Federal Communications Commission Technological Advisory Council Meeting

December 8, 2022

FCC Technological Advisory Council Agenda – December 8, 2022

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	AI/ML WG Presentation
12:00pm – 1pm	Lunch Break
1pm – 1:45pm	Advanced Spectrum Sharing 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: December 8, 2022

Working Group Roster

Ahmad Armand	T-Mobile
Mark Bayliss	Visual Link
Nomi Bergman	Advance
Ranveer Chandra	Microsoft
Bill Check	NCTA
Lynn Claudy	NAB
Andrew Clegg	WInnForum
Mischa Dohler	Ericsson
Jeff Foerster	Intel
Peter Gammel	Global Foundries
Russ Gyurek	Cisco
Dale Hatfield	UC Boulder
Mark Hess	Comcast
Frank Huang	Deutsche Telekom

Steve Lanning	Viasat
Greg Lapin	ARRL
Kaniz Mahdi	Deutsche Telekom
Jennifer Manner	Hughes
Lynn Merrill	NTCA
Michael Nawrocki	ATIS
Jack Nasielski	Qualcomm
Madeleine Noland	ATSC
Jesse Russell	Inc Networks
Lewis Shepard	VMWare
Marvin Sirbu	SGE
Ted Solomon	NRTC

Advances in IoT Ecosystem and Devices

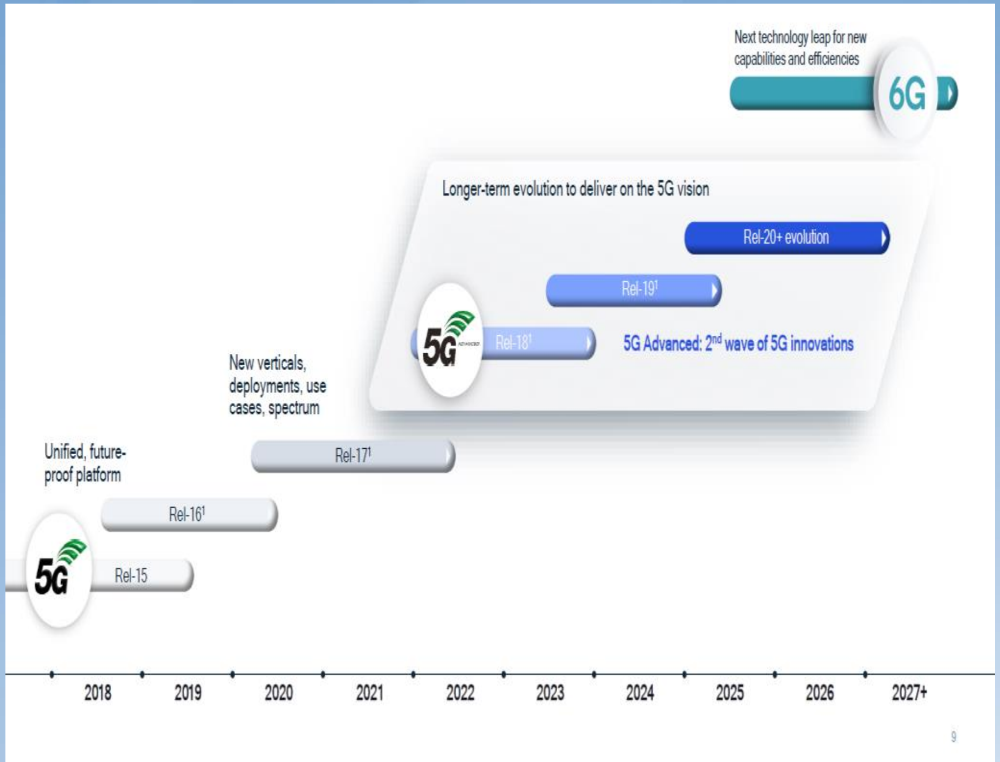
- IoT ecosystem and spectrum access needs including advances in semiconductor technologies for RF front ends, antennas and digital basebands

Topic	Speaker	Company
Current 5G chipsets	Sunil Patil	Qualcomm
IC evolution to 6G	Mingxi Fan	Mediatek
Steerable flat panel satellite antennas	Lilac Muller, Ryan Stevenson	Kymeta
Array antennas and beamforming	Gabriel Rebeiz	UC San Diego
Advancements in RF front ends	Harish Krishnaswamy	Columbia University

Current 5G chipsets

Sunil Patil, Qualcomm

- 3GPP Release 18 sets off the 5G advanced evolution
  - Strengthen the end-to-end 5G system foundation
  - Proliferate 5G to virtually all devices and use cases
- X70 modem has incorporated AI
  - AI based channel state feedback,
  - AI based beam forming
  - AI cell edge coverage improvement
- Qualcomm working on smart transmit architecture which specifically improves the performance of uplink
- Takeaway: AI is being incorporated in 5G chipset leading to 5G coverage enhancement and uplink performance improvement



IC Evolution to 6G

Dr. Mingxi Fan, MediaTek

- Optimization at all layers
- Antennas, packaging, semiconductor technology
- RFFE integration, PA efficiency
- Lean protocol stacks, dynamic QoS, awareness between app and radio
- AI assisted radio access
- Takeaway: increasing level of technology integration continues in smartphones

	5G	6G Projection
Data Rate	100Mbps –10Gbps	1Gbps–1Tbps
Device MIMO	2Tx / 4+Rx	4Tx / 8+Rx
Spectrum	+3.5-7GHz +mmW (28-60GHz) ~3+ GHz more	+7-14GHz +Sub-THz ~50+GHzmore?
Network Densification	+ massive MIMO	Infrastructure and device cooperation

Steerable (holographic) Flat Panel Antennas

Lilac Muller & Ryan Stevenson, Kymeta

- Always on, go anywhere comms
- Military, first responders, maritime
- GEO and LEO compatible
- Holographic beamforming: a type of analog beamforming with phased arrays
- Manufacturing similar to LCD flat panel technology
- Looking to LEO integration and 5G NTN
- Power consumption is high for consumer vehicle use
- Plans for future reductions in size of antenna

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Phased Array Antennas

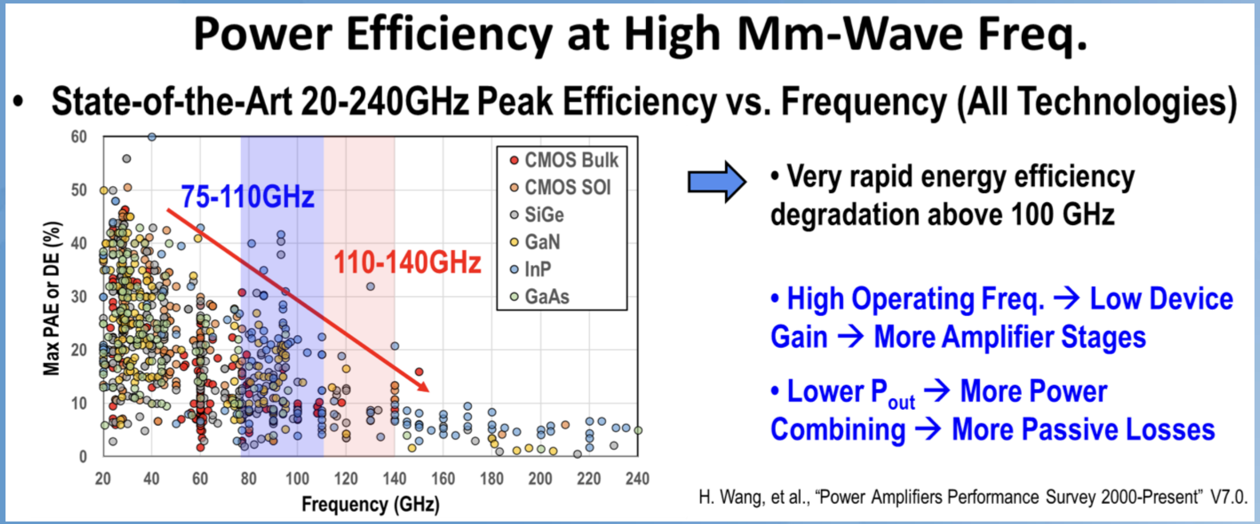
Dr. Gabriel Rebeiz, UCSD

- Phased array antennas now ubiquitous
  - Hundreds of thousands of base stations
  - Millions of smartphones
- DARPA funded underlying research on mixed signal systems, GaN, SiGe and mm-Wave array technology
- Analog beamforming well established
  - But are the system issues resolved?
  - Is it underutilized in 5G?
- Current research on digital beamforming at the antenna element

Advancements in RF front ends

Prof. Harish Krishnaswamy, Columbia University, now Mixcomm

- Focus on RF Silicon on Insulator (SOI) for millimeter-wave applications
- mmWave frequencies are roughly 1/10th of f_{max} (250-300 GHz for RF SOI), which lowers power efficiency
- Current products are mmWave beamforming front end ICs for 5G market
  - Integrates power amplifiers, low noise amplifiers, T/R switching, beamformers, and gain control



Key Insights

- The rising challenge of complexity for cellular UEs due to ever increasing number of bands, channel bandwidths, and MIMO order may be addressed through:
  - radio interface overhead reduction
  - lean protocol design
  - high power efficiency
  - AI-assisted communication design
- Incorporation of AI in 5G chipsets is expected to result in uplink performance enhancement, cell-edge coverage improvement, and potentially greater overall system spectrum efficiency
- Use of Silicon along with advances in highly dense multi-layer PCB boards have resulted in low-cost phased arrays and transceivers for 5G

Key Insights (2)

- Beamforming
  - All base-stations at sub-6 GHz use digital beamforming at element
  - Future is digital beamforming at the element in both sub-6 and above 6 GHz
  - DARPA is sponsoring research on digital beamforming at the element at 12 GHz and 20-50 GHz
  - UAV detection radars are based today on silicon beamformers at Ku and Ka-band
    - Defense agencies are benefiting from commercial development
- AI-based optimization towards native AI-Integrated System
  - AI-efficient radio network design
  - AI-assisted radio access optimization

- Industry may consider testable and collaborative AI among vendors

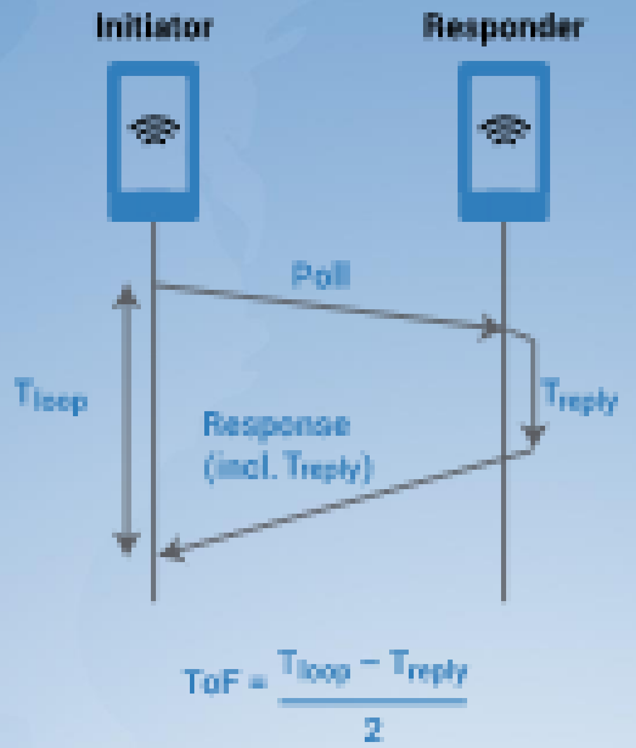
New Features and Chipsets

- **Question**: What are the new features or additional chipsets that are expected to be embedded into wireless devices, including UWB and other sensors, and how would they promote additional services and applications?

Topic	Speaker	Company
UWB and FiRa Consortium	Karthik Srinivasa Gopalan	Samsung
UWB in phones	Nihar Jindal	Google
UWB technology and applications	Tim Harrington	UWB Alliance
Sidelink in 5G	Tingfang Ji	Qualcomm

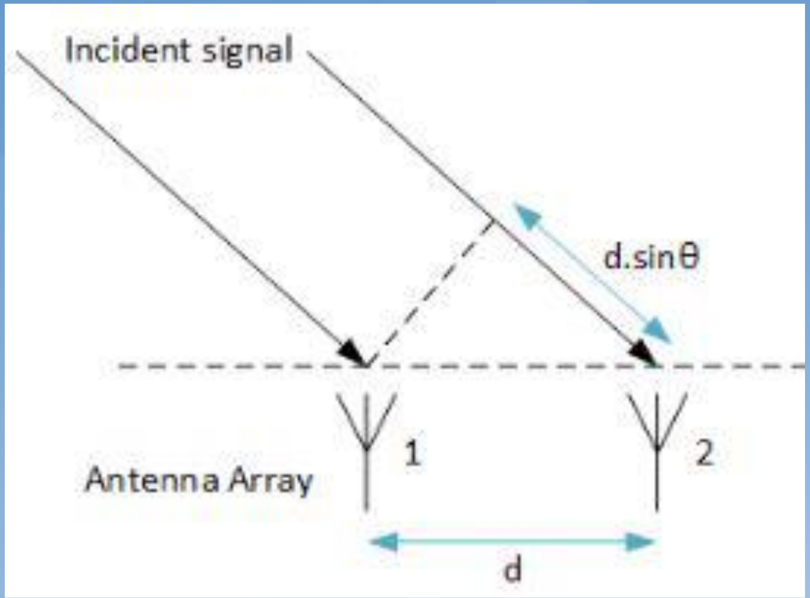
Karthik Srinivasa Gopalan, Samsung

- Speaking as FiRa Consortium technical working group chair
- Impulse radio UWB, enhanced in IEEE 802.15.4z
- Very accurate ranging (10 cm)
- Full protocol stack for secure, accurate ranging
- FiRa Consortium adds use cases, specifications and certification



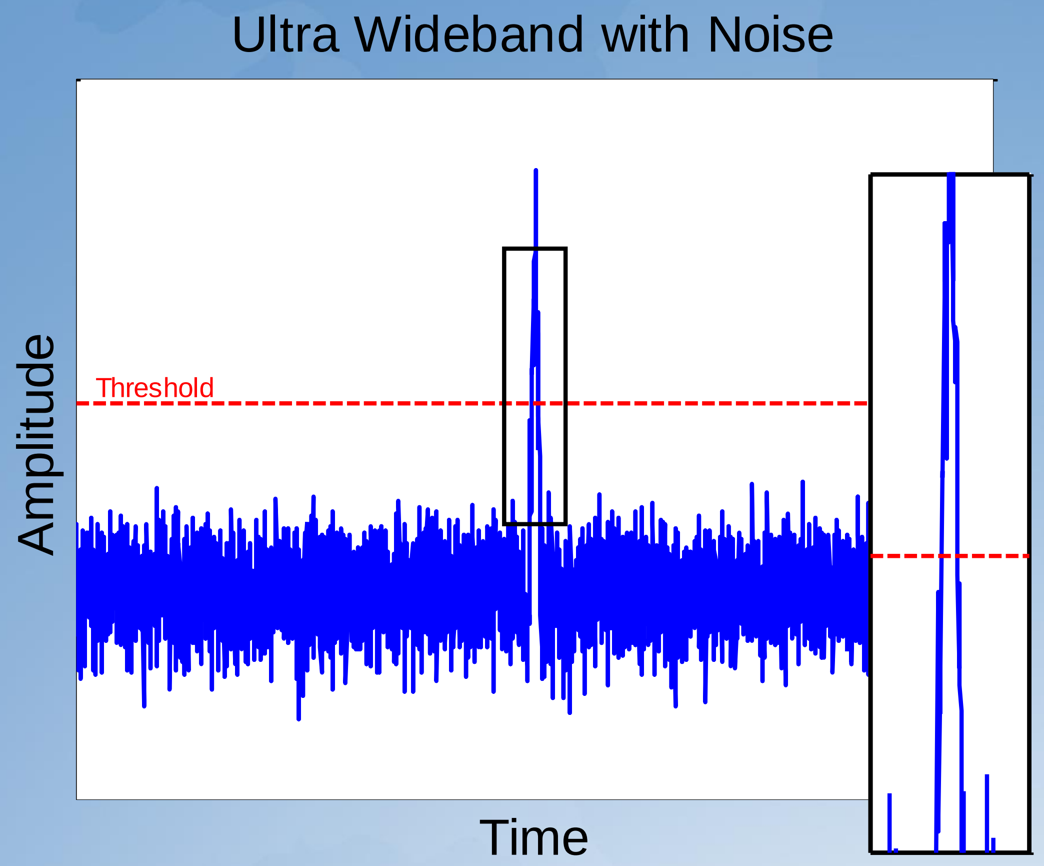
Nihar Jindal, Google

- UWB in Pixel phones
- Pixel 6, first UWB ranging in Google product
- Use Cases
  - Digital Car Key support
  - Identify a recipient for peer-to-peer file sharing (Nearby Share)
- Why UWB
  - Accurate ranging and location (AoA)
  - Secure
  - Allows data communication
- Challenges
  - Link Budget
  - Antenna design



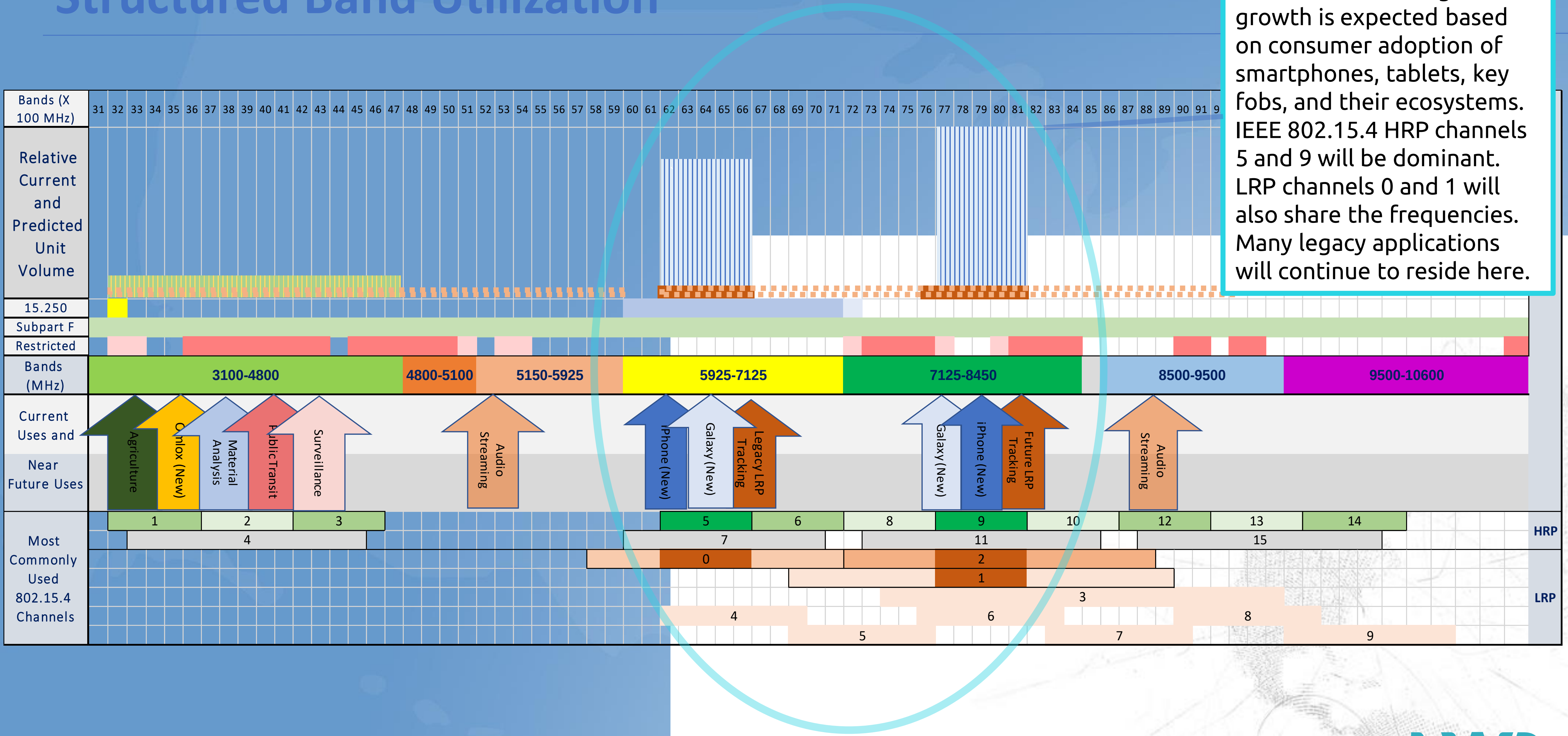
Tim Harrington, UWB Alliance

- Impulse-based waveforms, wideband but spaced in time
- 2003 UWB approved in USA: 3.1- 10.6 GHz
- Limited applications until IEEE 802.15.4z and SOC improvements
- 2019 breakthrough to smartphones, tags
  - keyless entry, secure payment, AR/VR ranging
- Possible regulatory changes in EU, waivers in US for certain applications



Structured Band Utilization

This portion shows the bands where the highest growth is expected based on consumer adoption of smartphones, tablets, key fobs, and their ecosystems. IEEE 802.15.4 HRP channels 5 and 9 will be dominant. LRP channels 0 and 1 will also share the frequencies. Many legacy applications will continue to reside here.



UWB ALLIANCE

UWB Discussion

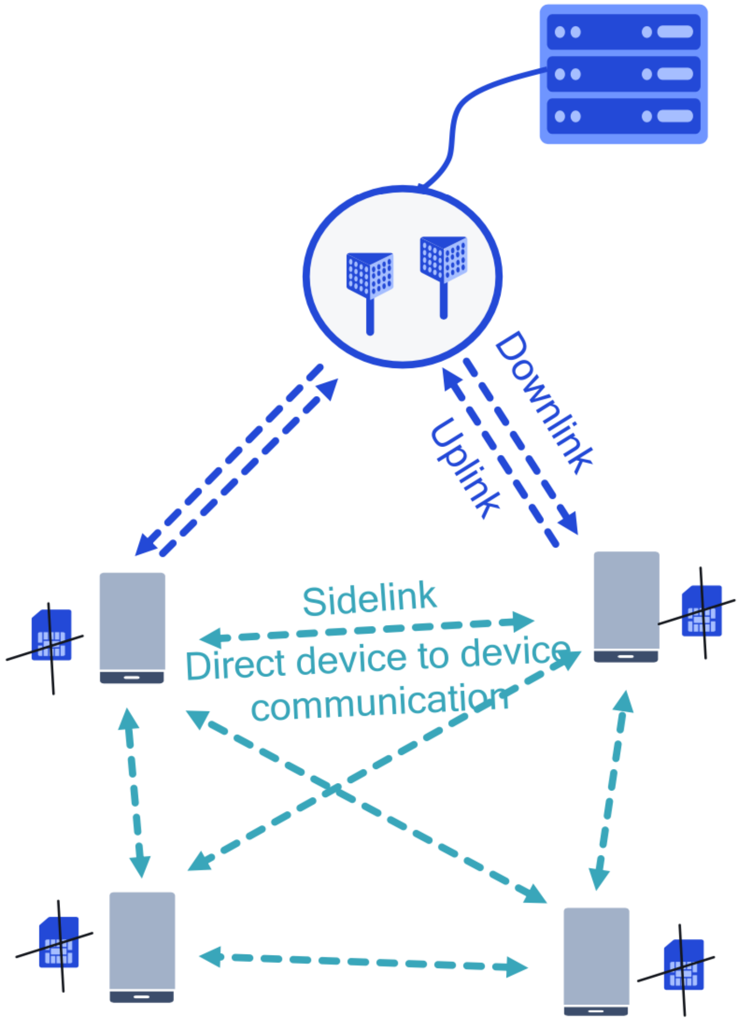
- Adoption in smartphones is driving rapid growth
- More than 500 million UWB devices in the field worldwide*
- Expect one billion per year by 2025*
- UWB rules accommodate a large variety of applications
- Specific waiver requests are coming in to FCC for certain applications
- EU considering some rule changes
- CSMAC has a UWB working group

* TSR 2021 UWB Market Report

UWB Recommendations

- In light of the fact that UWB is intended to operate “in the noise” and UWB is undergoing rapid growth, the Emerging Technology Working Group recommends <u>that UWB be monitored closely</u>, including potential rule changes in other countries, while the FCC follows normal procedures in handling recent waiver requests.

