the United States and around the world
- The FCC, taking into account the recommendations and other input from future TACs, CSRIC, and others, including the output from the major wireless standards bodies, will play an important role in ensuring that 6G equipment is fully secure, as it has done with equipment for the prior generations of wireless
- 6G is in an early discussion phase, however, it is noteworthy that the NextG Alliance, the North American group working on 6G, has already issued a white paper on 6G Trust, Security and Resilience
- FCC's CSRIC continues to produce recommendations and best practices for security, which have implications for 6G
- ORAN Alliance WG11 is focused on open RAN security topics including virtualization, multi-vendor and related topics

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Sample of Security References

- 3GPP SA3 has published 246 specifications, studies, and technical reports dating back to 2G systems. 42 of these are specific to 5G
- O-RAN ALLIANCE WG11: 12 security specifications to date
- National Security Council position on 6G
- CSRIC VIII report: Promoting Security, Reliability, and Interoperability of Open Radio Access Equipment (Dec 2022) & How Virtualization Technologies Can Be Used to Promote 5G Security and Reliability (Dec 2022)
- CISA Vulnerability Scanning & CISA Cyber Resilience Review
- NextG Alliance: Trust, Security, and Resilience for 6G Systems whitepaper
- NIST Zero Trust Architecture (800-207)

We recommend that future TACs continue to monitor and provide input on 6G security and resilience, along with the input to the Commission of other groups as the technology development and standards process matures.

Potential Solutions for the Digital Divide in Education in Emerging 6G

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Digital Divide Introduction

- In today's digital age, access to the internet is an indispensable tool for acquiring knowledge and skills.
- Millions of students struggle with digital learning because they don’t have quality internet connections or devices - an issue known as the homework gap
- Investing in connectivity and technology, digital literacy, and digital learning solutions help connect today’s learners with success – in and out of the classroom
- Having full-time, mobile access to the internet—at school, on the way to and from school, and at home-- has become an essential ingredient for a comprehensive education
- Providing connectivity at home for all students is paramount and should be considered the first priority, which can be accomplished with a combination of technologies including mobile, fiber, Wi-Fi , and Non-terrestrial networks
- Closing the digital divide includes focusing not only on access to affordable high-speed internet, but also the skills and community resources that encourage safe and successful adoption
- Congress and the FCC have recognized this through the enactment and successful implementation of the Emergency Connectivity Fund, the Affordable Connectivity Program, and recent changes and proposed changes to the E-rate program.
- In the early design and planning for 6G, it’s essential that public and private stakeholders build upon this momentum and adopt specific mechanisms aimed to optimize the future 6G for this important objective of ensuring affordable, full-time access to the internet for all students.

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Benefits of Full-Time Internet Access for Education

- Information and Resource Availability
  - The internet provides an unparalleled wealth of information and resources, enabling students to access a vast array of educational materials, research articles, multimedia content, and interactive platforms.
  - Full-time internet access ensures students can utilize these resources to enhance their learning experiences and deepen their understanding of various subjects.
  - A high-speed internet connection bridges distances and provides access to resources and people enhancing and leveling the educational experience
- Collaborative Learning Opportunities
  - The internet facilitates collaboration among students, both within their own school and with peers globally.
  - Through online platforms and tools, students can engage in virtual discussions, share ideas, work on group projects, and gain exposure to diverse perspectives.
  - Full-time high-speed internet access fosters a collaborative learning environment and prepares students for the interconnected world they will enter
- Personalized and Adaptive Learning
  - Online platforms and educational software offer personalized learning experiences tailored to individual student needs and learning styles.
  - High-Speed Internet access allows students to benefit from adaptive learning technologies, virtual tutors, and online assessments, enabling them to progress at their own pace and receive immediate feedback.
- Global Perspective and Cultural Awareness
  - The internet provides access to information from around the world, exposing students to diverse cultures, perspectives, and global issues.
  - Full-time high-speed internet access empowers students to become global citizens by expanding their horizons, promoting tolerance, and fostering a greater understanding of the world.