Introduction to Sidelink



Sidelink is used for timing, configuration, control, data

Introduction

- Sidelink is direct device to device communication
- Sidelink is Infrastructure-less wireless communication

Technology Benefits

- Completely out of coverage operation with no timing/configuration from the network
- Distributed operation that can work at scale
- Performance supports safety applications

Standards

- Sidelink communications has been standardized in 3GPP. 3GPP is consensus driven standards
- Support for PS band (4940 - 4990MHz) is in the standards.
- 3GPP defines mission-critical services such as push-to-talk voice and video and prioritized access of different services over the same side link channel.
- 3GPP also support Direct discovery through Proximity Services (ProSe)

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Sidelink Discussion and Recommendation

- Sidelink is designed to coexist seamlessly with the cellular access link in licensed and unlicensed spectrum. There are a wide range of sidelink applications over existing and new spectrum. Examples include:
  - first responder emergency communications
  - Industrial applications from CNC to AGVs
  - Enterprise uses cases
  - out of coverage range extension for consumers
  - mesh deployment of meters and IOT devices.
- Sidelink has been deployed successfully on ITS spectrum for V2X. Extension to other use cases in progress
- 4.9 GHz band (4940-4990 MHz) has potential to support sidelink for public safety
- Drives greater spectrum utilization

Internet Restoration

- What are the new tools to restore internet access during shutdowns?

Topic	Speaker	Company
Electric utility resilience and security	Emma Stewart	NRECA
See also Project Taara		

Electric Utility Resilience and Security

- Dr. Emma Stewart, Chief Scientist at the National Rural Electric Cooperative Association (NRECA)
- What rural electric cooperatives are doing to ensure reliability and recovery in the face increasing cyber threats
- Grid is being transformed from a one-way flow (generation to transmission to distribution) to a complex system (generation to transmission to microgrids)
- Communication systems are essential to operating and restoring power
  - Communications network overlaying power grid to pinpoint outages and restore power

Internet Restoration Discussion

- How can we improve outside plant stand-by power, e.g., via advanced lead-acid batteries and Li-ion or capacitor hybrids?
- How can providers more quickly locate outages?
- How can providers offer more accurate restoration time estimates?
- Can the reporting of outages (e.g., to DIRS) be automated?
- How can solar and EV batteries readily power in-home or small enterprise communication equipment?
- Can the transition to USB-C power allow ONT and other broadband CPE to be easily battery-backed?

Advances in Cable and Broadcasting

- **Question**: What are latest enhancements and capabilities of cable and broadcasting standards that may benefit the consumers?

Topic	Speaker	Company
ATSC 3.0 broadcast standard	Madeleine Noland	Advanced Television Systems Committee (ATSC)
CableLabs 10G	Jeff Chen/Mark Walker	CableLabs

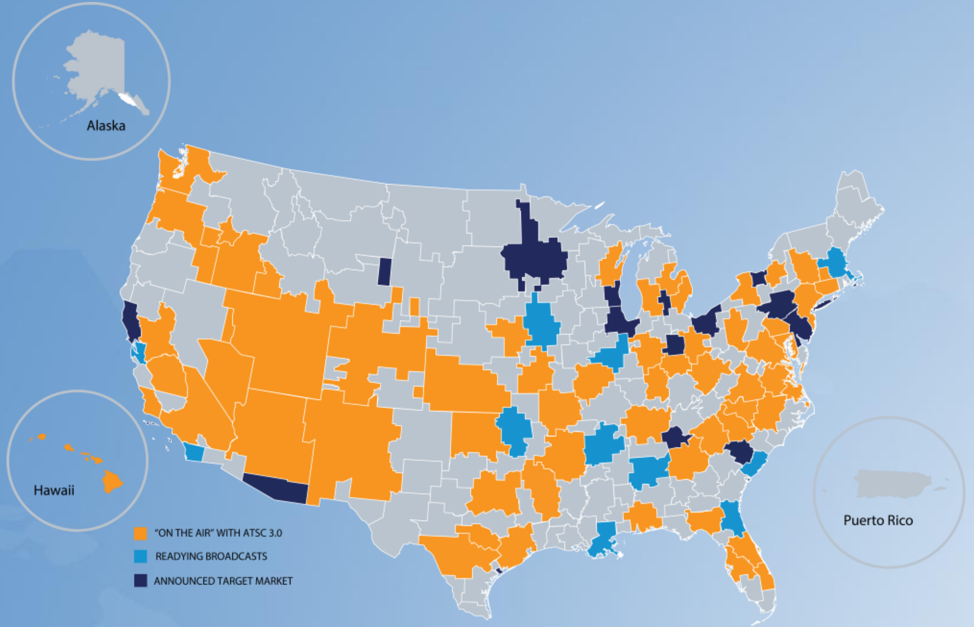
Madeleine Noland, ATSC

ATSC 3.0 Summary – Broadcasting Using IP

- Physical Layer – flexible, configurable, world's most efficient one-to-many DTT system
- Transport – IP-based protocol via MMTP and ROUTE/DASH
- Video - UHD, HDR, WCG, HFR, scalable video coding via HEVC H.265
- Audio – immersive audio, personalization via Dolby AC-4, MPEG-H Audio
- Apps – web-based interactivity via HTML5, CSS, JavaScript and Websocket APIs
- Accessibility – new capabilities for visually and hearing-impaired audience
- Advanced Emergency Messaging – new rich media capabilities and receiver "wake-up"
- Datacasting – ability to deliver data to IoT, e.g., cars, agriculture, signage, smart cities, etc.
- Convergence Ready – designed to easily interoperate with other IP data delivery networks

ATSC 3.0 Broadcasting Discussion

- Current deployment of ATSC 3.0 stations in markets covering over 50% of US population
- 4.5 million ATSC 3.0 TV sets expected in 2022; 75% of all new set sales in 2025
- Growth of station deployments and TV sets are continuing steadily along with emergence of low cost receiver appliances
- International interest in adopting the ATSC 3.0 standard is substantial, including South Korea, Jamaica, Brazil, India, Canada and Mexico
- ATSC 3.0 is a platform that is technically evolving to serve changing market demands



ATSC 3.0 Broadcasting Discussion

- Broadcast core network project underway to facilitate regional/national datacasting opportunities and enable convergence with 5G networks
- Inter-Tower Communications Network development underway to enable one-way and two-way communications among broadcast towers as alternative to microwave or fiber STL connections
- Work is ongoing to identify and document potential solution architectures for ATSC 3.0 – 5G convergence (Layer-1, Layer-3, Core)

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ATSC 3.0 Broadcasting Key Insights

- Goal of ATSC 3.0 is to maximize use of the broadcast spectrum for the benefit of the public
  - FCC policies and guidance that optimize the transition to ATSC 3.0 facilitate increased spectrum efficiency and service to consumers
- International adoption of ATSC 3.0 can be beneficial to US broadcasters and consumers
  - FCC consideration of international advocacy for ATSC 3.0 adoption may be appropriate

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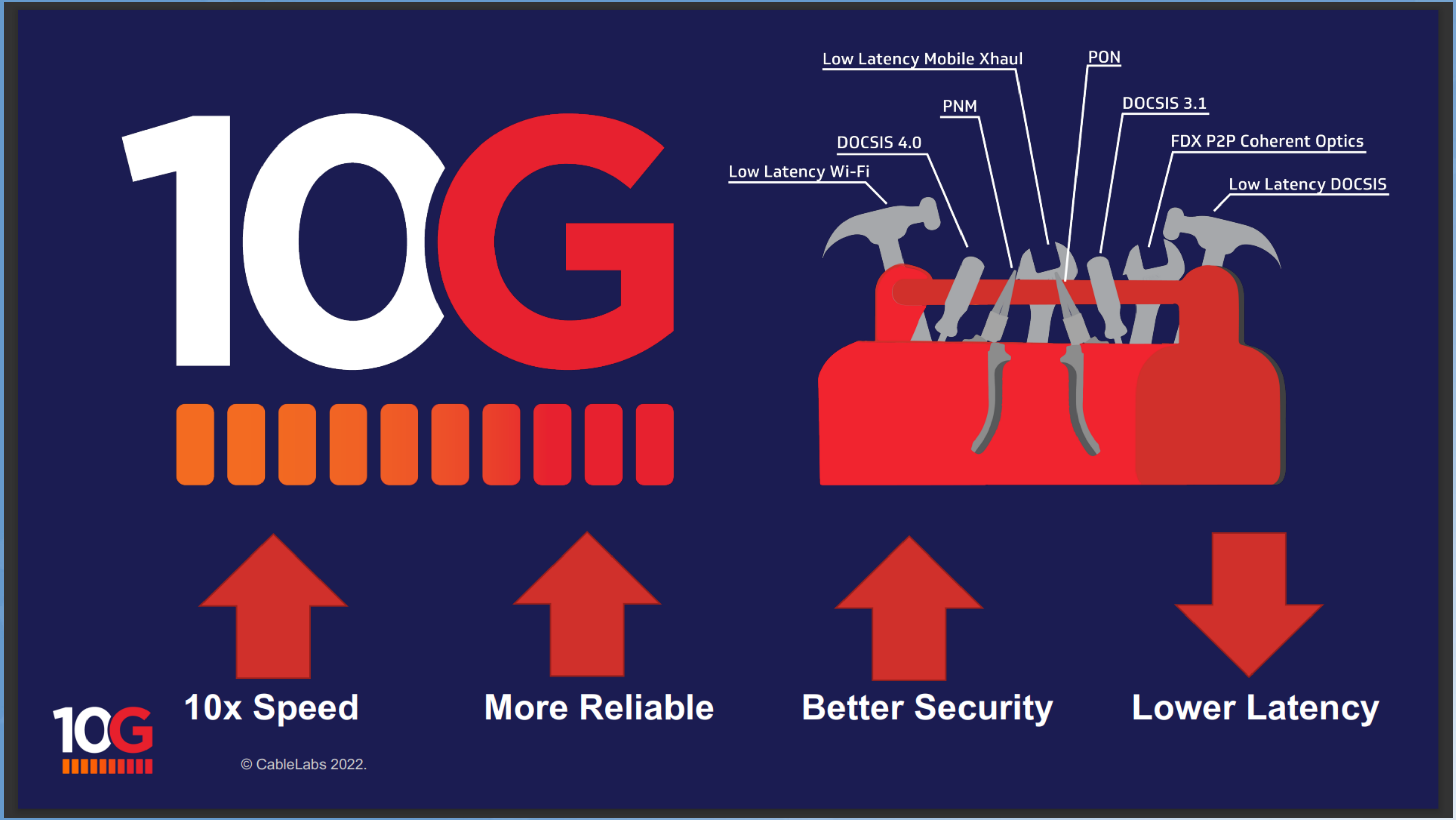
10G
Low Latency Mobile Xhaul
PON
PNM
DOCSIS 3.1
DOCSIS 4.0
FDX P2P Coherent Optics
Low Latency Wi-Fi
Low Latency DOCSIS
10x Speed
More Reliable
Better Security
Lower Latency
© CableLabs 2022.

HFC Networks Are Rapidly Upgradable

- Jan 7, 2019: *"In just 2 years, the cable industry has made an unparalleled technological leap by increasing availability of [1 gigabit broadband internet from only 4 percent to 80 percent] of US households."*

Source: 10G Platform: Coming to Homes, Offices and Cities Near You - CableLabs

Currently:

- *Cable broadband is available to approx. 90% of US households* *(Source: NCTA)*

Cable Networks Continued Evolution…

- Fiber being pushed deeper into networks and some FTTH deployments
- 1G speeds deployed to 80% of US households in just two years
- DOCSIS 3.1 widely deployed and 4.0 in early stages of deployment → improves network reliability, speeds, security and latency
  - Better telemetry and use of AI/ML provides for proactive maintenance and outage detection
  - Latency speeds of 10ms with 3.1 and 1ms with 4.0
  - Downstream capacity up to 10GBPS and Upstream capacity of 1-2Gps with 3.10 and 6Gps with 4.0
- Driving Wi-Fi improvements with deployment of Wi-Fi 6 and 6E, along with continued enhancements

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Cable Networks Discussion

- The working group is not recommending any further work in this area.

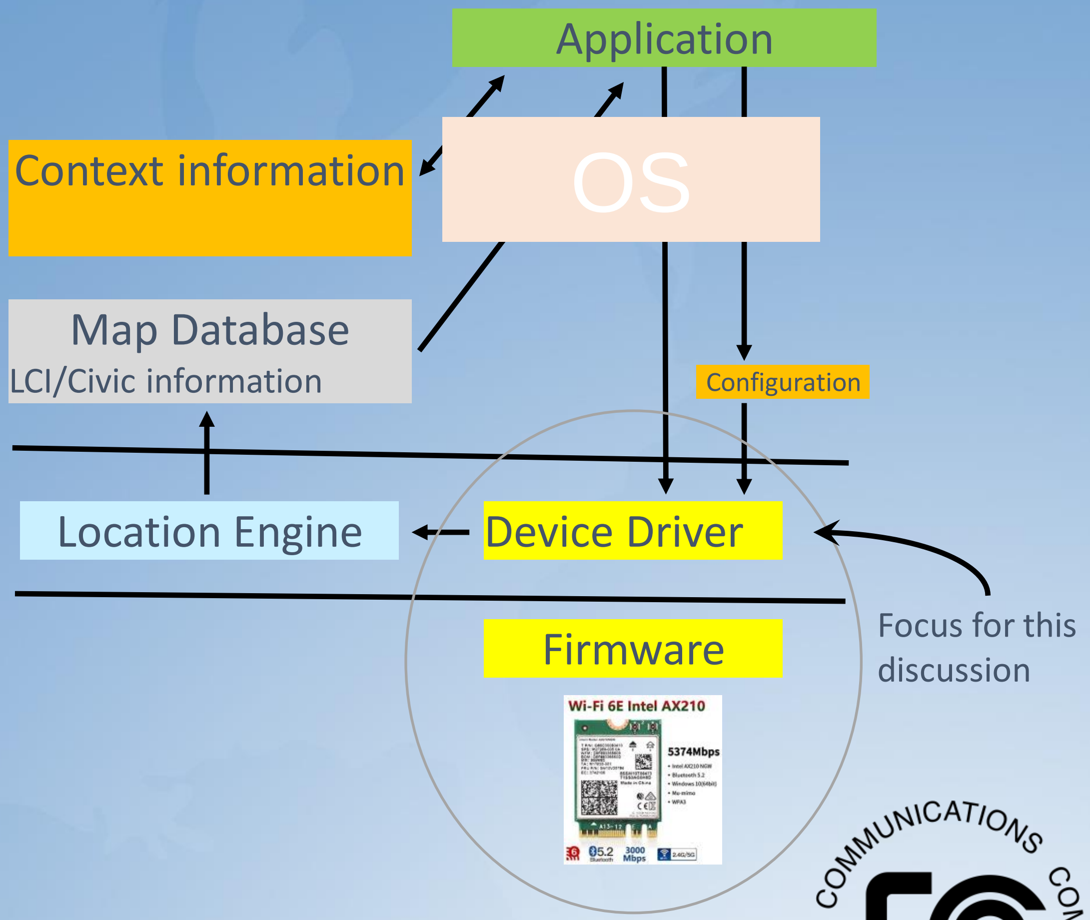
Location and Positioning

- **Question**: How is indoor/outdoor location service envisioned to improve and what are the technologies that are under consideration?

Topic	Speaker	Company
Location services via Wi-Fi	Ganesh Venkatesan, Carlos Cordeiro	Intel

Ganesh Venkatesan & Carlos Cordeiro, Intel

- Speaking as active contributors to IEEE 802.11
- Original Time Measurement Protocol standardized in IEEE 802.11 – 2012
- Fine Time Measurement Protocol added in IEEE 802.11 – 2020
- Secure Fine Time Measurement Protocol currently in Sponsor Ballot (802.11az)
  - Target < 1m accuracy, few cm @ 60 GHz
- Market adoption slow, expected wider adoption once 802.11az is ratified
  - Legacy FTM Wi-Fi Certified Location 1.0 (EDCA) natively supported in Android, Aruba Open Locate (1-2m accuracy)
  - Wi-Fi Certified Location 2.0 defined (non-Triggered & Triggered)



Location Services Discussion

- Adoption is slow, but technology is available and usage models are emerging
- Accuracy is 1-2m consistently today, improvements to < 1m and a few cm coming
- Other technologies also capable of delivering high accuracy (UWB, mmWave)
- Need infrastructure & driving biz model to accelerate adoption
- WG did not discuss other alternatives
- WG did not discuss how this technology could be used to identify indoor users for regulatory purposes

Location Use Cases

- Location determination has important traditional and novel use cases:
  - Location for emergency calls (911), particularly indoors
  - Spectrum sharing: determine whether a device is indoors or outdoor or geofencing
  - Consumer location-based applications (e.g., indoor or outdoor navigation, AR)
  - Proximity-based applications (e.g., physical security)
  - Industrial and enterprise precision location applications
  - Autonomous vehicles
- Not all use cases have solutions
- Our working group did not fully explore this area

Small Satellite Development

- **Question**: What is the status of small satellite development, what frequency bands are under consideration for use, and what services are envisioned?

Topic	Speaker	Company
Satellite links for smartphones	Rob Reis	Higher Ground
LEO satellite systems throughput	Nils Pachler de la Osa	MIT
Satellite technology update	Jennifer Manner	Echostar
Starlink and LEO systems	David Goldman	SpaceX

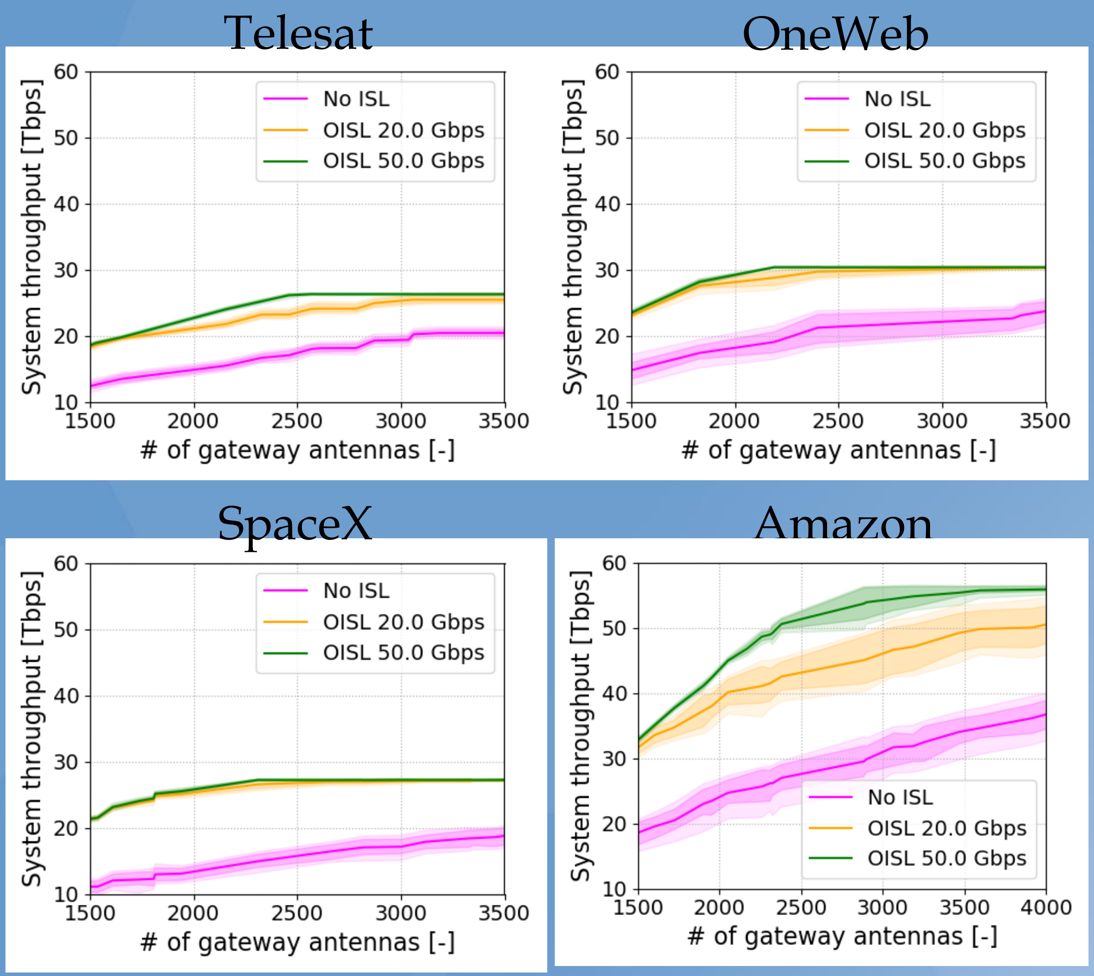
What is the status of small satellite development, what frequency bands are under consideration for use, and what services are envisioned?

Satellite Orbits

- Geosynchronous Earth Orbit (GEO) (22,300 miles)
  - Satellites move at the same speed as the Earth's rotation
  - Three satellites can cover most of the globe
  - High latency
- Medium Earth Orbit (MEO) satellites are closer to users on Earth
  - 10 to 18 satellites are required for continuous coverage
  - Medium latency
- Low Earth Orbit (LEO) satellites, or Non Geostationary Satellites (NGS), are closest to users (300 500 miles)
  - 40 to 70 satellites are required for full coverage
  - Proposed new constellations looking to use thousands of satellites
  - Low latency

- Supports all services including mobility
- Important part of network resilience integration
- Interworking of satellites incorporated into 3GPP standards
- Enable true global coverage not limited to limitations of terrestrial deployment engineering and economics
- Support higher fidelity timing and positioning services to enable new applications
- Satellite sharing bands today and need for sharing for LEOs with overlapping orbits presenting new challenges
- Use low, mid and high frequency band spectrum including THz band
- Use of ISLs reduce costs of using radio frequency bands

Four Mega Constellations With Different Designs And Estimates Of Capacity



- Telesat achieves **25.4 Tbps maximum throughput** when using 20 Gbps ISL, which they can achieve with about 2500 gateway antennas.
- Thanks to a **more flexible satellite design** and **a larger network**, OneWeb manages to increase their throughput to **30.3 Tbps**.
- SpaceX **improves previous results by 4 Tbps** thanks to the combination of **lower altitude** and **lower minimum elevation angle**.
- Despite being second-to-last in number of satellites, Amazon achieves the **highest throughput at 53.4 Tbps** when using 20 Gbps ISL. However, they suffer a 25% loss (to 41.4 Tbps) when not using it.

ISL: Inter-Satellite Links

Source: Nils Pachler TAC briefing on A brief comparison of the next generation of Satellite Communications

Small Satellite Discussion

- Small satellite development has both large and small companies working on low earth orbit satellite systems
- There will be multiple systems with overlapping business cases
  - There will be more in line events and in the event of dispute, FCC rules say the available spectrum is split
  - FCC and ITU looking at different approaches for sharing
  - Perhaps this represents a powerful incentive for non-governmental Coasian Bargaining along the lines highlighted by Elinor Owstrom with fisheries and other shared resources in her cited Nobel Prize research

Small Satellite Discussion (2)

- Space debris and Kessler
  - Need more focus on control of small satellites. Space is big, but with many large systems from many countries and a five year life – decommissioning may become a frequent event with many opportunities for one or more satellites to be in de-orbit with need to cross through shells
  - With the dramatic increase in use of optical links for inter satellite links in large LEO clusters, the FCC should examine whether the possibilities for interference and co-existence require additional regulation and whether that lies within the jurisdiction of the FCC
  - *<u>Need US world leadership and recommend FCC take a leadership role. Newly formed Space Bureau seems well positioned for such leadership, working with substantive USG agencies</u>*

Optical/Laser Technologies

- **Question**: What optical/laser technologies are being utilized for space or terrestrial communications, what is the performance of these technologies in supporting communications, and what steps should be taken to ensure proper use of these technologies?

Topic	Speaker	Company
Free Space Optical Network	John Cooper	Google/Taara
PON (Passive Optical) to the edge/end user	Ed Harstead	Nokia
LiFi	Heinz Willebrand	Signify

Free Space Optical

- John Cooper, Project Taara (Google X)
- Optical communications transferred from Project Loon
- 20 Gbps at 10 km, point to point links
- 193 THz, Class 1 eye safe
- Fog interferes with service
- Quick install, ~$30K
- Proposed as quick-deploy solution during fiber installation or where fiber is difficult (cities). Currently about 100 sites deployed.

Next Generation Passive Optical Networks

- Ed Harstead (Nokia)
- Excellent taxonomy and history of PON technology
- PON leverages technologies matured in other domains
- Transition from 10 GPON to 40 GPON fizzled out
- Data centers driving PON technology cost curve down
- Can we get to 100 GPON without going to coherent optical technology?

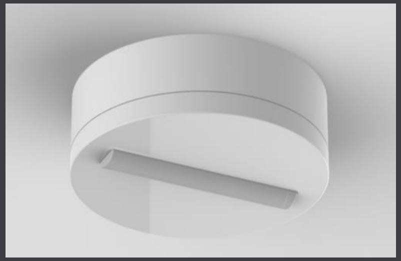
Optical Wireless Communications

- Dr. Heinz Willebrand and Dr Andreas Bluschke
- Taxonomy of Optical Wireless – indoor is VLC and LiFi
- Review of LiFi Tx – phosphor, LED and Laser with focus on VCSEL array for high speed
- Review of LiFi Rx photodetectors
- Regulation by eye safety IEC/EN 60825-1 (LASER) and IEC/EN 62471 (LED)
- Standards IEEE 802.16.7-2011 (VLC) IEEE 802.15.7r1 (OCC) IEEE 802.15.13 (FSO) 802.11.bb (LiFi) IYU G.9991 (ratified march 2019)
  - 802.11.bb is amendment to 802.11n/ac/ax for light communications

Present Day LiFi Solutions

Access point

Infrared Ceiling Transceiver



Ceiling Holder

USB Access Key

Optical and Laser Technology in Space

- Optical and laser-based communications technologies currently operate in unregulated portions of the electromagnetic spectrum
- Optical technologies are already used for satellite technologies including intersatellite links (ISLs) between satellites and satellite imaging, among other things
- Advanced laser-based communications technologies are under development
  - NASA is testing its Laser Communications Relay Demonstration: A GSO two-way laser communications satellite system; later this will be furthered with communications transmitted by lasers from the international space station to ground stations on the earth.
  - Lasers are also seen as important for ISLs
  - Lasers have already been tested between the moon and earth for communications and is seen as important for interplanetary communications

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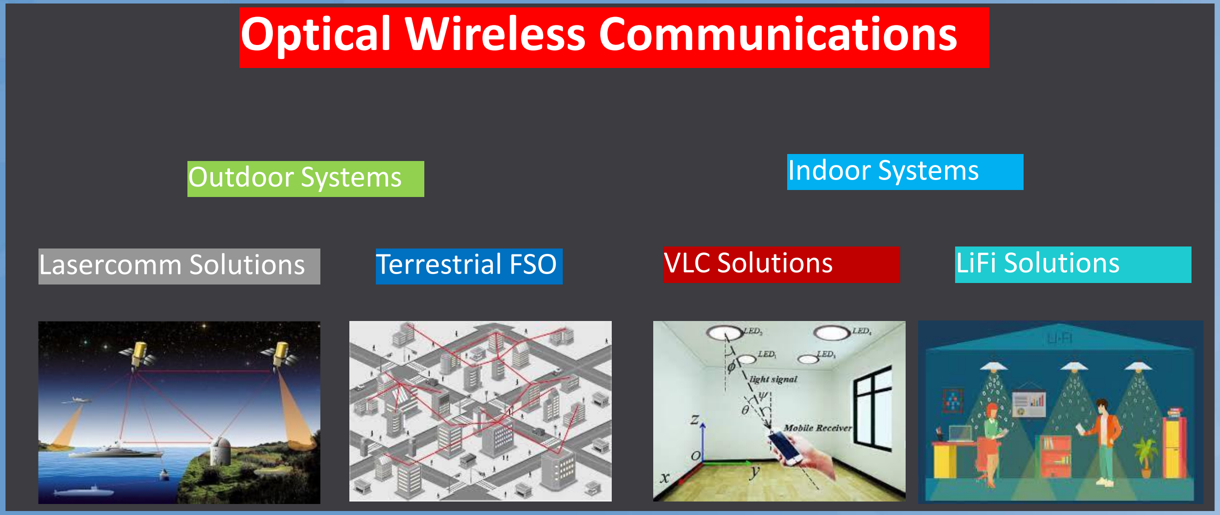
Optical/Laser Discussion

- Optical data transfer over fiber is the core technology for the network core, for data centers and increasingly to the network edge
- Optical technologies are experiencing rapid growth for satellite systems including intersatellite links (ISLs) between satellites and satellite imaging.
- Passive Optical Networks have a path to reach 100Gbps end user rates by 2030
- Free Space Optical Communications are being deployed both indoor and outdoor. Indoor LiFi is an extension of the 802.xx standards.



Optical/Laser Recommendations

- With the dramatic increase in use of optical links for inter satellite links in large LEO clusters, the FCC should examine whether the possibilities for interference and co-existence require additional regulation and whether that lies within the jurisdiction of the FCC
- Optical extensions of WiFi, also known as LiFi, are in the early phases of development and are well covered under existing standards and rules.
- Free space optical network links fill an important, but specialty, niche in existing network deployment and are well covered under existing standards and rules. The FCC should explore whether free space optics can be encouraged as a means of rapid network restoration.

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Emerging Tech – Quantum and Blockchain

- **Question**: What are the network-driven emerging technologies such as quantum computing and blockchain, and how would they improve user experience in communications services?

Topic	Speaker	Company
Quantum Sensing	Reza Nejabati & Mischa Dohler	University of Bristol & Ericsson Inc
Blockchain	Deborah Simpier	Althea

Quantum Tech Overview – Mischa Dohler, Ericsson Inc

1. Quantum Sensing

Example: BT announced a trial of a new hyper-sensitive quantum antenna technology using "excited atomic states", which could boost the capability of next-generation 5G and IoT networks. *Pertinent to telecoms & spectrum.*

2. Quantum Key Distribution

QKD Protocol BB84: Alice creates key in the form of qubits, and sends via optical fiber. Bob "key sifts" & "key distills" to estimate coherence of the key and thus if there has been intercept. *Not clear if useful for telecoms, or spectrum.*

3. Quantum Internet

Use of quantum repeaters; and/or quantum teleportation by creating pairs of entangled photons and then sending one to the sender creating a "memory qubit" and the other to a recipient. *Long-term impact on telecoms and spectrum.*

4. Quantum Computing

Mid-term impact on telecoms/spectrum due to maturing stack. Able to solve NP-hard problems in telecoms in linear time:

Q-Apps

Q-OS

Q-Hardware

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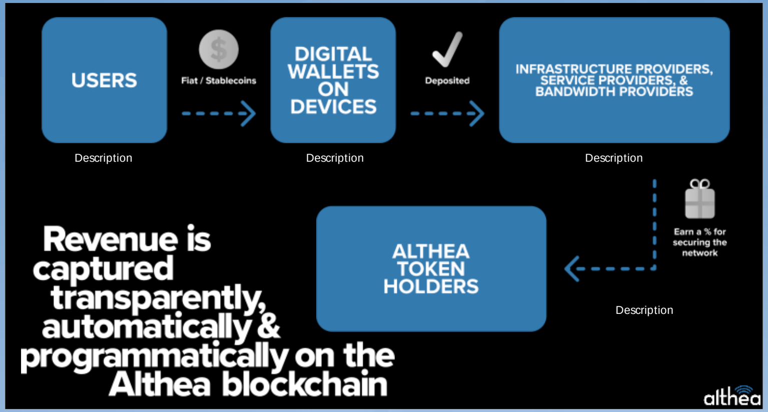
Quantum Sensing – Reza Nejabati, University of Bristol

- With heterodyne detection based on Diamond Nitrogen Vacancy, spectral resolution below 1 Hz up to 4 GHz spectrum can be achieved
- Quantum sensing devices could have the following impact on wireless spectrum:
  - Exceed traditional electronics in sensitivity, bandwidth, dynamic range and frequency range
  - Can be used for RF/microwave component testing and characterization including
    - Antenna field measurements
    - RF field mapping of circuitry and electronics
  - Can be used for RF metrology as RF field probe to improve calibration and push metrology limits
  - Can act as electrically small antennas and detect the modulation of a carrier wave
- Significant engineering effort is still necessary before the quantum spectrum analysers can integrated into a field-testable devices

Blockchain for telecom infrastructure

- Deborah Simpier, Althea
- Use of blockchain to create incentives for deploying infrastructure
  - mesh network: get paid on blockchain for relaying data
- Tokenized assets such as towers or spectrum
- Currently, Althea provides LTE-based fixed wireless networks
  - listed as operational in 7 locations (NC, WA, OR, CO)
  - fixed + per-GB pricing
- Advantages compared to traditional billing or incentive payments remain to be proven
  - underlying assets may not appreciate
  - currency risks



Summary

Covered by Emerging Tech Working Group

- Direct to satellite from mobile devices (NTN)
- Reliability/Restoration (Internet restoration) – propose for further study
  - Power outages are big issue. Better battery technology. Secondary systems (hydrogen etc)
  - AI for network operations and restoration (presentation to AI WG)
- Addressing device location use cases

Possible Future Study

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

Thank You

FCC Technological Advisory Council Agenda – December 8, 2022

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	AI/ML WG Presentation
12:00pm – 1pm	Lunch Break
1pm – 1:45pm	Advanced Spectrum Sharing WG Presentation
1:45pm – 2:30pm	6G WG Presentation
2:30pm – 2:45pm	Closing Remarks
2:45pm	Adjourned

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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: Paul Steinberg, Motorola Solutions
Michelle Thompson, ORI

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

Date: December 8th, 2022

Agenda

- Working Group Membership
- Charter and Topic Areas
- Approach
- Findings
- Summaries and Recommendations
  - Cross Cutting Issues
  - AI/ML Pilot Projects for the FCC
  - Safe Uses of AI/ML and Software Algorithms
  - Spectrum Sharing Evolution
  - Use of AI/ML in Telecommunication Networks
  - Proposed Directions for 2023
- Appendices (Presentations, SME Speakers, Bibliography)

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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
William Check	NCTA	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	Meryem Simsek	VmWare
Alex Diaz-Martinez	FCC Army Fellow	Paul Steinberg	Motorola Solutions
Monisha Ghosh	Notre Dame	Michelle Thompson	ORI
Lisa Guess	Ericsson (Cradlepoint)	Tom Van Meter	Juniper
Mark Hess	Comcast Corporation	James Goel	Qualcomm
Lauren Lambert	FCC Intern		

Charter and Topic Areas

For 2022 there were five items in the Artificial Intelligence, Machine Learning, and Computing Working Group (AIWG) Charter.

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 2022 there were five items in the Artificial Intelligence, Machine Learning, and Computing Working Group (AIWG) Charter (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 2022 there were five items in the Artificial Intelligence, Machine Learning, and Computing Working Group (AIWG) Charter (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.

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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)	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

Charter and Topic Areas

Results and Outcomes

- **Recommendations:** Covering all Four Topic Areas
- **Briefings:** Detailed Background, Findings, and Summary for each Topic Area (In the Appendices)
- **SME Speaker and Participants:** Presentation and Panel Titles, and Biographies (In the Appendices)
- **Bibliography:** Literature on AI/ML, Policy Documents, White Papers, etc. (In the Appendices)

Approach

Approach

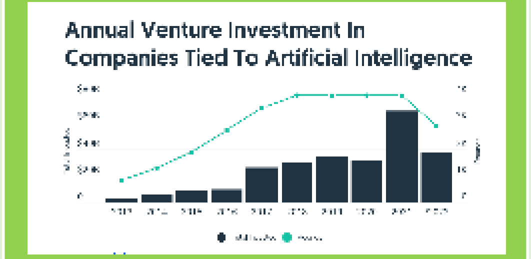
Issues Addressed

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

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



Considerations

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

Inputs

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

The FCC
Service Providers
Consumers
Industry
The Public Sector

Nature of Recommendations

- Lasting Impacts on the FCC
- Build FCC capacity for AI/ML
- Anticipate the changes in Network Architectures driven by intertwining of AI/ML, Computing, Storge, and Data.
- Safe Uses of AI/ML in Disaggregated, Digitized, and Automated Networks

Findings

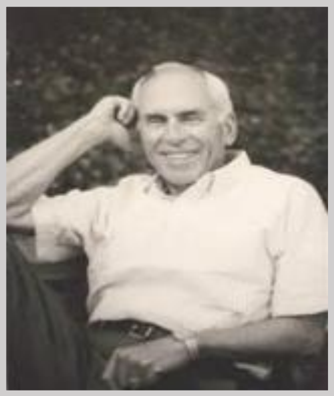
Findings

The Promise and Challenge of Artificial Intelligence, Machine Learning, and Computing

- The Solution of Complex Problems and the Enablement of New Capabilities that are important to Telecommunications and have been unreachable in the past!

- The avoidance and elimination of negative impacts from the use of AI/ML in the Softwarization and Disaggregation of the Network, and remediation of other hazards!

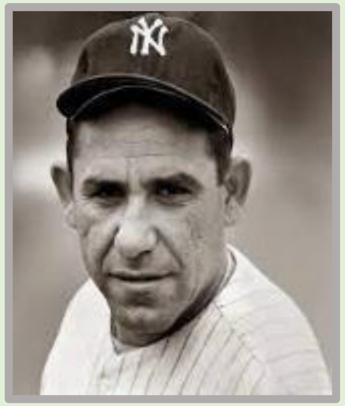
Findings



Roy Amara

"We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run." Coined by Roy Amara, past president of The Institute for the Future**.**

Alan Kay



Yogi Berra

“It's tough to make predictions, especially about the future”
”You’ve got to be very careful if you don’t know where you are going, because you might not get there.”

"The best way to predict the future is to invent it.”

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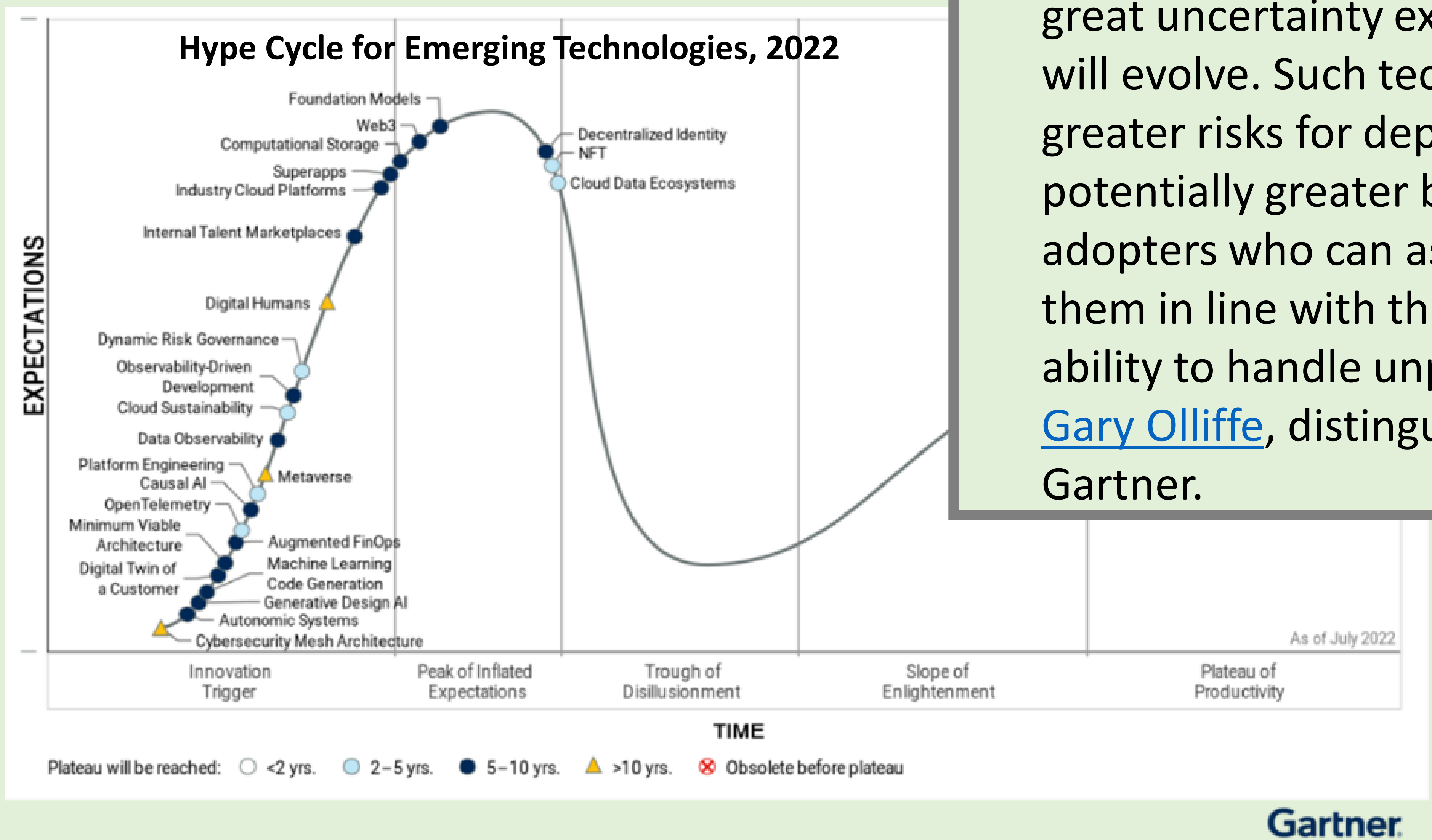
Findings



"All technologies on this Hype Cycle are at an early stage, but some are nascent and great uncertainty exists about how they will evolve. Such technologies present greater risks for deployment, but potentially greater benefits for early adopters who can assess and exploit them in line with their organization's ability to handle unproven technologies." Gary Olliffe, distinguished VP analyst at Gartner.

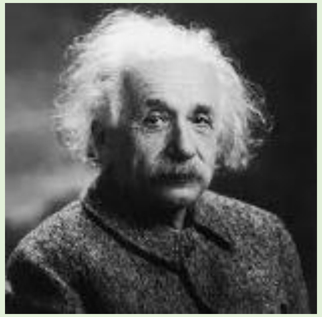
Findings

William of Occam

The Law of Occam's Razor, The Principle of Parsimony

"Plurality is not to be assumed without necessity", "What can be done with fewer assumptions is done in vain with more." One consequence of this methodology is the idea that the simplest or most obvious explanation of several competing ones is the one that should be preferred until it is proven wrong.

Ted Woodward



Albert Einstein

A Few Corollaries

"Everything should be made as simple as possible, but not simpler than necessary."
"We cannot solve our problems with the same thinking we used when we created them.",

The Zebra Principle

"When you hear hoofbeats behind you, don't expect to see a zebra."

Findings

Familiarity with and application of AI, ML, and DDAs is important for almost all FCC Offices and Bureaus and Strategic Goals.

	Offices		Bureaus
1.	Administrative Law Judges	1.	Consumer and Government Affairs
2.	Communication Business Opportunities	2.	Enforcement
3.	Economics and Analytics	3.	International
4.	Engineering and Technology	4.	Media
5.	General Counsel	5.	Public Safety and Homeland Security
6.	Inspector General	6.	Wireless Telecommunications
7.	Legislative Affairs	7.	Wireline Competition
8.	Managing Director		
9.	Media Relations		
10.	Secretary		
11.	Workplace Diversity		

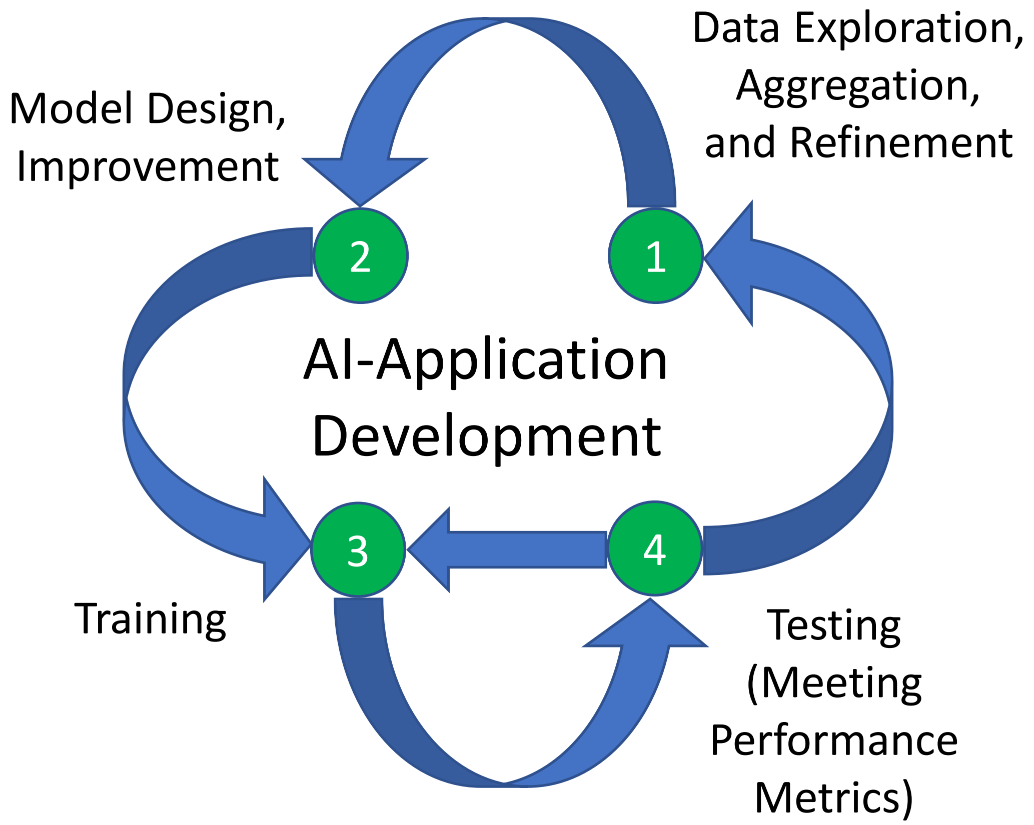
Findings

Findings

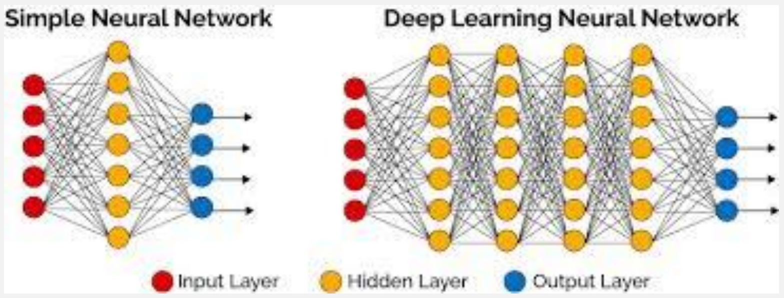
- AI/ML and DDAs represent a large variety of methods and techniques – there is considerable progress and advancement fueled by large investments in Industry, the Federal Government, and by Venture Capital.
- Much of the investments and exploration is for Applications
- The exploration of these techniques and methods is still on the learning curve. While great results have been achieved there is now considerable understanding that AI/ML techniques do have short comings – and the focus is on overcoming these!
- There is already a considerable use of AI/ML in common products and services – this includes widespread use in the Telecommunications sector.
- The processes around the use of AI/ML are complex and are supported by multiple infrastructures – computing, storage, communication, and data networks!