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Challenges & Concerns

- Infrastructure and Connectivity:
  - Practicality- Achieving full-time internet access for every K-12 student requires infrastructure and connectivity, especially in remote or underprivileged areas. The end-to-end cost and logistical challenges of establishing and maintaining such infrastructure may be economically impractical and resource intensive.
  - Public-private partnerships can increase broadband penetration in the short-term while setting the stage for long-term success.
  - The TAC proposes to investigate ways in which newly designed 6G-based infrastructure and connectivity can be tailored to the needs of education and which can be delivered at acceptable costs.
- Digital Literacy and Online Safety
  - Potentially Dangerous: Granting unrestricted internet access to students without proper digital literacy and online safety education may expose them to potential risks such as cyberbullying, online predators, misinformation, and excessive screen time.
  - The Commission's recent proposal to dedicate E-rate funds for enhanced cybersecurity initiatives and the funding for digital literacy programs in the federal infrastructure law highlight the importance of this point.
  - Parents play an important role in helping today's connected students safely engage in online learning.
  - Ensuring adequate training and support for students, parents, and teachers in navigating these risks is essential.
  - Digital literacy resources are needed for students and their parents to get the skills they need to effectively use the internet and technology.
  - Programs are needed that help people and communities develop digital literacy skills to thrive in our modern world.

Challenges & Concerns - continued

- Equity and Accessibility
  - Economics: Bridging the digital divide and providing full-time high-speed internet access to all students at reduced cost or without charge, particularly those from economically disadvantaged backgrounds, is likely to be a costly endeavor, as Congress itself recognized in establishing the one-time $7.2 billion Emergency Connectivity Fund.
  - The TAC proposes to investigate ways in which a combination of in-kind subsidies (such as low-cost/no-cost spectrum use and access to infrastructure such as towers and cell sites) can make dedicated delivery of educational connectivity an economically acceptable enterprise opportunity.
- Distractions and Dependency
  - Potentially Dangerous: Unrestricted internet access may lead to distractions and potential addiction to social media, online gaming, or other non-educational activities, negatively impacting students' focus, productivity, and overall well-being.
  - Balancing internet usage and fostering responsible digital habits are essential considerations.
  - Again, the Commission and the educational community has recognized this in the context of the E-rate program.

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Challenges & Concerns - continued

- Education as a Use Case
  - In designing and deploying 5G, the wireless industry focused on various use cases (massive IoT, ultra low-latency, reliable communications, etc) and various technologies and network topologies (non-terrestrial networks, vehicle-to-vehicle communications, etc).
  - In the early design and planning phases of 6G, the TAC believes the wireless industry, educational groups, and regulators should prioritize development of an end-to-end 6G solution optimized to provide low-cost, full-time internet access for all K-12 students.
  - Making this a top objective in the early design of 6G is important from the outset.
- Spectrum:
  - Emerging 6G architectures are expected to continue to utilize, at least in part, higher bands such as cm/mmWave and mmWave, and emerging sub-THz and THz bands.
  - These bands have tremendous value related to throughput and capacity however, they have limited propagation characteristics.
  - The FCC should be aware of these physical characteristics and explore spectrum and technical solutions that would address the specific needs of providing high-speed internet access to devices to leverage the connectivity with the latest software and security.
  - The FCC should consider the end-to-end needs related to providing access to all.
- Backhaul/Transport Gaps
  - Consider initiatives to address backhaul/transport gaps.
  - Without adequate backhaul {e.g. fiber, Integrated Access and Backhaul (IAB) and satellite} more spectrum or higher spectral efficiency will not result in the expected business, service, and experience improvements.