Findings

Findings – Development to Operations



Typically done in the Cloud
Communication, Storage
and Compute Intensive



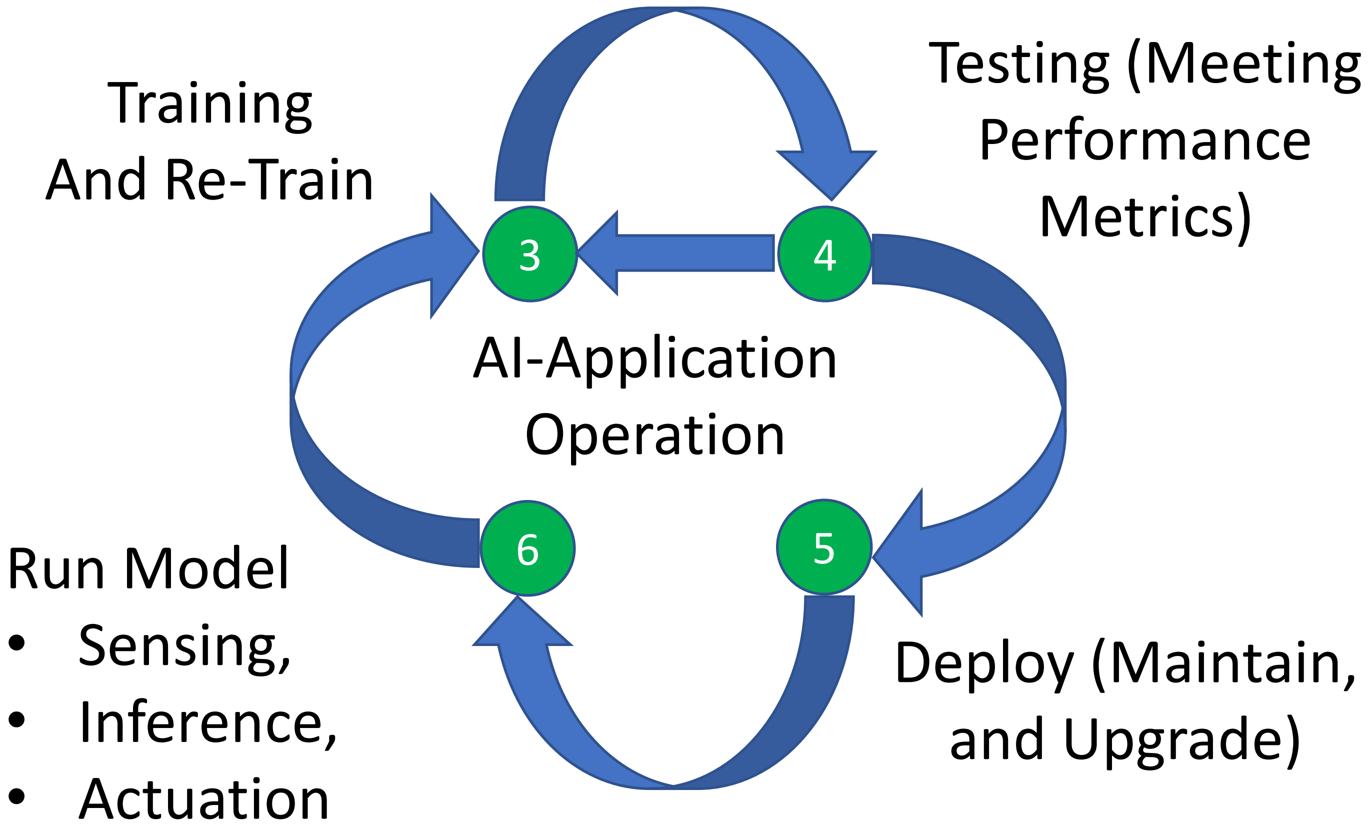
AI-Operation

Findings

Findings – Development to Operations

Typically done on the Platform and the Edge Communication, Storage and Compute Intensive, with input from sensors and commands to actuators

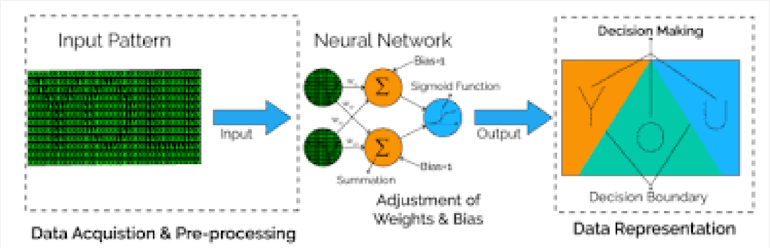
AI-Development



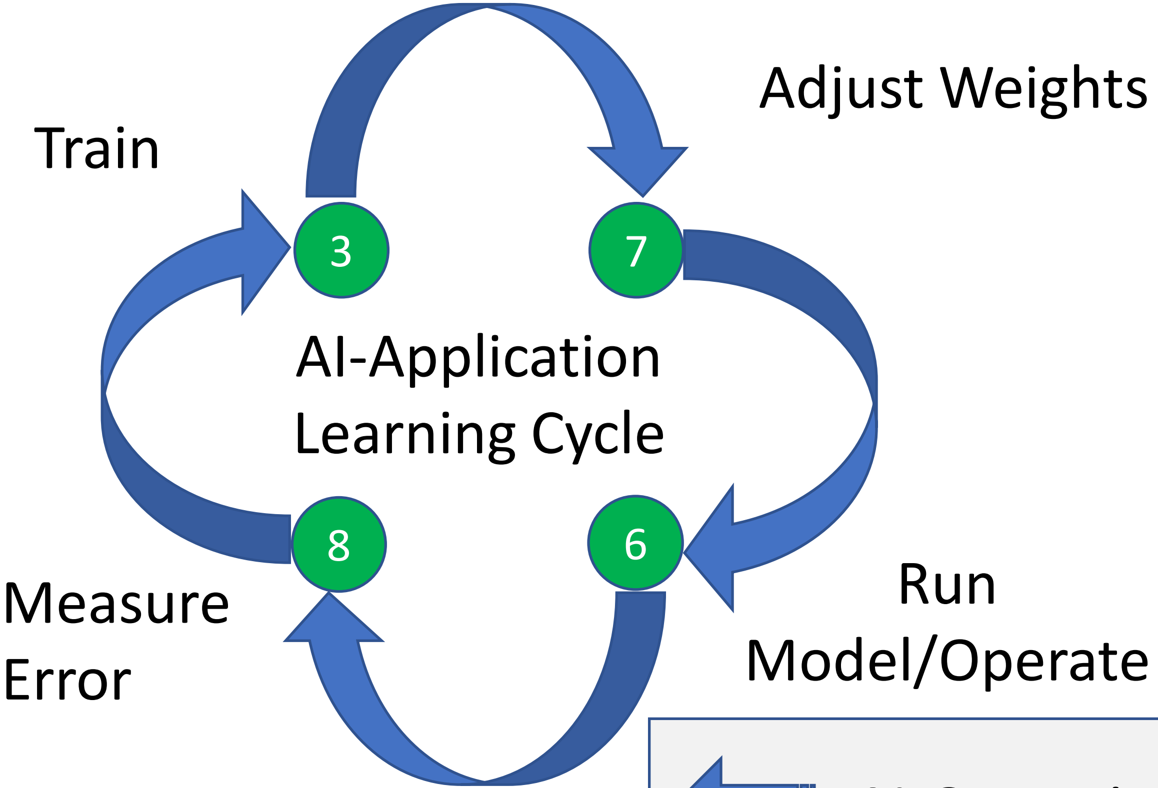
Findings

Findings – Development to Operations

Typically done on the the Edge and in the Cloud, Communication, Storage and Compute Intensive, with input from sensors.



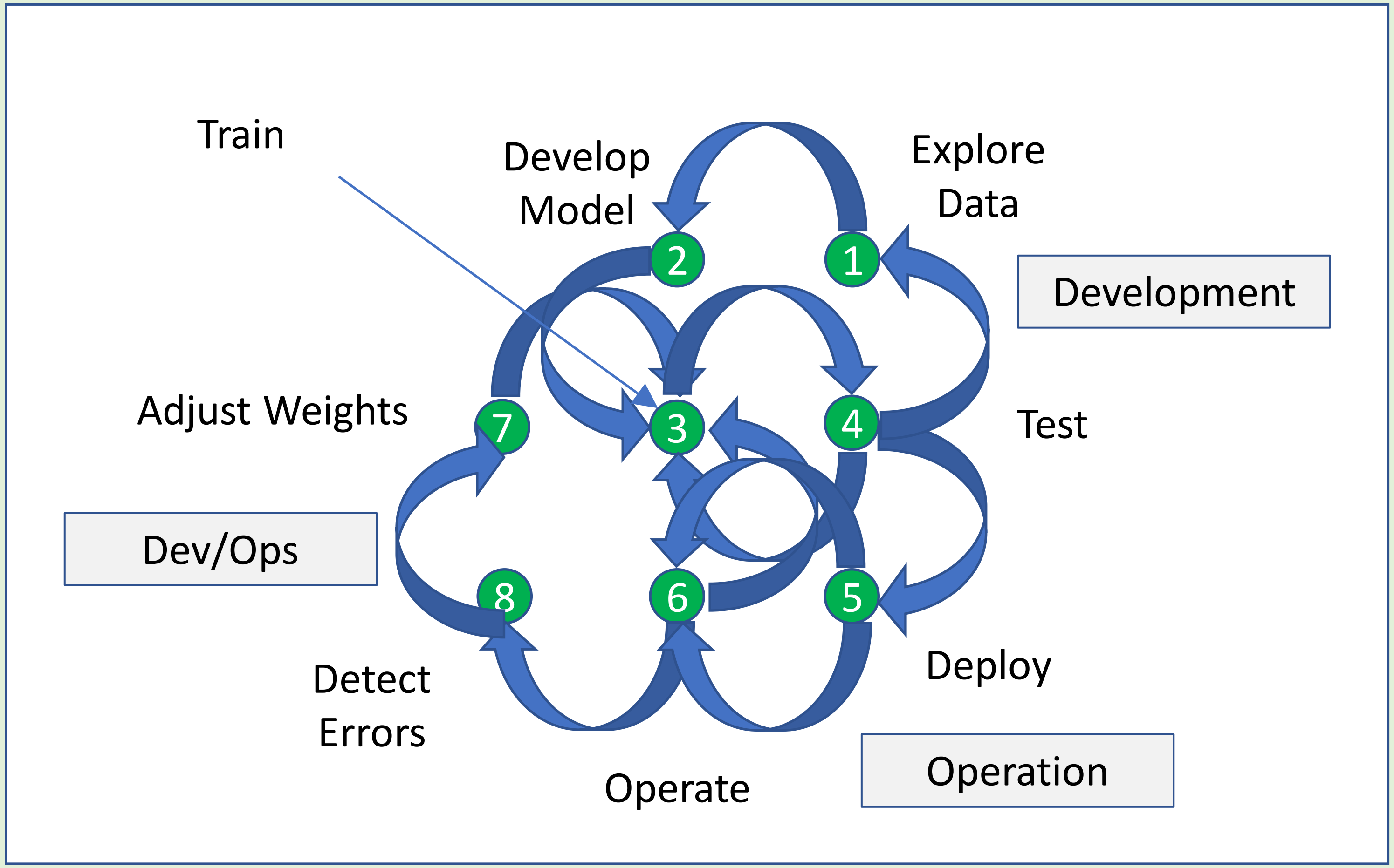
AI-Development



AI-Operation

Findings

Findings – Development to Operations



Distributed Resources:
- Computing
- Storage
- Communications

Other Components:
- Sensors
- Actuators
- Human Interfaces

Software
- AI/ML Models
- Simulations
- Controls
- Operating Systems
- Applications

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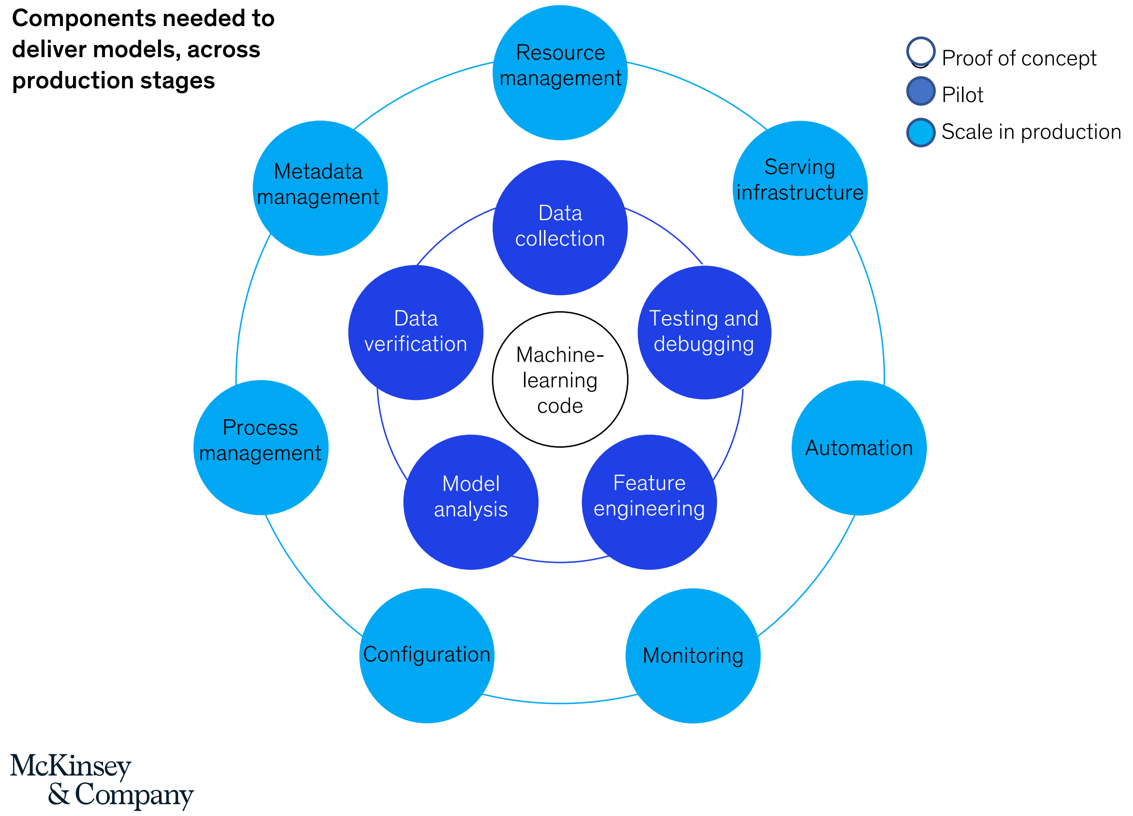
Findings

Findings – Development to Operations

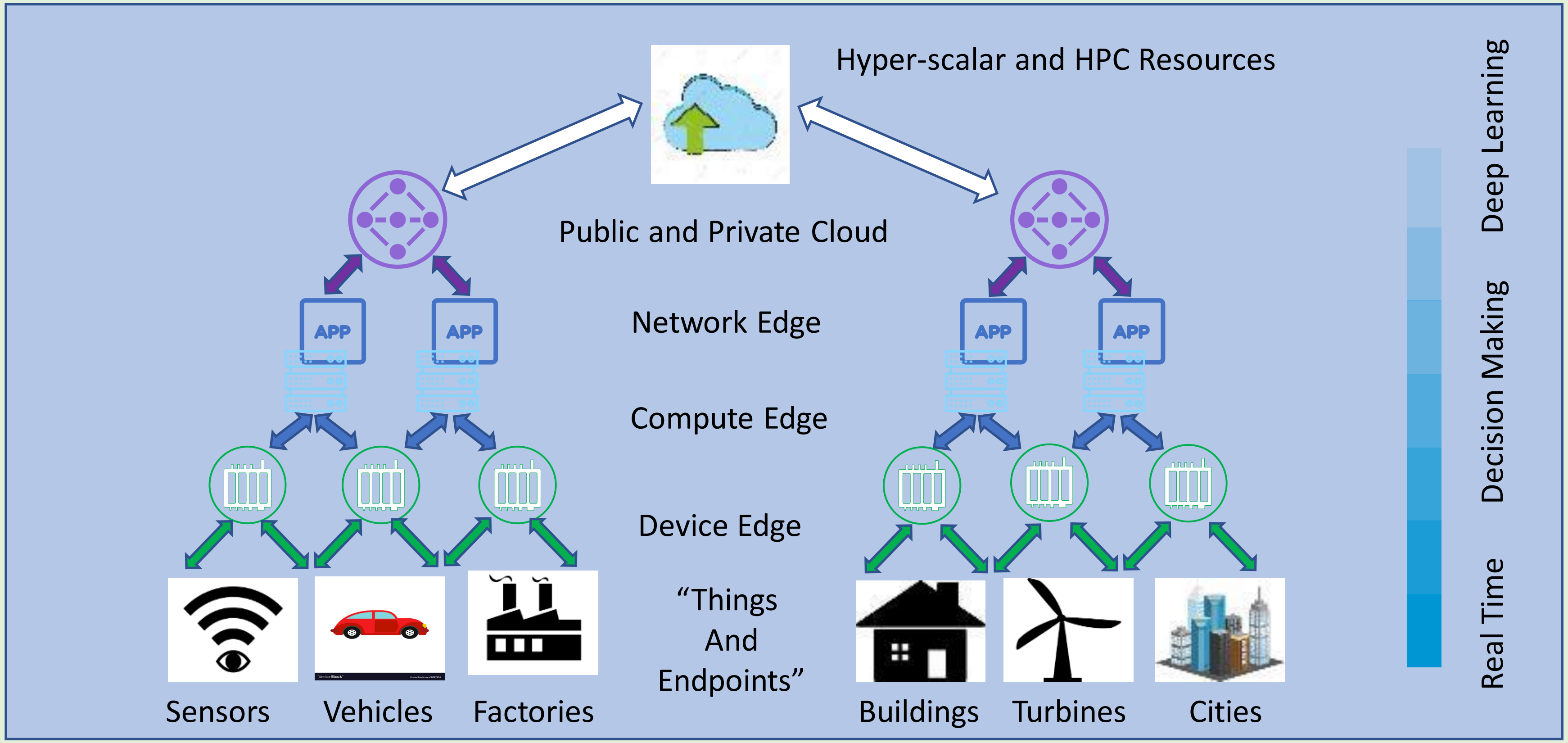
Machine-learning operations covers all components needed to deliver models.



No Free Lunch!!!

Findings

Findings – Infrastructure that Accompanies AI/ML



There is a Profound Influence of Distributed Computing, Information Storage, and Data Requirements for AI, ML and DDAs on Network Architectures and Resources

Evolution of Computing, Storage, and Data Practices is important in defining Future Network Needs!

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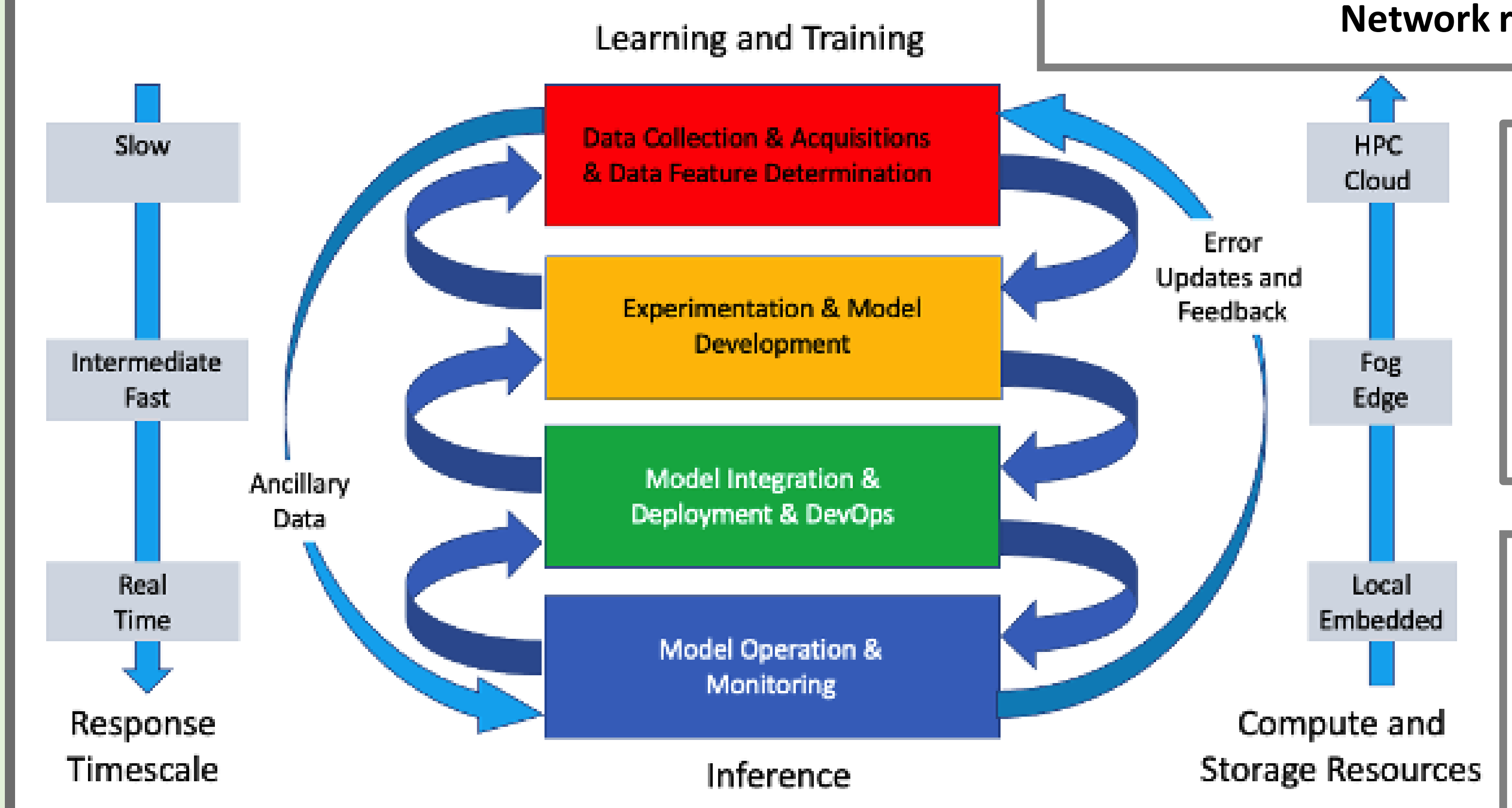
Findings



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

Typical AI/ML Application Cycle and requirements for Connectivity

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

Findings

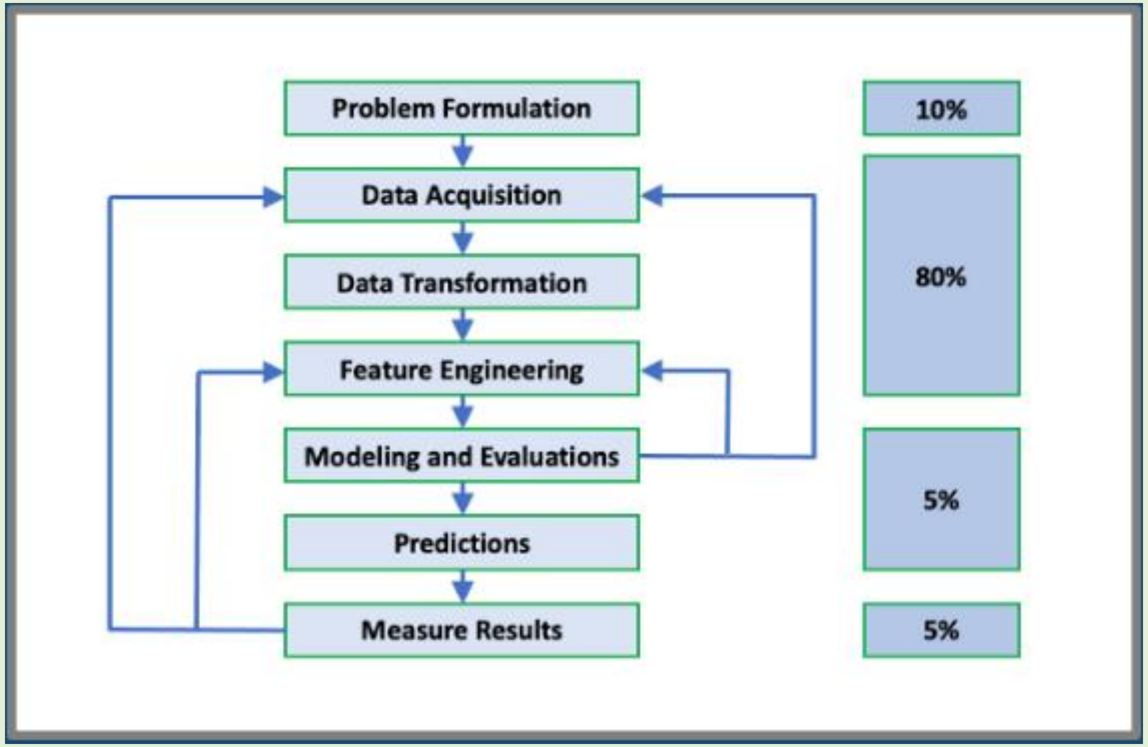
➢A Few Factoids as a guide

- ➢ 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 2020 FCC TAC Final Briefing

The AI/ML Solution Cycle



Findings

Considerations for curation and use of ”Data”

Type	Characteristics	Source	Ownership	Regimes
Technical	Volume	Sensors/Devices	Public Domain	Private Person Info
Operational	Velocity	Logs	Open Source	Protected
Performance	Variety	Media	Government	Restricted
Customer	Variability	Crowdsourced	The FCC	Open-Source License
Documentation	Veracity	Specific Projects	Operators	Private Proprietary
Survey	Value	Reporting Req.	Vendors	Commercially Available
Legal	Visualization	Purchased	Restricted	Sensitive

From 2020 FCC TAC Final Briefing

Findings

- The Curation of Data Sets is an important aspect of operationalizing AI/ML applications. Curated Data becomes an assets with multiple, meaningful uses and its value often increases when it is easy to fuse Data from multiple Data Sets and to provide tools for searching, displaying, and analyzing the Data and providing common Data services (an example would be notifications that Data of interest to a user has been modified and augmented, configurable maps for displaying overlays from multiple Data Sets, time series displays, and compatibility with and interfaces to widely used Data tools)

From 2020 FCC TAC Final Briefing

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Summaries and Recommendations

Summaries and Recommendations – Cross Cutting Issues

Cross Cutting Issues – Summary and Landscape

- Organization in Government and in Industry are undergoing major changes that are driven by Digital Transformation. This affects:
  - Resources
  - Processes and the way processes are managed and executed
  - Mindset of both management , the employees involved, and stakeholders across the ecosystem

- Artificial Intelligence (AL), Machine Learning (ML), and Data Driven Algorithms (DDAs) play a central role in enabling Digital Transformation to create value

  - There are 3 important considerations that make this possible
    - Widespread availability of Computing (A hierarchy that includes embedded, local, edge, cloud, hyper-scalar, and high-performance computing.
    - The use of Large data sets (Big Data) to achieve significant value from AI, ML, and DDAs across many applications now in common use.
    - Connectivity and access to the Data and Models (AI, ML, and DDAs) has led to widespread adoption across many verticals and that includes the Telecommunications Industry

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Summaries and Recommendations – Cross Cutting Issues

Cross Cutting Issues – Summary and Landscape - continued

- AI, ML, and DDAs come in many different forms and work best when focussed on specific problems where they are part of the solution in conjunction with other methods based on cause and effect understanding. Domain knowledge and intuition is necessary!

- Success requires competency in both the underlying area of application of AI, ML, and DDAs and in understanding the fundamentals of AI techniques and methods, Data Science, Computing, Storage, and the accompanying governance of processes and management practices. [https://www.mckinsey.com/capabilities/transformation/our-insights/perspectives-on-transformation].

- Appropriate staffing, teaming, and access to resources is necessary for success. Practicing organizations are more likely to be part of an ecosystem with all the necessary competencies rather than vertically integrated entities.

Summaries and Recommendations – Cross Cutting Issues

Cross Cutting Issues – Summary and Landscape - continued

- AI consists of many different techniques (each represented by specific methods and algorithms). A subset of AI methods, ML, and DDAs are fundamentally based on establishing pattern matching between input data and output results. The results (false positives and false negatives) are sensitive to two factors:
  - The quality and properties of the underlying models and the features captured.
  - The quality and comprehensiveness of the Data used to train the AI, ML, and DDAs.
- The use of AI, ML, and DDAs is on a learning curve and results can have unexpected flaws due to incomplete data, flaws in the underlying models and feature sets, less than rigorous testing, and human factors.
- The largest effort in achieving results is devoted to data, and its availability, collection, processing, and curation.
- Typical applications require the fusion of Data from multiple sources and currently the sharing of data across institutional lines is a significant bottleneck. In practice AI, ML, and DDAs can only be tuned when the underlying model and its training is done with access to Data. It is often the case that the owners of data and the owners of the models do not openly share data.

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!

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

Summary and Landscape

- Rapid 'Softwarization' of the Network makes AI broadly accessible and applicable. Development of AI (along with the requisite data) and software go hand-in-hand and share many principles, processes, and practices.

- AI is already being increasingly applied to optimize, operate, and protect network services
  - The network is more complex to understand, operate and optimize due to dynamic adaptations along with an ever-increasing number of operational indicators and "knobs" (thousands of optimization/control parameters).
  - Due to Softwarization, a service provider network is comprised of multi-party services from an ecosystem of providers with inter-dependencies that must be orchestrated and coordinated.
  - The network and computing topologies are increasingly geographically distributed with local autonomy.
  - Anomaly detection, as a leading indicator of environmental events or due to malicious (cyber) activity, can be conducted with high fidelity.

Summaries and Recommendations – Topic 2

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

Summary and Landscape (continued)

- Connections are increasing machines/things (vs humans) which are powered by AI
- There is already considerable use of AI in the ‘applications’ that run over the network
- Managing these issues will become a differentiator among function providers and end service providers to optimize costs, tailor user experiences, and mine intelligence from their operations. As such they will increasingly turn to machine algorithms and AI vs. Human beings to engage in these issues.
- There is considerable dialog (academia, government, industry) wrestling with the ‘safe use’ question

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)

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.

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Summary and Recommendations – Topic 2
Recommendation Mapping to FCC Strategic Goals

TAC Recommendation	**FCC Strategic Goals** (Federal Communications Commission Strategic Plan Fiscal Years 2022-2026)					
	Pursue a 100% Broadband Policy	**Promote Diversity Equity and Accessibility**	**Empower Consumers**	**Enhance Public Safety and National Security**	**Advance America's Global Competitiveness**	**Foster Operational Excellence**
Recommendation 1.1: Develop and disseminate an FCC Code of Conduct for AI		+	+	++	++	++
Recommendation 1.2: Convene an Industry Expert Group for knowledge and best practices development/sharing	+			++	++	++
Recommendation 1.3: Engage with other US Agencies to share knowledge and develop common/consistent policies for AI		+		++	++	++
Recommendation 2.1: Assess Existing Regulations for Implications of AI		+	++			
Recommendation 2.2: Monitor/Leverage EU AI Regulatory Activities					++	+
Recommendation 2.3: Leverage NIST AI RMF				++		++
Recommendation 3.1: Facilitate Data Access for Training and Performance Assessment of AI	+		+	++	++	++
Recommendation 3.2: Promote an Integrated SW/AI Maturity Model for Telecommunications					+	++

Legend: **++** = Recommendation relevant to charter topic, **+** = Recommendation may be relevant to FCC Strategic Charter

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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!

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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Summaries and Recommendations – Suggestions for 2023

Suggestions for 2023 - Proposed Directions

1. Consider the things not addressed this year
2. Pending Legislation and Regulation in other parts of the world
3. A Technology Roadmap that considers the major technological factors driving telecommunications
4. AI OPS
5. ORAN – the path to Automation – AI and Radio Decoupled from Spectrum Functions
6. Open Source
7. Advancing Safe Use
    a. Detailed Landscape Analysis: EU Regulations, Impacted Existing Regulation
    b. Facilitate Outreach: Industry Expert Group Formation, Other USG Entities
    c. Facilitate Practices: Data Identification/Sharing, Extension of Maturity Models to AI/ML
    d. Develop Input Content: AI NIST RMF Profile, FCC AI/ML Code of Conduct
    e. Expanded progress/focus on societal addictive / human behavior implications

Appendices

AI, ML, and Computing Working Group - AIWG

- Presentation: AI/ML Pilot Projects for the FCC
- Presentation: Safe Uses of AI
- Presentation: Spectrum Sharing Evolution
- Presentation: Use of AI/ML and Computing in Telecommunications Networks
- List of Speakers and Presenters
- Bibliography

- AI/ML Pilot Projects for the FCC

- Safe Uses of AI

Topic 2 – Safe Uses of AI, ML and SW Algorithms

Impacts on Consumers, the Network, and the FCC

Considerations for Security, Privacy, and Trust

Safe Uses SWG

Chairs: Paul Steinberg and Michelle Thompson

Safe Uses of AI, ML and Software Algorithms

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

Topics

1. **Summary**
2. Concerns and Risks to Consumers, Ecosystem Players and the FCC
3. Proactively Advancing Regulatory Processes and Practices for FCC Leadership
4. Promoting SW and Data Quality in the Implementation of AI/ML
5. AI and Implications for Addictive or Human Behavior Modification

Safe Uses of AI, ML and Software Algorithms

Safe Uses of AI, ML and Software Algorithms
Landscape Summary

Landscape Summary

- Rapid 'Softwarization' of the Network makes AI broadly accessible and applicable. Development of AI (along with the requisite data) and software go hand-in-hand and share many principles, processes, and practices.

- AI is already being increasingly applied to optimize, operate, and protect network services
  - The network is more complex to understand, operate and optimize due to dynamic adaptations along with an ever-increasing number of operational indicators and "knobs" (thousands of optimization/control parameters).
  - Due to softwarization, a service provider network is comprised of multi-party services from an ecosystem of providers with inter-dependencies that must be orchestrated and coordinated.
  - The network and computing topologies are increasingly geographically distributed with local autonomy.
  - Anomaly detection, as a leading indicator of environmental events or due to malicious (cyber) activity, can be conducted with high fidelity.

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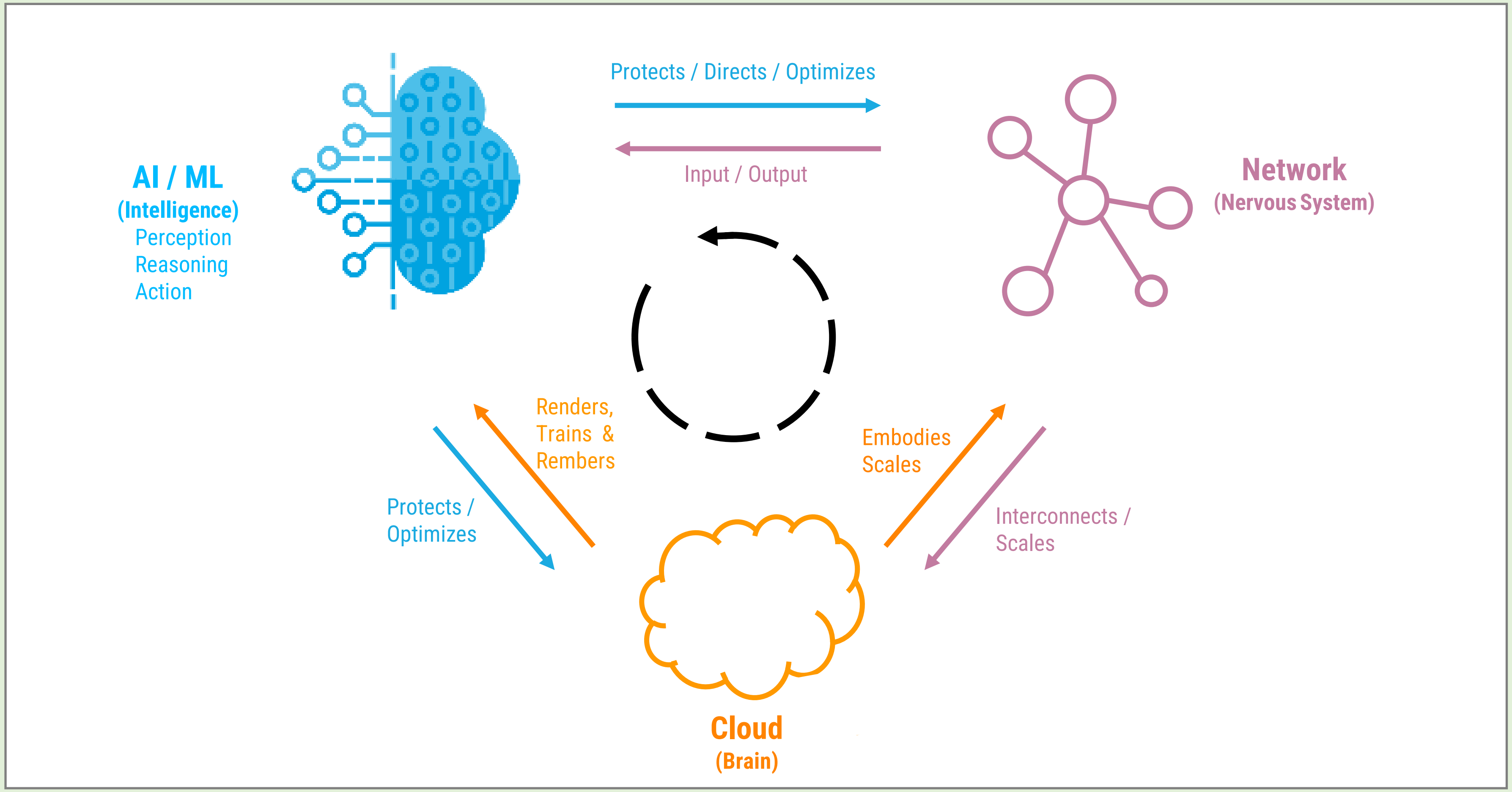
Landscape Summary - continued

- Connections are increasing machines/things (vs humans) which are powered by AI
- There is already considerable use of AI in the ‘applications’ that run over the network
- Managing these issues will become a differentiator among function providers and end service providers to optimize costs, tailor user experiences, and mine intelligence from their operations. As such they will increasingly turn to machine algorithms and AI vs. Human beings to engage in these issues.
- There is considerable dialog (academia, government, industry) wrestling with the ‘safe use’ question

Safe Uses of AI, ML and Software Algorithms
Disaggregation and Softwarization and Dependencies

- <u>Observation</u>: The Network is increasingly rendered in Software; Service Layers for the Network are dispersed among different suppliers. AI increasingly drives Network behavior and is also rendered in Software.



Safe Uses of AI, ML and Software Algorithms
Recommendation Summary

- **<u>Recommendation 1.1</u>:** 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.

- **<u>Recommendation 1.2</u>: 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.

- **<u>Recommendation 1.3</u>: 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.

Safe Uses of AI, ML and Software Algorithms

Recommendation Summary - Continued

- **<u>Recommendation 2.1</u>: 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).

- **<u>Recommendation 2.2</u>: 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.

- **<u>Recommendation 2.3</u>: 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**)

Safe Uses of AI, ML and Software Algorithms
Recommendation Summary - continued

- **<u>Recommendation 3.1</u>: 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.

- **<u>Recommendation 3.2</u>**: 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.

Safe Uses of AI, ML and Software Algorithms

Recommendation Mapping to FCC Strategic Goals

TAC Recommendation	**FCC Strategic Goals** (Federal Communications Commission Strategic Plan Fiscal Years 2022-2026)					
	Pursue a 100% Broadband Policy	Promote Diversity Equity and Accessibility	Empower Consumers	Enhance Public Safety and National Security	Advance America's Global Competitiveness	Foster Operational Excellence
Recommendation 1.1: Develop and disseminate an FCC Code of Conduct for AI		+	+	++	++	++
Recommendation 1.2: Convene an Industry Expert Group for knowledge and best practices development/sharing	+			++	++	++
Recommendation 1.3: Engage with other US Agencies to share knowledge and develop common/consistent policies for AI		+		++	++	++
Recommendation 2.1: Assess Existing Regulations for Implications of AI		+	++			
Recommendation 2.2: Monitor/Leverage EU AI Regulatory Activities					++	+
Recommendation 2.3: Leverage NIST AI RMF				++		++
Recommendation 3.1: Facilitate Data Access for Training and Performance Assessment of AI	+		+	++	++	++
Recommendation 3.2: Promote an Integrated SW/AI Maturity Model for Telecommunications					+	++

Legend: **++** = Recommendation relevant to charter topic, **+** = Recommendation may be relevant to FCC Strategic Charter

Safe Uses of AI, ML and Software Algorithms

Recommendation Mapping to FCC WG Charter Items for AI/ML Working Group

TAC Recommendation	Charter item #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.	Charter item #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 item #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.
Recommendation 1.1: Develop and disseminate an FCC Code of Conduct for AI	++	++	++
Recommendation 1.2: Convene an Industry Expert Group for knowledge and best practices development/sharing	++	++	++
Recommendation 1.3: Engage with other US Agencies to share knowledge and develop common/consistent policies for AI	++	+	+
Recommendation 2.1: Assess Existing Regulations for Implications of AI	++	+	+
Recommendation 2.2: Monitor/Leverage EU AI Regulatory Activities	+	++	++
Recommendation 2.3: Leverage NIST AI RMF	++	++	++
Recommendation 3.1: Facilitate Data Access for Training and Performance Assessment of AI	++		
Recommendation 3.2: Promote and Integrated SW/AI Maturity Model for Telecommunications	++		

Legend: **++** = Recommendation relevant to charter topic, **+** = Recommendation may be relevant to charter topic

Safe Uses of AI, ML and Software Algorithms

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

Topics

1. Summary
2. **Concerns and Risks to Consumers, Ecosystem Players and the FCC**
3. Proactively Advancing Regulatory Processes and Practices for FCC Leadership
4. Promoting SW and Data Quality in the Implementation of AI/ML
5. AI and Implications for Addictive or Human Behavior Modification

Safe Uses of AI, ML and Software Algorithms

Concerns and Risks to Consumers, Ecosystem Players and the FCC - Recommendations

Recommendation 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**). This could be analogous to the memorandum published by the Deputy Secretary of Defense on the topic 'Implementing Responsible Artificial Intelligence in the Department of Defense.'

Background and Rationale: As the FCC has wisely noted, the use of AI an ML is progressing widely, rapidly and necessarily across telecommunications networking and related societal interfaces. The extent, impact and implications are not possible to anticipate. Regulatory responses / positions take time to enact, and uncertainty may have a quelling effect on progress. A good starting point would be for the FCC to outline expected behaviors, practices, and norms as AI is assessed and applied to provide some guidance and certainty.

Impact and Relation to FCC Goals: This publication would provide a framework for the FCC to follow in advancing its responsibilities as well as establish its purviews.

Suggested 2023 TAC Supporting Work: The TAC could be chartered to develop a draft proposal for this publication or serve in a review capacity for an FCC authored publication.

Safe Uses of AI, ML and Software Algorithms

Concerns and Risks to Consumers, Ecosystem Players and the FCC – Recommendations (cont.)

Recommendation 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**.**

- Consider an ISAC-like structure (Information Sharing & Analysis Center) to enable different factions (even competitors) to collaborate and share for the benefit of the broader interests.
- Leverage a risk-based framework such as the NIST AI RMF to assess the implications of AI and develop profiles specific to telecommunications (**See Recommendation 2.3**).

Background and Rationale: Repeatedly we see that industry, even competing factions, find common ground to share information, advance technology, develop best practices and establish behavioral frameworks for the common good of the industry and the country. But those with critical expertise need a convening function to establish the need/context, guide outcomes and work products and encourage adoption where necessary.

Impact and Relation to FCC Goals: The FCC has an excellent track record of convening forums of experts to advance broad awareness, share information and inform its own actions/policies. The FCC could leverage its bully pulpit to convene and guide this group. The output of the previous **Recommendation 1.1** – a code of conduct for the use of AI – could be an initial work product of this group.

Suggested 2023 TAC Supporting Work: The TAC could help the FCC organize (and partially populate) this group.

Safe Uses of AI, ML and Software Algorithms

Concerns and Risks to Consumers, Ecosystem Players and the FCC – Recommendations (cont.)

Recommendation 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 (e.g., US NRC Artificial Intelligence Strategic Plan).

Background and Rationale: In our cursory assessment of the landscape, we found several other USG agencies grappling with the implications of AI for their particular area(s) of responsibility (DoD, NRC, GAO, NIST, etc.). There are inter-relationships among these groups and certainly there will be common issues among them. It seems to make sense to establish collaborations and/or liaisons among groups that are developing positions and content.

Impact and Relation to FCC Goals: This could provide input and perspective to the FCC as it works through this area itself. Furthermore, we believe there could be a consistent set of practices and policies that might be elevated and reinforced.

Suggested 2023 TAC Supporting Work: The TAC could do a more comprehensive study of other USG entities engaged in accretive activities to facilitate the FCCs outreach.

Safe Uses of AI, ML and Software Algorithms

Other Government Agency Activities of Note

Table 1 Notional AI and Autonomy Levels in Commercial Nuclear Activities

Notional AI and Autonomy Levels	Potential Uses of AI and Autonomy in Commercial Nuclear Activities
Level 1: Insight (Human decisionmaking assisted by a machine)	AI integration in systems is used for optimization, operational guidance, or business process automation that would not affect plant safety/security and control
Level 2: Collaboration (Human decisionmaking augmented by a machine)	AI integration in systems where algorithms make recommendations that could affect plant safety/security and control are vetted and carried out by a human decisionmaker
Level 3: Operation (Machine decisionmaking supervised by a human)	AI and autonomy integration in systems where algorithms make decisions and conduct operations with human oversight that could affect plant safety/security and control
Level 4: Fully Autonomous (Machine decisionmaking with no human intervention)	Fully autonomous AI in systems where the algorithm is responsible for operation, control, and intelligent adaptation without reliance on human intervention or oversight that could affect plant safety/security and control

- [US NRC Artificial Intelligence Strategic Plan](#)
  (The role that AI is allowed to play)

- [United States Government Accountability Office – Artificial Intelligence](#) ([Accountability Framework for Federal Agencies](#))

Safe Uses of AI, ML and Software Algorithms

Topics

1. Summary
2. Concerns and Risks to Consumers, Ecosystem Players and the FCC
3. **Proactively Advancing Regulatory Processes and Practices for FCC Leadership**
4. Promoting SW and Data Quality in the Implementation of AI/ML
5. AI and Implications for Addictive or Human Behavior Modification

Safe Uses of AI, ML and Software Algorithms

Proactively Advancing Regulatory Processes and Practices for FCC Leadership - Recommendations

<u>Recommendation 2.1</u>: 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). Specifically:

- We recommend updating current Wiretap and Intercept rules to contemplate the use of AI
- To prevent AI robocall abuse, we recommend that for any electronic communications, voice or text, between an AI Bot and a person, that the person should be notified that they are communicating with an AI Bot *(Note: The Draft EU Regulatory Act also recommends this requirement)*.

Background and Rationale: AI can understand, interpret and converse with human communication such as voice and written electronic communications at large scale. With the advances in AI, it is increasingly difficult for a person to determine if they are interacting with another person or an AI powered Bot. However, laws such as wiretapping, lawful intercept and automated/robocalling only contemplate human to human interactions.