Summary

- A complete education today requires that students have affordable full-time high-speed internet access.
- Many students in the U.S. lack such access either because there is no access to broadband services where they live, or they can't afford access fees for such service.
- While full-time high-speed internet access for all K-12 students offers numerous benefits, it is crucial to acknowledge and address the challenges and concerns associated with its implementation
- Education is a societal equalizer and is critical to the future success of America- providing all an equal opportunity
- The FCC alone cannot solve the digital-divide challenge.
  - No one public or private sector stakeholder can do so.
  - This is why extensive, deep technical collaboration in the early design of 6G is necessary so that the goal of ensuring that affordable full-time internet access is available to all students.
  - The FCC should encourage industry (vendors, providers, etc), as well as the Department of Education, to focus on creating 6G based solutions that extend connectivity to all students.
- It is proposed that a future TAC continue to explore possible technological solutions with the objective of making specific actionable recommendations to the FCC.
  - Of special interest is the possibility that private enterprise can assist in providing full-time access to students at low cost (for example, $5-10 per month per student) if subsidized with available shared/free spectrum use, low-cost/free siting, and possibly low-cost/free backhaul and interconnect options.

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Digital Divide - Recommendations

- Encourage private stakeholders working now on the early design and planning for terrestrial and non-terrestrial-based 6G to consider making the provision of low-cost, full -time internet access for K-12 students a paramount goal for 6G.
- Explore technology interoperability and options to solve last mile, mid-haul and back-haul needs such as terrestrial and satellite-based technical solutions that may use existing spectrum in conjunction with technologies such as MIMO and Open-RAN to lower the end-to-end cost of providing rural broadband.
  - Encourage public and private sector research and development in these areas.
- Encourage specification/standards and industry organizations to focus on technical solutions aimed at reducing or closing the digital divide.
- In making spectrum allocations and in considering technical rules for existing and new spectrum bands (including power levels), the FCC should prioritize solutions aimed at reducing or closing the digital divide.
  - Likewise, in their ongoing collaborations over spectrum policy, the FCC and NTIA should work together to identify spectrum and on other policies aimed at reducing or closing the digital divide.
- Investigate creative policy and technical tools to drive down the cost of backhaul.
- Speed and Connection to Service:
  - Agencies should prioritize the completion of fiber projects to student locations or cell sites for last mile connectivity.
  - Including the removal of construction barriers, support for construction or support for long-term operations cost specific to the needs of education.
  - Address high cost of fiber drop placement in rural or remote areas.

Digital divide – Recommendations (continued)

- Encourage much greater technical collaboration and seek public/private partnerships between terrestrial and non-terrestrial wireless industry technical experts and the educational community to establish use cases and to qualify and quantify the bandwidth needs for K-12 students during the lifespan of 6G.
- Consider solutions to the need for full-time access that make use of local siting opportunities like schools, libraries and other public facilities and the opportunity to utilize school and other government-owned assets for infrastructure placement and use.
  - Survey infrastructure manufacturers seeking specific solutions that drive down the cost of providing internet access to students in rural and other areas
  - For example, Use of advanced massive MIMO to optimize capacity and range including mid/backhaul (IAB), or simplifying infrastructure to tailor it to the needs of students/education.
- Explore availability of unused, desirable spectrum in rural areas and how rural areas can acquire access via spectrum bands that may offer broader geographic coverage. For greater coverage the 600 MHz, 700 MHz and 850 MHz bands provide the greatest reach especially when enhanced with multi-user MIMO technology.
- Explore the availability of unused, desirable spectrum that can be used for non-terrestrial technologies to offer greater capacity to offer higher speed capabilities.
- Explore the use of advanced spectrum sharing techniques across various frequencies in the rural areas with the goal of significantly increasing spectrum efficiency by allowing for access to a wider range of bandwidth.
- Ensure that the FCC broadband maps include accurate and updated information on internet access at all schools, libraries, and other educational institutions.

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Thank you!

FCC Technological Advisory Council Agenda – August 17, 2023

10am – 10:30am	Introduction and Opening Remarks •Welcome Message (TAC Chair) •Opening Remarks by OET Chief •DFO/Deputy DFO Remarks •Member Introduction/Roll Call
10:30am – 11:15am	Emerging Technologies WG Presentation
11:15am – 12:00pm	Advanced Spectrum Sharing WG Presentation
12:00pm – 1pm	Lunch Break
1pm – 1:45pm	AI/ML WG Presentation
1:45pm – 2:30pm	6G WG Presentation
2:30pm – 2:45pm	Closing Remarks
2:45pm	Adjourned

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