Impact and Relation to FCC Goals: Advancing trustworthy AI is an important consideration of the FCC's goals of advancing the telecommunications services for the country.

Suggested 2023 TAC Supporting Work: The TAC could assist in more detailed evaluation of these area and suggest or review changes.

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Safe Uses of AI, ML and Software Algorithms

Proactively Advancing Regulatory Processes and Practices for FCC Leadership - Recommendations

<u>Recommendation 2.1 - Detail</u>

Background and Rationale: Wiretap, Robocall, AI Bots

- Wiretap and Intercept Rules for Electronic Communications services only apply to a person or persons.
- Since AI is capable of Intercepting Voice and Written Electronic Communications on a large scale. We recommend updating current Wiretap and Intercept rules to include the use of AI
- Robocall
    - AI provides the ability for advanced Robocalling along with interactive voice and text communication that is indistinguishable from that of a human
    - To prevent AI robocall abuse, we recommend that any electronic communications, voice or text, between an AI and a person, that the person should be notified that they are communicating with an AI *(Note: The Draft EU Regulatory Act also recommends this requirement)*.

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Safe Uses of AI, ML and Software Algorithms

Proactively Advancing Regulatory Processes and Practices for FCC Leadership – Recommendations (cont.)

Recommendation 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. (e.g., risk-based approach, proposed bans on the use of AI to influence perception or behavior of individuals).

Background and Rationale: The EU is looking to create wide scale regulation around the use of AI across its members (analogous to the GDPR and data). This is the most sweeping action of its kind in world so it will have implications to the US. While we don't advocate the same approach for US, there are aspects of the EU work that have direct relevance to our own challenges and values.

Impact and Relation to FCC Goals: The EU regulatory work is very wide (not industry specific) and it remains to be seen how it will apply to telecommunications. The FCC might be first to take steps to encourage awareness and voluntary actions by employing its bully pulpit and through establishment of expectations as well as facilitation and encouragement of best practices (vs. outright regulation).

Suggested 2023 TAC Supporting Work: The TAC could analyze the full EC (European Commission) and EP (European Parliament) work products as they continue to evolve and make specific recommendations on areas to consider adoption (or adaptation) and how as well as areas to avoid.

EU Regulation on AI: Background and Status

- In April of 2021, the European Commission submitted a proposal for a European Union (EU) regulatory framework on AI. This is the first attempt globally to horizontally regulate AI (in and of itself). Analogous in scope to GDPR, this AI regulation, if ratified, will have a range of implications for the development of AI regulation globally, as well as efforts to build international cooperation on AI.

- The proposal is progressing through the EU Council and the EU Parliament where it is undergoing review and revision by both bodies. A ‘trilog’ meeting is expected in Q1/Q2-2023 where the EU Council, EU Commission and EU Parliament will come together and attempt to reconcile / finalize a unified act that can then be submitted for ratification.

- It is expected that there will be every effort to finalize and achieve ratification of the act by YE-2023 since 2024 is a year that will bring a new EU administration.

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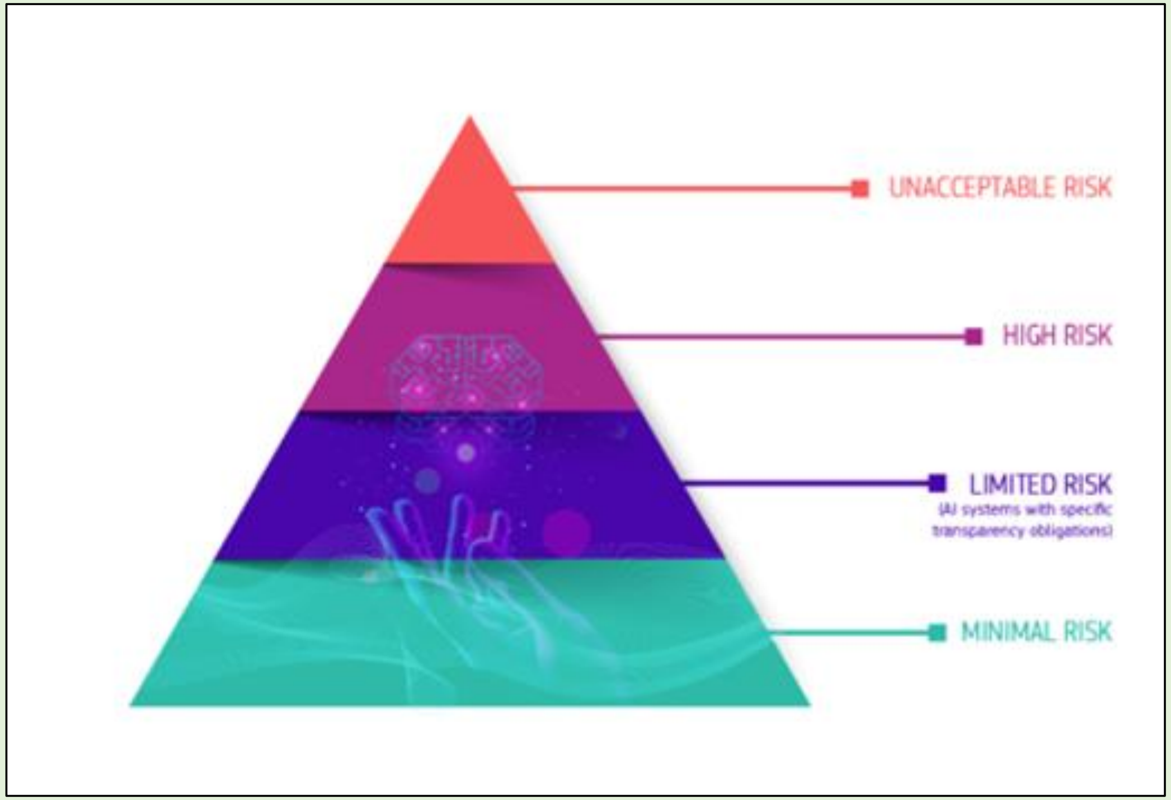
EU Regulation on AI: Risk-Based Approach



Graphic Source: The European Union's Artificial Intelligence (AI) Act – Presentation, Marco Lehto Barone and Guido Lobrano (ITI), 12-May-2022

Unacceptable Risk: Banned (e.g., manipulation, vulnerability exploitation, social scoring, *live face recognition by law enforcement [with defined exemptions for permitted use]*

High Risk: subject to conformity assessment (e.g., critical infrastructure, biometrics, employment decisions, law enforcement)

Limited Risk: AI intended to interact with humans (e.g., deepfakes)

Minimal Risk: out of scope of the act (all other uses)

EU Regulation on AI: Prohibited (Banned) AI Practices

- … an AI system that deploys **subliminal techniques** beyond a person's consciousness with the objective to or the effect of **materially distorting a person's behavior** in a manner that causes or is reasonably likely to cause that person or another person physical or psychological harm
- An AI system that **exploits any of the vulnerabilities of a specific group of persons due to their age, disability or social or economic situation**, with the objective to or the effect of in materially distorting the behavior of a person pertaining to that group in a manner that causes or is reasonably likely to cause that person or another person physical or psychological harm
- AI systems for the **evaluation or classification of natural persons** over a certain period of time based on their social behavior or known or predicted personal or personality characteristics, with the social score leading to [detrimental or unfavorable treatment of certain natural persons or whole groups]…
- the use of **'real-time' remote biometric identification systems in publicly accessible spaces** by law enforcement authorities or on their behalf for the purpose of law enforcement
  [specific defined exceptions for permitted use – these remain highly contentious]

Source: "Proposal for a Regulation of the European Parliament and of the Council laying down harmonized rules on artificial intelligence (Artificial Intelligence Act) and amending certain Union legislative acts - Second Presidency compromise text", Council of the European Union, 19-October-2022 (circulated/unpublished draft)

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EU Regulation on AI: High Risk Uses

High Risk Defined:

- An AI system that is **itself a product covered by the Union harmonization legislation** *[listed in Annex II]* shall be considered as high risk if it is required to undergo a third-party conformity assessment…
- An AI system intended to be **used as a safety component of a product** covered by the legislation *[referred to in paragraph 1]* shall be considered as high risk if it is required to undergo a third-party conformity assessment…
- AI systems *[referred to in Annex III]* shall be considered high-risk unless:

the output of the system is **purely accessory in respect of the relevant action or decision** to be taken and may therefore *[NOT?]* lead to a significant risk to the health, safety or fundamental rights.

Source: "Proposal for a Regulation of the European Parliament and of the Council laying down harmonized rules on artificial intelligence (Artificial Intelligence Act) and amending certain Union legislative acts - Second Presidency compromise text", Council of the European Union, 19-October-2022 (circulated/unpublished draft)

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EU Regulation on AI: High Risk Uses

High-Risk AI Uses – Annex III

Standalone AI Systems used in the following areas:

- Real time and post remote biometric identification of natural persons
- Safety components for the management of critical infrastructure (heating, gas, electricity, water)
- Determining access to education or training or assessing students
- Recruitment or work-related decisions (promotions, termination…)
- Determining access to public or private services (credit score, emergency response, public benefits)
- Law enforcement (predictive policing, emotion recognition, evidence assessment, profiling)
- Migration (asylum application, emotion recognition)
- Use by a judicial authority

ITI

Promoting Innovation Worldwide

Source: The European Union's Artificial Intelligence (AI) Act – Presentation, Marco Lehto Barone and Guido Lobrano (ITI), 12-May-2022

- This is relative to the original proposal. It is slightly different in the current Oct-2022 text and continues to evolve
- There appears to be general and widespread agreement that some additional filter or principle is required to qualify this broad list of use-cases

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EU Regulation on AI: Useful Aspects of Proposed Regulation

- The overarching objective of advancing trustworthy AI
- Establishing consistent and stable rules vs. local rules and regulations
- Advancing a risk-based approach to assess AI applications and uses
- Recognizing the need for open and diverse data sets
- Identifying and establishing some broad principles for uses of AI in democratic societies
  - A (small number) of use cases that should be prohibited
  - Characterization of 'High Risk'
  - Use cases and applications that imply high risk and thus require careful adjudication

EU Regulation on AI: Concerns with Proposed Regulation

- **Scope**

  - The horizontal approach (regulation of AI in and of itself) will be intractable. A better solution is to provide overarching behaviors/rules and resources (e.g., a risk framework) to guide individual industries and regulatory bodies to apply in the context of their associated industry and responsibility (e.g., don't regulate AI independent of health care but rather in the context of the health care governing bodies).
  - Defining AI is elusive. Initial definitions were broad (well beyond convention) and many of the behaviors that are being 'regulated' as AI can be realized independently of AI technology (e.g., algorithmically).

*Current Definition: 'artificial intelligence system' (AI system) means a system that is designed to operate with elements of autonomy and that, based on machine and/or human-provided data and inputs, infers how to achieve a given set of objectives using machine learning and/or logic- and knowledge based approaches, and produces system-generated outputs such as content (generative AI systems), predictions, recommendations or decisions , influencing the environments with which the AI system interacts. **

* "Proposal for a Regulation of the European Parliament and of the Council laying down harmonized rules on artificial intelligence (Artificial Intelligence Act) and amending certain Union legislative acts - Second Presidency compromise text", Council of the European Union, 19-October-2022 (circulated/unpublished draft)

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EU Regulation on AI: Concerns with Proposed Regulation

Concerns

- The proposed **compliance structures** are mandatory, complex, burdensome and in many case not achievable.
  - It is difficult to assign accountability (e.g., is it the providers of a core AI [platform] technology or those who deliver outcomes on them)
  - Access to the data need to assess compliance may be impossible for the provider
- The Annex III (**High Risk Systems**) identified use cases are far too general and difficult to interpret (hence the concern over a horizontal vs. contextual risk assessment)

* "Proposal for a Regulation of the European Parliament and of the Council laying down harmonized rules on artificial intelligence (Artificial Intelligence Act) and amending certain Union legislative acts - Second Presidency compromise text", Council of the European Union, 19-October-2022 (circulated/unpublished draft)

Safe Uses of AI, ML and Software Algorithms

Proactively Advancing Regulatory Processes and Practices for FCC Leadership – Recommendations (cont.)

Recommendation 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**)

Background and Rationale: Industry would benefit from a consistent framework for collaboratively identifying, assessing, measuring and mitigating risks. This enables a community-based approach to share best practices and learnings. The AI RMF framework is lifecycle based and recognizes that risk management is a function of the context of the AI usage. A tailoring (use-case and temporal) profile methodology allows the baseline framework to be applied to different contexts (a shortcoming of the EU regulatory approach).

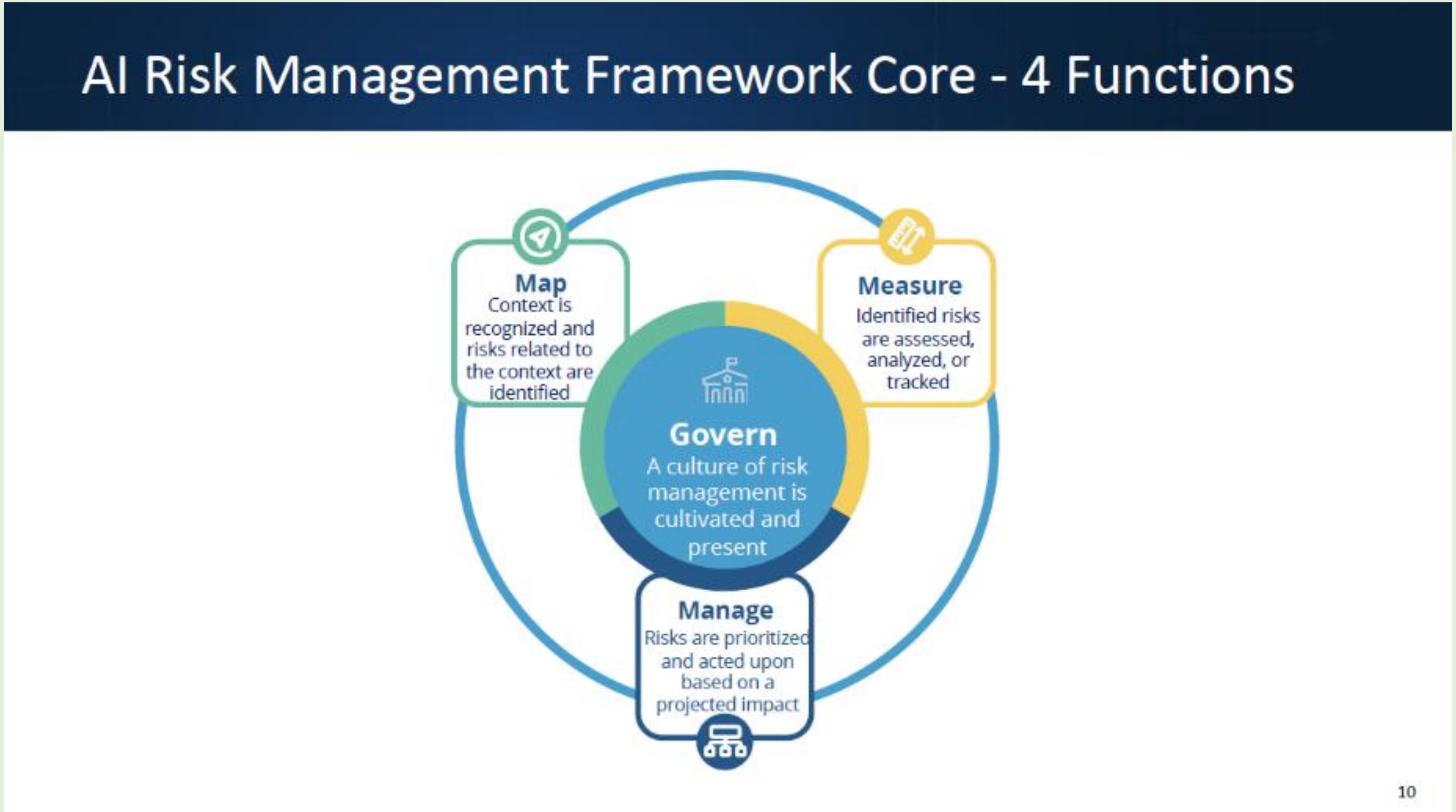
Impact and Relation to FCC Goals: The FCC recognizes the challenges in the burgeoning adoption of AI in telecommunications so it could benefit industry and the country by promoting a common approach to risk management. The FCC would benefit from having common and collaborative approach across industry that normalizes expectations, challenges and terminologies. While voluntary in adoption, the AI RMF and corresponding telecommunications profiles could provide a standard across which participates need to conform.

Suggested 2023 TAC Supporting Work: There is no known telecommunications-specific AI RMF profile development underway. The TAC could undertake the identification of a profile or family of profiles and collaborate with the FCC/industry to create them.

NIST AI RMF: Summary

- Framework to Allow an Organization to Identify, Assess, Measure and Manage risk incumbent in operational AI systems
- Patterned after Cybersecurity Management Framework
- Key Attributes
  - Lifecycle oriented
  - Risk-based approach
  - Extensible by profiles that allows that RMF to be applied in context of a specific industry/domain
    - Risks
    - Implications
    - Affected Groups
  - Voluntary and patterned adoption
  - Enthusiastic multi-national following and vetting across industries and academia
- Release 1.0 of NIST AI RMF is planned for Jan-2023
- See: https://www.nist.gov/itl/ai-risk-management-framework

NIST AI RMF: A Lifecycle Approach



Source: NIST AI Risk Management Framework – Presentation

Elham Tabassi (Chief of Staff, Information Technology Laboratory, NIST)

22-Sept-2022

NIST AI RMF: Operational Context

Source: NIST AI Risk Management Framework – Presentation

Elham Tabassi (Chief of Staff, Information Technology Laboratory, NIST)

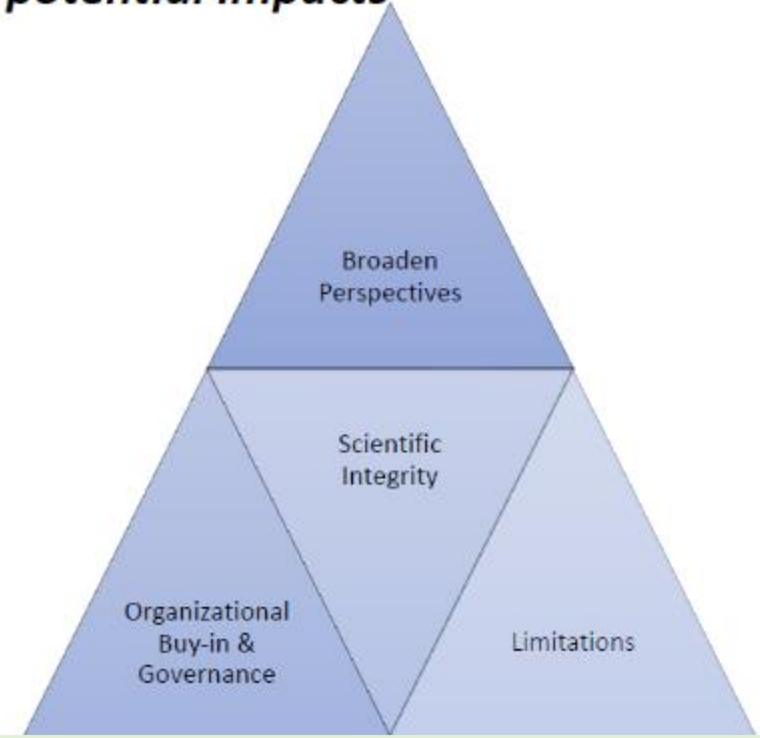
22-Sept-2022

Transforming Culture – Socio-technical Systems Approach

NIST

Takes into consideration the larger social system in which AI operates, its purpose and potential impacts

- Manage risk within/connected to specific operational **context**
  - utilize broader set of perspectives and expertise
  - apply **human-centered** design to AI systems
- Apply the **scientific method** to AI systems
- Set up **governance** structures for the people who build and maintain AI systems
- Consideration of **limitations** from an impact and values-based perspective



7

NIST AI RMF: Contextually Relevant via Profile-based Extension

AI RMF Profiles

Use-case profiles

- Instantiations of the AI RMF functions, categories, and subcategories for a certain application or use case based on the requirements, risk tolerance, and resources of the Framework user.

Temporal profiles

- descriptions of either the current state or the desired, target state of specific AI risk management activities within a given sector, industry, organization, or application context

NIST welcomes contributions towards development of AI RMF use case profiles as well as current and target profiles.

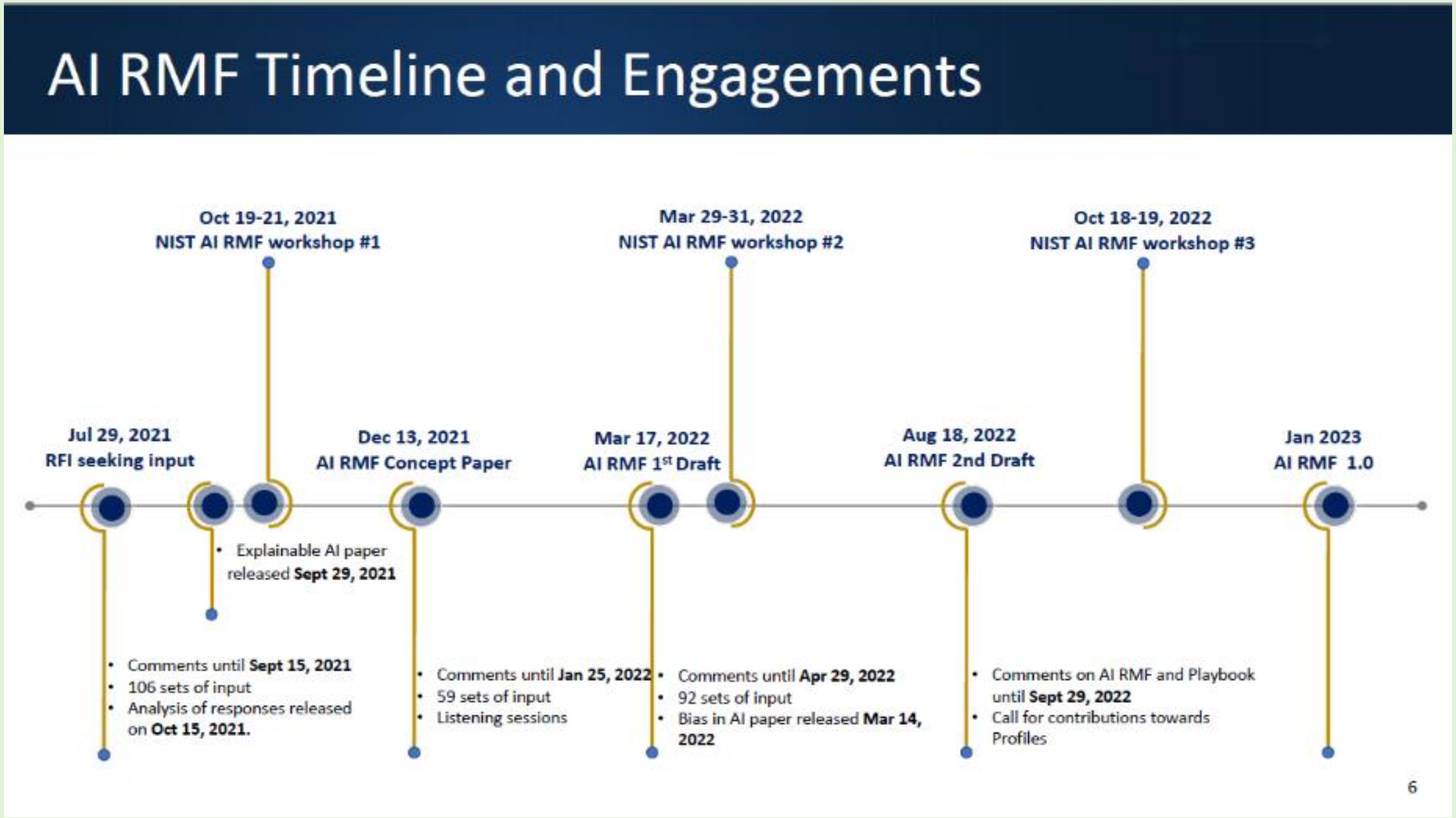
12

Source: NIST AI Risk Management Framework – Presentation

Elham Tabassi (Chief of Staff, Information Technology Laboratory, NIST)

22-Sept-2022

NIST AI RMF: Contextually Relevant via Profile-based Extension



Source: NIST AI Risk Management Framework – Presentation

Elham Tabassi (Chief of Staff, Information Technology Laboratory, NIST)

22-Sept-2022

Safe Uses of AI, ML and Software Algorithms
Topics

1. Summary
2. Concerns and Risks to Consumers, Ecosystem Players and the FCC
3. Proactively Advancing Regulatory Processes and Practices for FCC Leadership
4. **Promoting SW and Data Quality in the Implementation of AI/ML**
5. AI and Implications for Addictive or Human Behavior Modification

Safe Uses of AI, ML and Software Algorithms

Promoting SW and Data Quality in the Implementation of AI/ML: Recommendations

Recommendation 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. (There are many techniques such as anonymization, pseudonymization, differentiated privacy, etc. that may apply - this is also an active area of research.)

Background and Rationale: Access to operational system data (real world data) is essential for two reasons: 1) Assessing the performance of AI in the system (the NIST AI RMF advocates 'Measure' as one of 3 key lifecycle steps) and 2) Curating the data sets for training and improving the AI. A challenge that we repeatedly encountered as we spoke with various experts is access to the needed data since it is generated in the context of an operational environments and may have competitive, security or privacy implications. Thus, providers of AI powered capabilities lack the insights and/or where-with-all to assess and improve/mitigate the performance of their products/services. An aggregated corpus of data across multiple users and operating domains obviously has the potential to improve the efficacy of the system.

Impact and Relation to FCC Goals: The FCC is in a unique position to facilitate mechanisms to safely and securely expose data from operational contexts to facilitate understanding, innovation, safety, and reliability.

Suggested 2023 TAC Supporting Work: The TAC could be chartered to explore and identify methods that would allow data exposure and interchange.

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Safe Uses of AI, ML and Software Algorithms

Promoting SW and Data Quality in the Implementation of AI/ML: Recommendations (cont.)

<u>Recommendation 3.2</u>: 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.

Background and Rationale: Rapid 'Softwarization' of the Network makes AI and ML broadly accessible and applicable. Development, deployment and monitoring of AI/ML (along with the requisite training data) and software go hand-in-hand sharing many principles, processes, and practices. Extending/adapting related and accepted processes to encompass AI/ML provide a path to rigor in the application of AI/ML. Encouragement of rigorous open-source AI/ML software and training data sets (see Recommendation 3.1) to promote quality, transparency, accountability and integrity (supply chain – SBOM) of implementations for telecommunications is recommended.

Impact and Relation to FCC Goals: Promoting confidence and integrity in the US telecommunications services is fundamentally an objective of the FCC. Advancing processes and practices that can continue to promote quality, determinism and rigor in the application of AI, ML and data-drive algorithms to telecommunications is consistent with that FCC objective.

Suggested 2023 TAC Supporting Work: Engage with the CMMI working group chartered with addressing AI/ML to represent telecommunications considerations. Survey the AI/ML open-source software community landscape to identify applicable initiatives and encourage rigor/adaptation for telecommunications.

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Safe Uses of AI, ML and Software Algorithms

Integrated Software/AI Maturity Model for Telecommunications

- Maturity Models are a class of tools that structure and measure how well something is doing and what capabilities must be acquired next in order to improve performance. Maturity Models usually have definitions for Maturity Levels and a set of methods for aligning teams to work together to reach the next level.
- Maturity Models used in telecommunications, such as the Digital CMMI, aim to ease the process of digital transformation by expanding capabilities in particular human-centric ways (strategy, implementation, execution).
- AI/ML development is inconsistent with some of the assumptions made in existing software models concerning "speed" and "blast radius." AI/ML delivers results faster, and operates within more complex environments, than human workers do. Unrestrained AI/ML can deliver results that can cause a lot of damage.
- Considerations for lower Maturity Levels ("Does the software used to implement the AI/ML comply with safety-centric software standards?") may leverage other context-specific standard (e.g., A well-known example of a safety-centric software standard is MISRA-C, which specifically addresses safety through rules and guidelines for writing embedded software for automobiles), but no such domain specific standard exists for telecommunications.
- Data set maturity level used by the the AI/ML model. A mature data set is large enough and diverse enough to be as free from bias as possible. There are multiple sources and types of bias, ranging from historical to algorithmic to measurement to aggregation and more. Maturity Levels should be gated by the results of independent audits of fairness and bias of the data relied upon. There are practical methods for measuring and detecting bias and these should be incorporated into the Maturity Model for AI/ML systems to advance in Maturity Level.

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Safe Uses of AI, ML and Software Algorithms
Topics

1. Summary
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4. Promoting SW and Data Quality in the Implementation of AI/ML
5. **AI and Implications for Addictive or Human Behavior Modification**

Safe Uses of AI

AI and Implications for Addictive or Human Behavior Modification

- The Concern is Justified
  - Excessive Internet use has not been recognized as a disorder by the World Health Organization, the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) or the International Classification of Diseases (ICD-11). (excepting Gaming Disorder). Controversy around the diagnosis centers on whether the disorder is a separate clinical entity, or just “more of the same”. Evidence based solutions cannot exist without an agreement on what constitutes evidence.
  - There is a widely cited PLOS ONE study showing structural brain changes in line with chemical substance abuse (abnormal white matter). https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0030253
  - Addictive behaviors are considered a serious threat to basic human functionality and civil society in South Korea and China, and those governments have taken actions including dramatically limiting computer game use and wide-ranging interventions in schools.
  - From Dr. Russell’s talk about recommendation systems, we heard that a rapid effect from reinforcement learning algorithms applied to people is that a “good” algorithm will produce extremists. Extremists are predictable. Driving people to be extreme in preferences means things like clickthrough (a monetized metric) goes up.
  - There are clear and exploitable manipulation risks, but polarization isn't an individual harm. People aren't unhappy about being polarized or becoming extreme.

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Safe Uses of AI
AI and Implications for Addictive or Human Behavior Modification

- Possible Compensatory Steps
  - The EU has recognized the risk and proposes to ban AI, ML and algorithmic systems that distort behavior defined as:

    "… an AI system that deploys **subliminal techniques** beyond a person's consciousness with the objective to or the effect of **materially distorting a person's behavior** in a manner that causes or is reasonably likely to cause that person or another person physical or psychological harm."
  - Voluntary filters and institutional raters, third-party algorithmic audits, measures of online health/division, or circuit breakers for viral content are all potential mitigations.
  - "Bridging" as a metric for recommender systems: Instead of just amplifying posts that generate a lot of likes, emphasize ones that bridge communities. Break free of the echo chamber as much as possible.

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Safe Uses of AI
References

1. AI Risk Management Framework: Second Draft, National Institute of Standards and Technology, August 18, 2022 (See also: AI Risk Management Playbook, National Institute of Standards and Technology, August 18, 2022)
2. Actionable Guidance for High-Consequence AI Risk Management: Towards Standards Addressing AI Catastrophic Risks, Anthony M. Barrett, Dan Hendrycks, Jessica Newman, Brandie Nonnecke, UC Berkely September 7 2022.
3. Artificial Intelligence Strategic Plan – Fiscal Years 2023-2027, United States Nuclear Regulatory Committee, Draft Report for Comment, June 2022
4. Accountability Principles for Artificial Intelligence (AP4AI) in the Internal Security Domain (AP4AI Framework Blueprint) – Draft 22, Europol Innovation Lab & CENTRIC (Center of Excellence in Terrorism, Resilience, and Organized Crime Research), June 2022
5. Artificial Intelligence Act (Current Draft 15-July-2022), European Union, July 2022.
6. Demystifying the Draft EU Artificial Intelligence Act, Michael Veale (Faculty of Laws, University College London), Frederik Zuiderveen Borgesius (Interdisciplinary Hub for Security, Privacy and Data Governance, Radboud University, The Netherlands), Version 1.1, July 2021.
7. Implementing Responsible Artificial Intelligence in the Department of Defense, Memorandum from Deputy Secretary of Defense, May 21, 2021.
8. Tasks, Automation, and the Rise in US Wage Inequality, Daron Acemoglu (MIT) and Pascual Restrepo (Boston University), ECONOMETRICA: SEP 2022, VOLUME 90, ISSUE 5.

Safe Uses of AI, ML and Software Algorithms

Thank you!

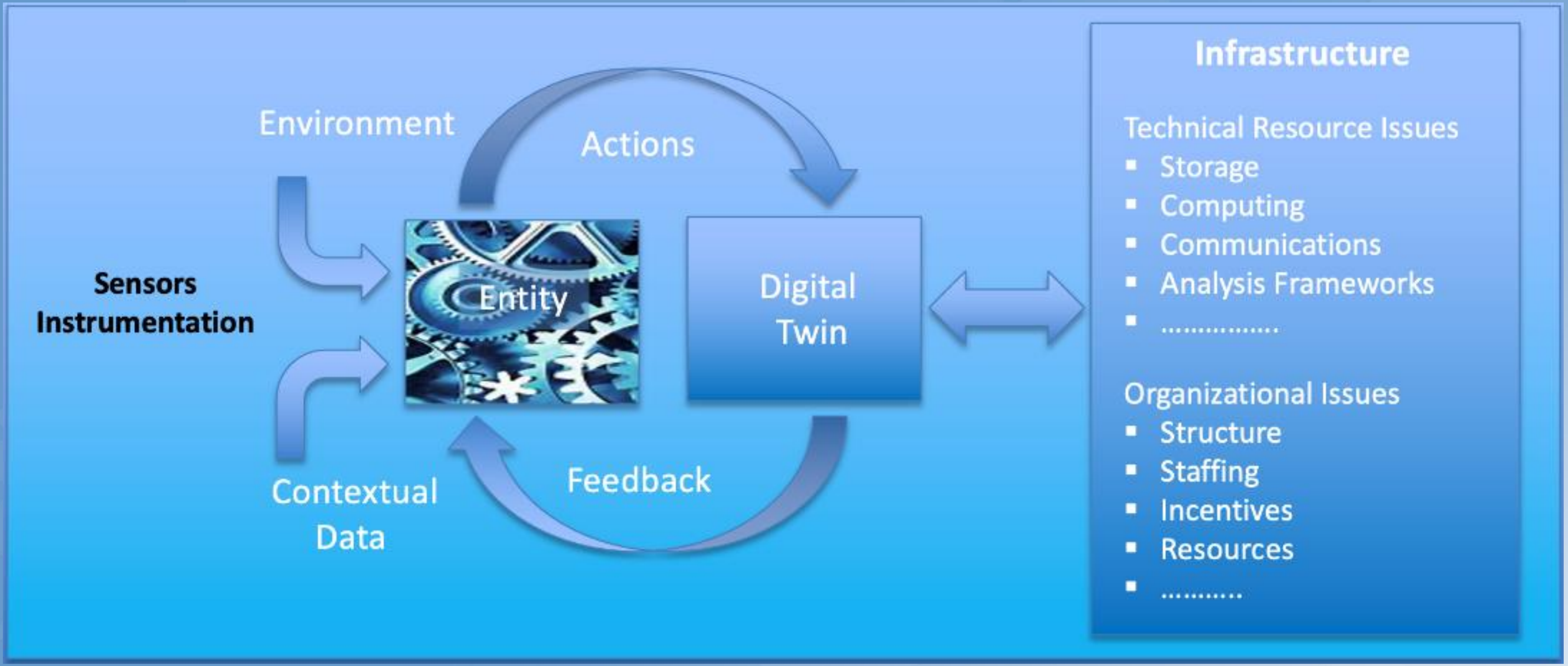
- Spectrum Sharing Evolution
  Digital Twins

Outline

"Networks for Digital Twins and Digital Twins for Networks"

- *Digital Twins*
  - *A Technological View of Digital Twins*
    - *Applications: Manufacturing, Products, Services, Processes, Concepts*
  - *Network Requirements*
    - *Infrastructure: Data, Storage, Computing, and Communications*
- *Managing The Network Lifecycle*
  - *A Use Case for Network Management using Digital Twins*

Digital Twins

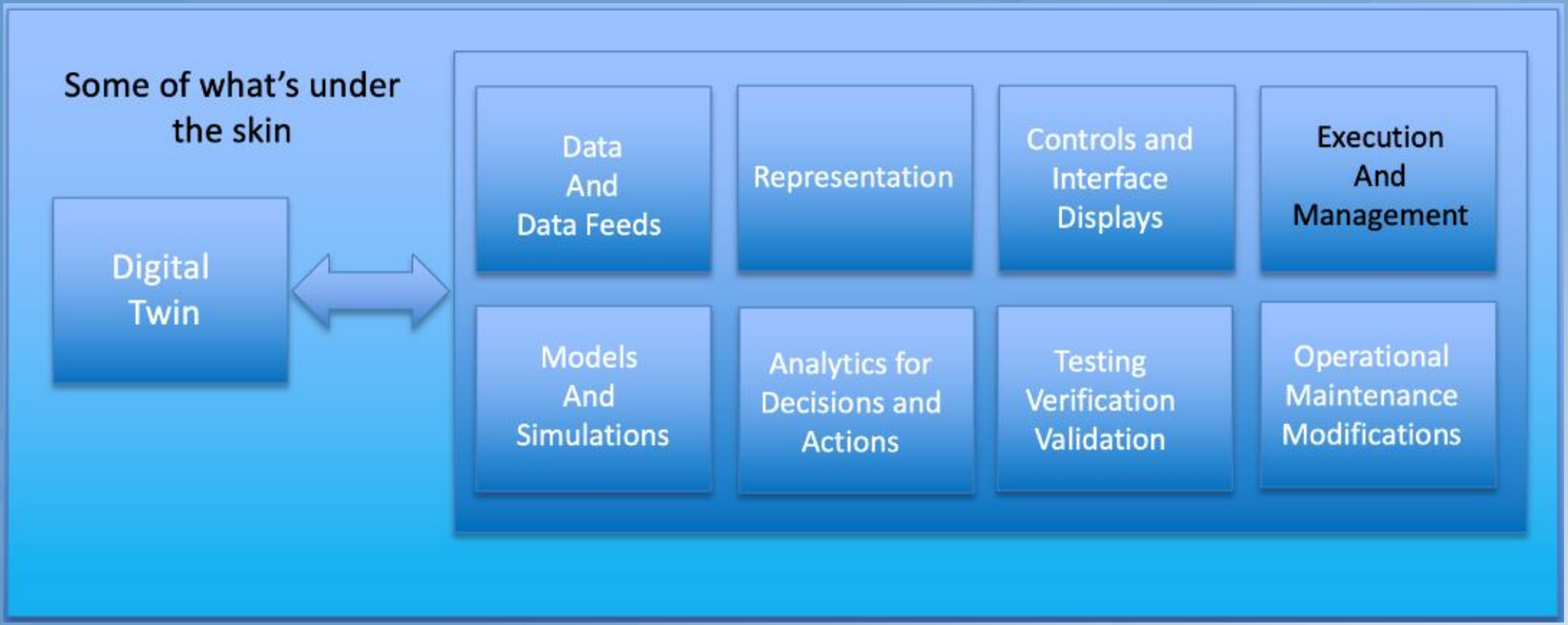


Digital Twin

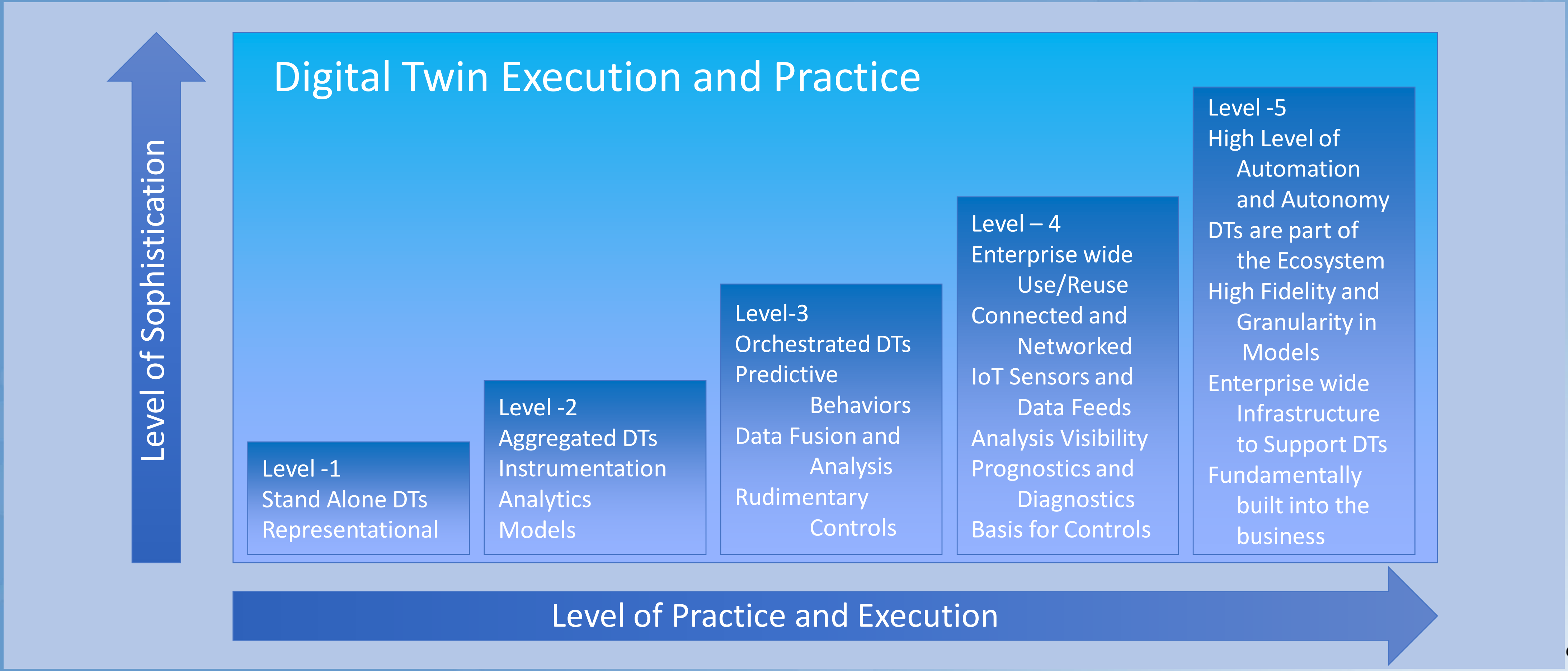
Complex/Compound Object/System

Digital Twins working in concert

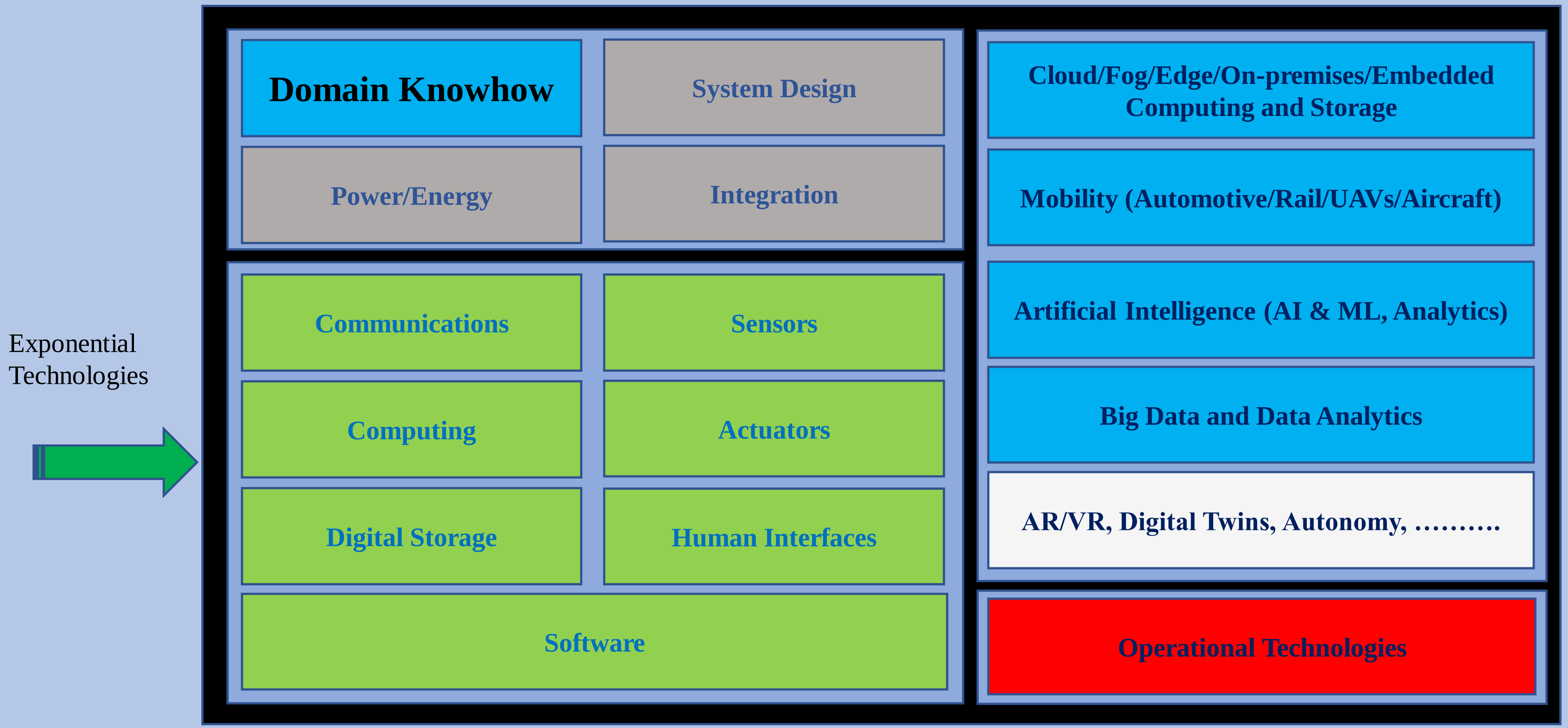
Digital Twins



Digital Twins



Digital Twins



Digital Twins

HPC and Hyperscale Data Centers

Cloud Computing

Fog/Edge Computing

Embedded Computing

Workstation Computing

Desktop Computing

Nomadic/Mobile Computing

Device Computing

Digital Twins

Cellular Communications

WiFi

GEO
Satellite

LEO
Constellations

mmWave
Communications

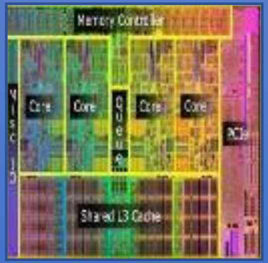
Point - Point
Communications

On Premise Fiber

Fiber Optic
Long Distance Cable

Digital Twins

On Chip Memory



On Board Memory

Solid State Disc

Flash Memory

Disk Drive

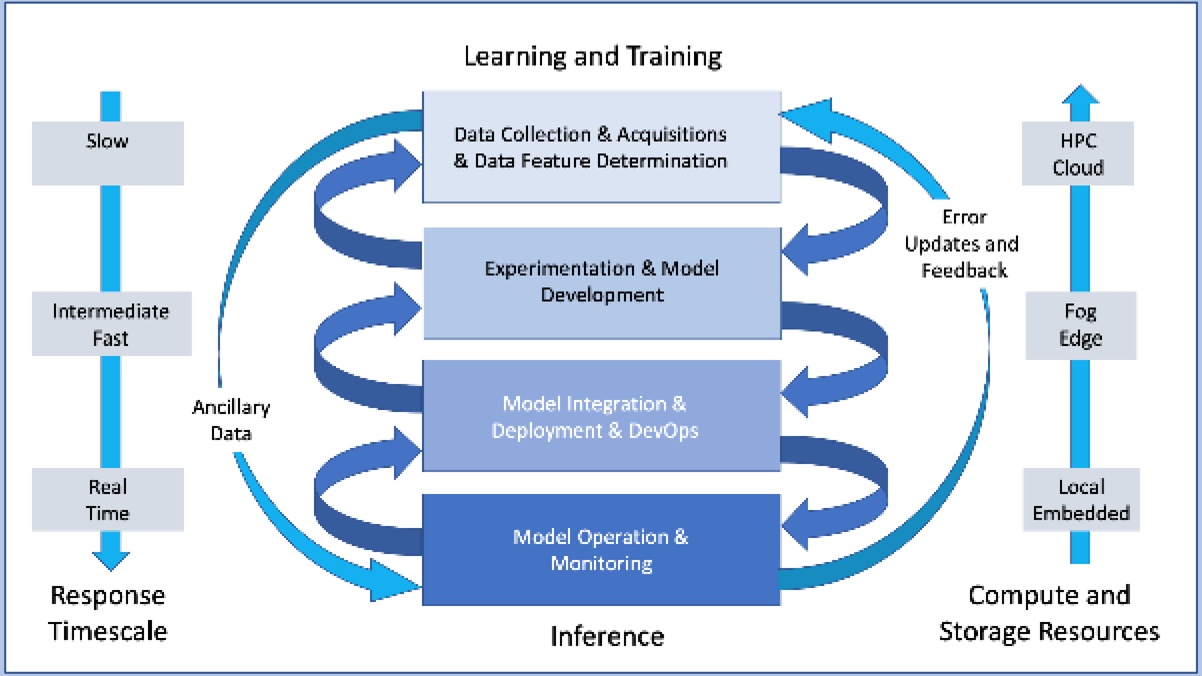
Disk Array

Data Center Storage

Automated Tape Vault

Digital Twins

A Digital Twin System with operational resources - complex!

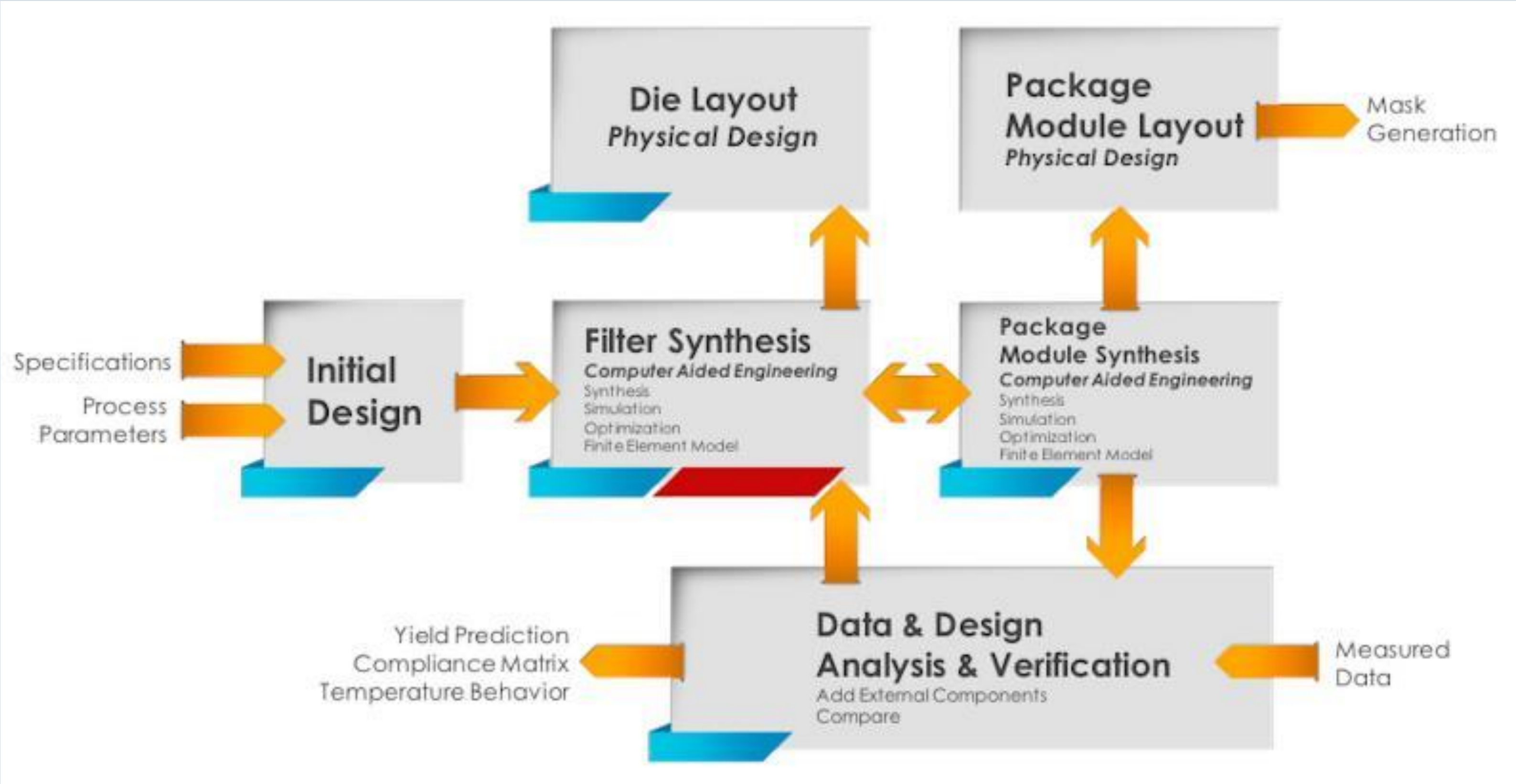


Digital Twins

- Management of Digital Twins requires management of four distinct types Networks:

➢ Data Network	→	Heterogenous
➢ Storage Network		Hierarchical
➢ Computing Network		Basically Distributed
➢ Communications Network		Stationary/Nomadic/Mobile

Tools, Technologies, and Sources of Data

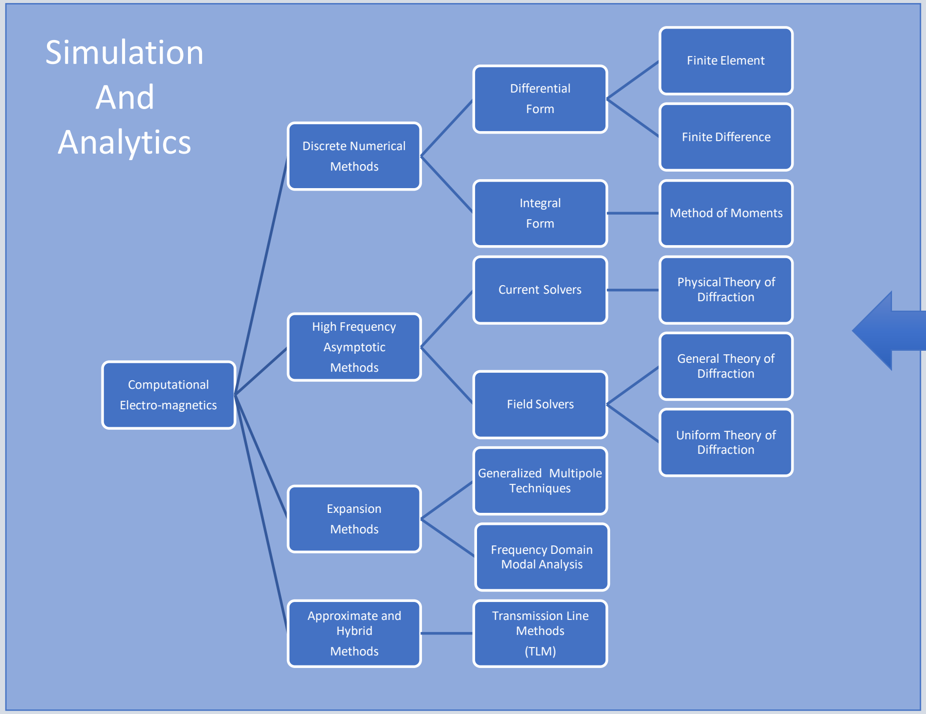


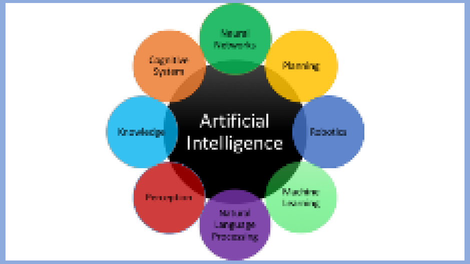
Tools, Technologies, and Sources of Data

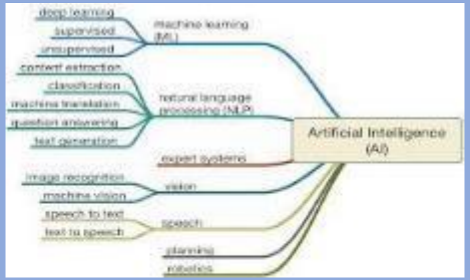
Physical Model → Mathematical Models → Numerical Models → Simulation Models

Physical Model	Mathematical Models	Numerical Models	Simulation Models
Geometry	Approximation	Methods	Problem Setup
Materials	Time Scales	Discretization	Execution
Context	Spatial Scales	Accuracy	Result Outputs
Statistics	Boundaries	(Order)	Analysis Tools

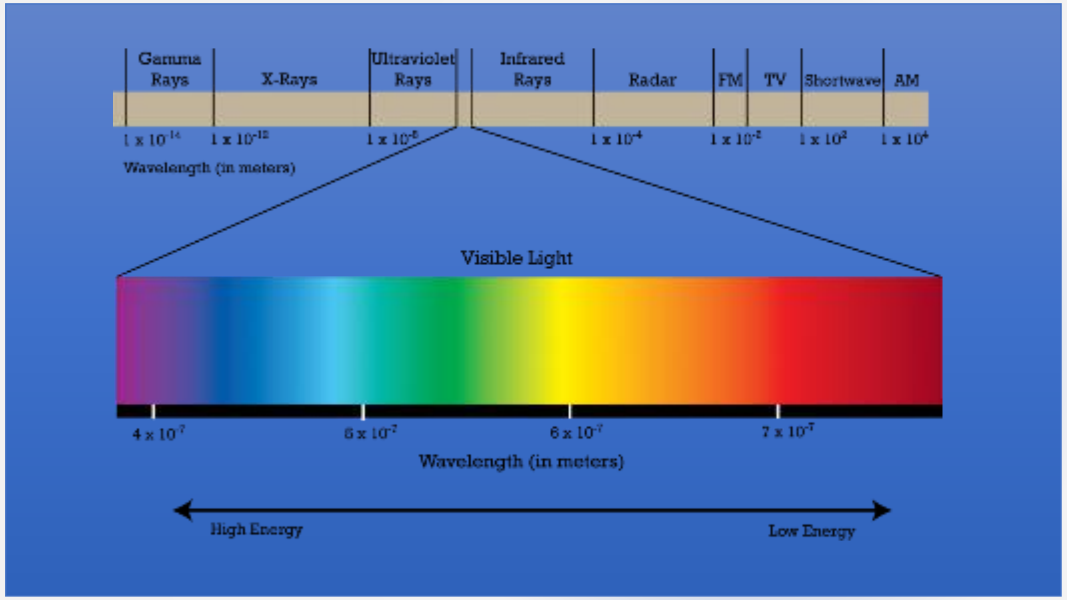
Tools, Technologies, and Sources of Data







Tools, Technologies, and Sources of Data



Using the full Electromagnetic Spectrum for Sensing

- ➢ Passive
- ➢ Active

- ➢ Distributed
- ➢ Multimodal

Tools, Technologies, and Sources of Data

Sensors, Platforms, and Data Sources Types

- Radar and Ground Penetrating Radar
- Video/Photographic Imaging
- LIDAR
- Multi-Spectral
- Multimodal

- Crowd Sourced Information From "Devices"
- Stationary Platforms - time resolved measurements
- Mobile Platforms (Drones)

- Existing Statutory Data Bases
- Scraping the web

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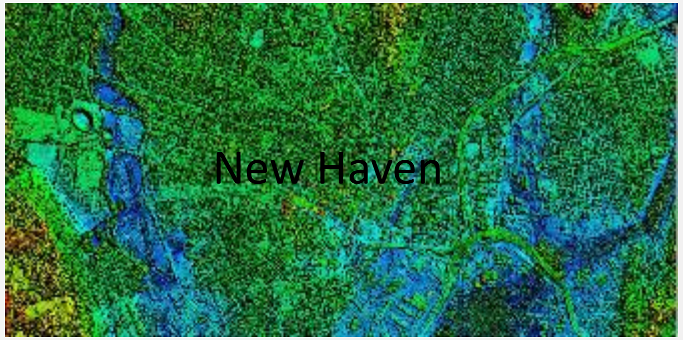
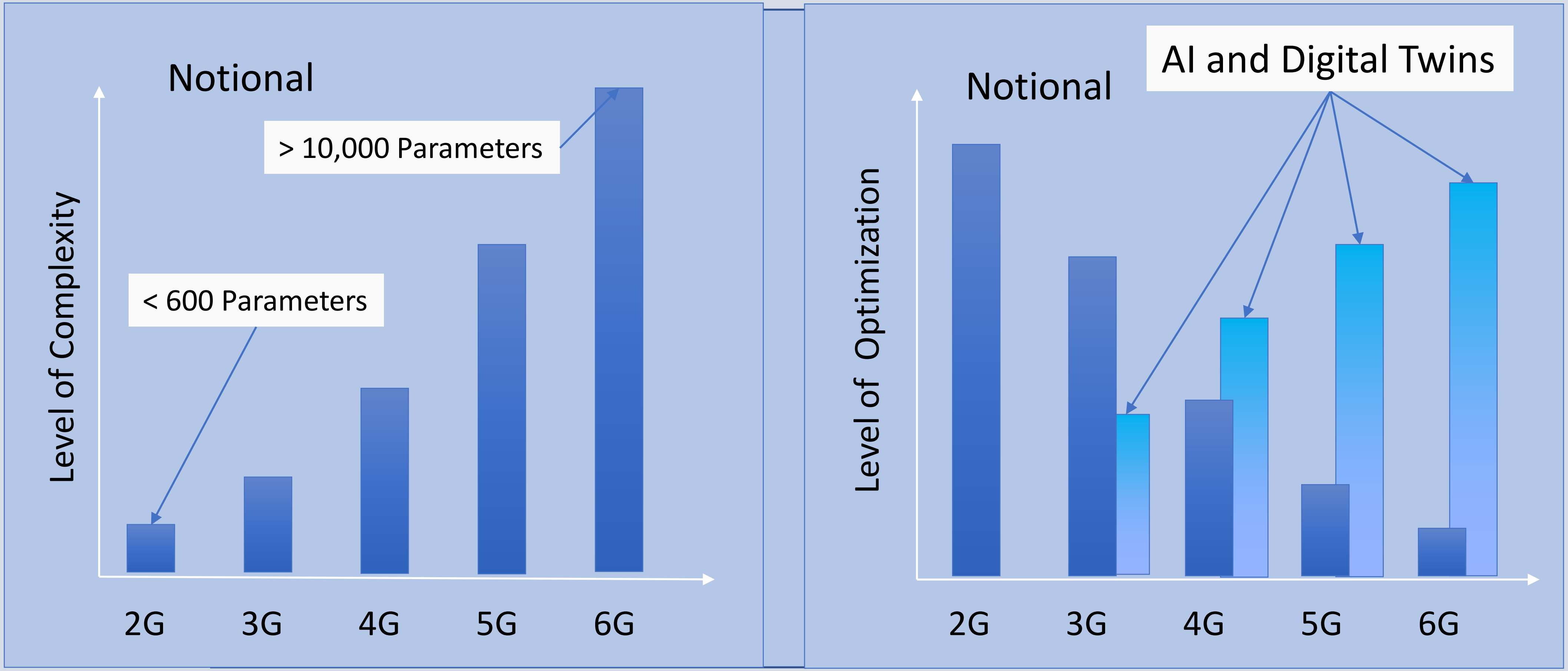
Tools, Technologies, and Sources of Data

Lidar/Radar Image and Feature Reconstruction



Digital Twins for Wireless Systems based on Local Sensing



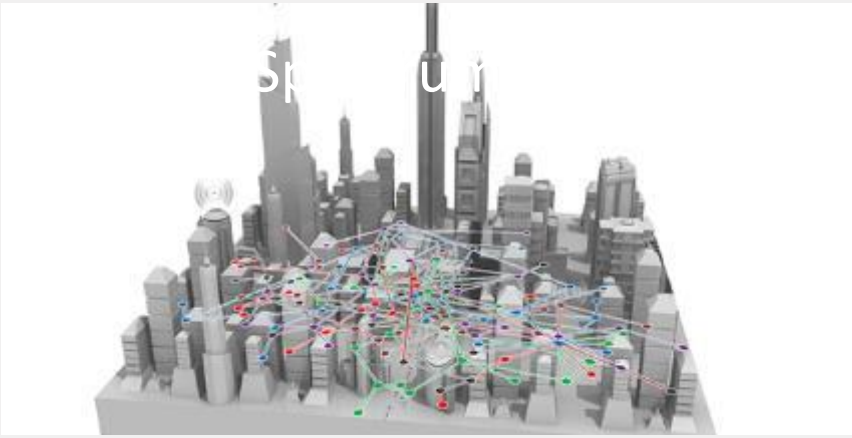
Digital Twins for Wireless Systems based on Local Sensing

- Progression of approaches to Network Management

- Manually Set Network Parameters
  - Recommend Network Configuration
    - Improve Network Settings using Rule based techniques
      - Use AI/ML Based Methods to Optimize the Network
        - Autonomous Network Operations with Digital Twins

Digital Twins for Wireless Systems based on Local Sensing

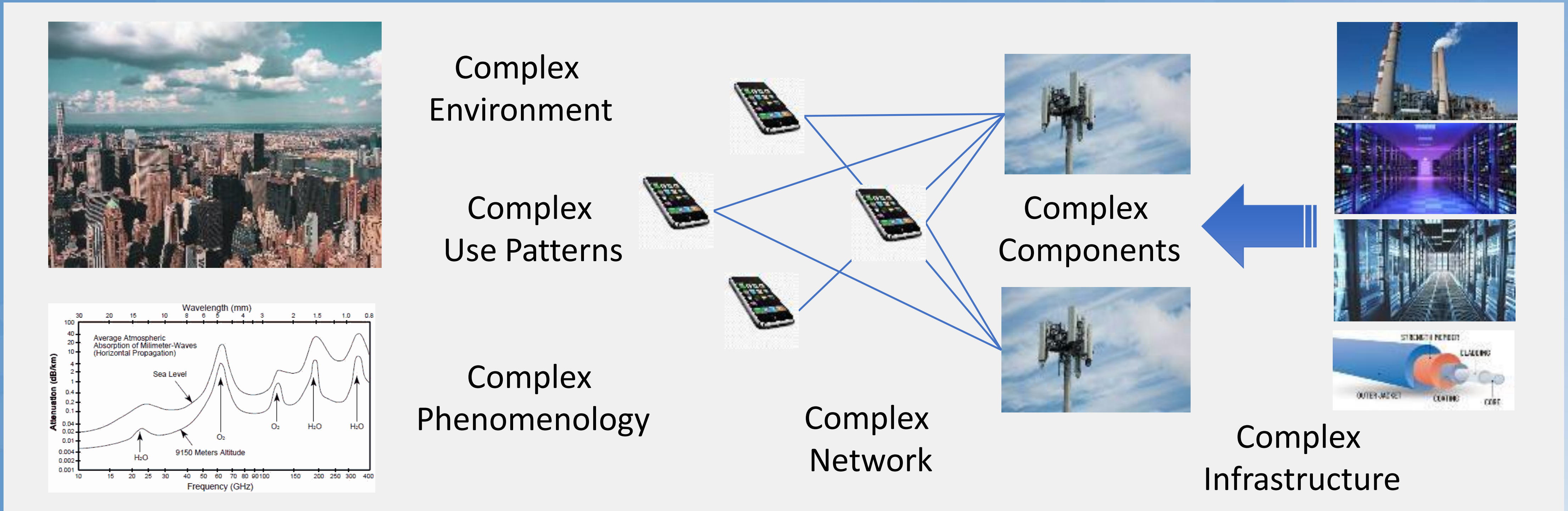
- Progression of approaches to Spectrum Sharing



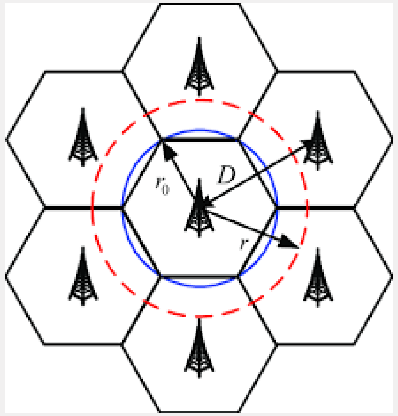
Intent: Use AI Methods and Techniques to Efficiently Share Spectrum

Digital Twins for Wireless Systems based on Local Sensing

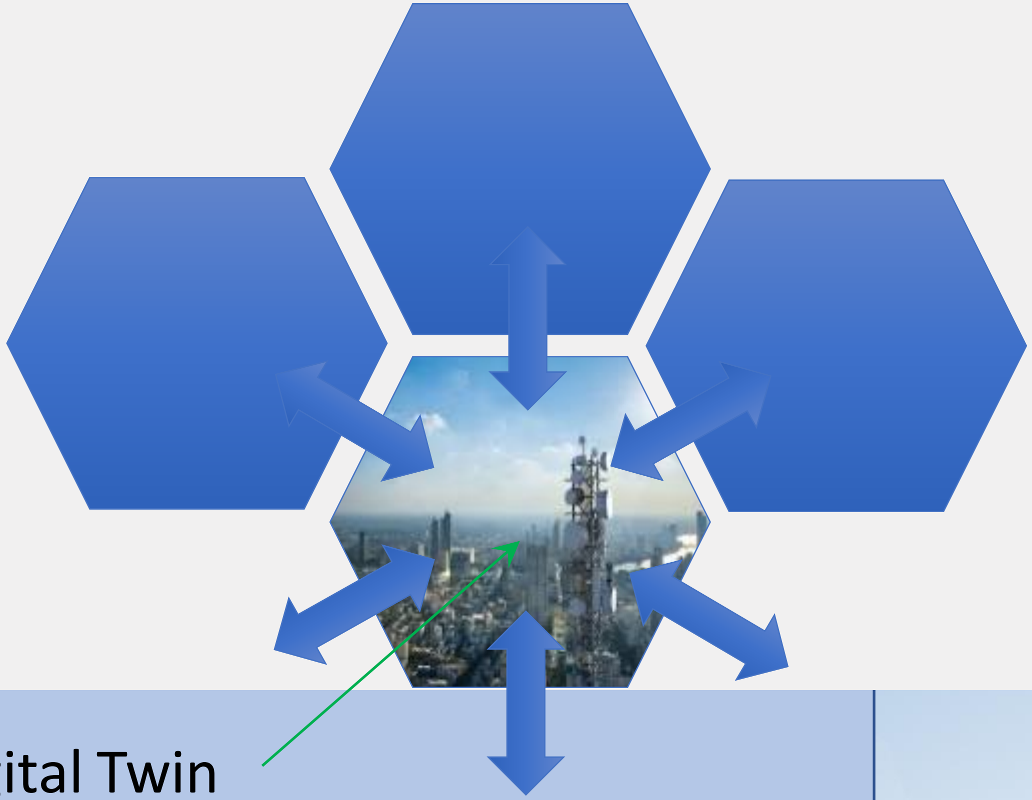
- Progression of approaches to Network Management



Digital Twins for Wireless Systems based on Local Sensing



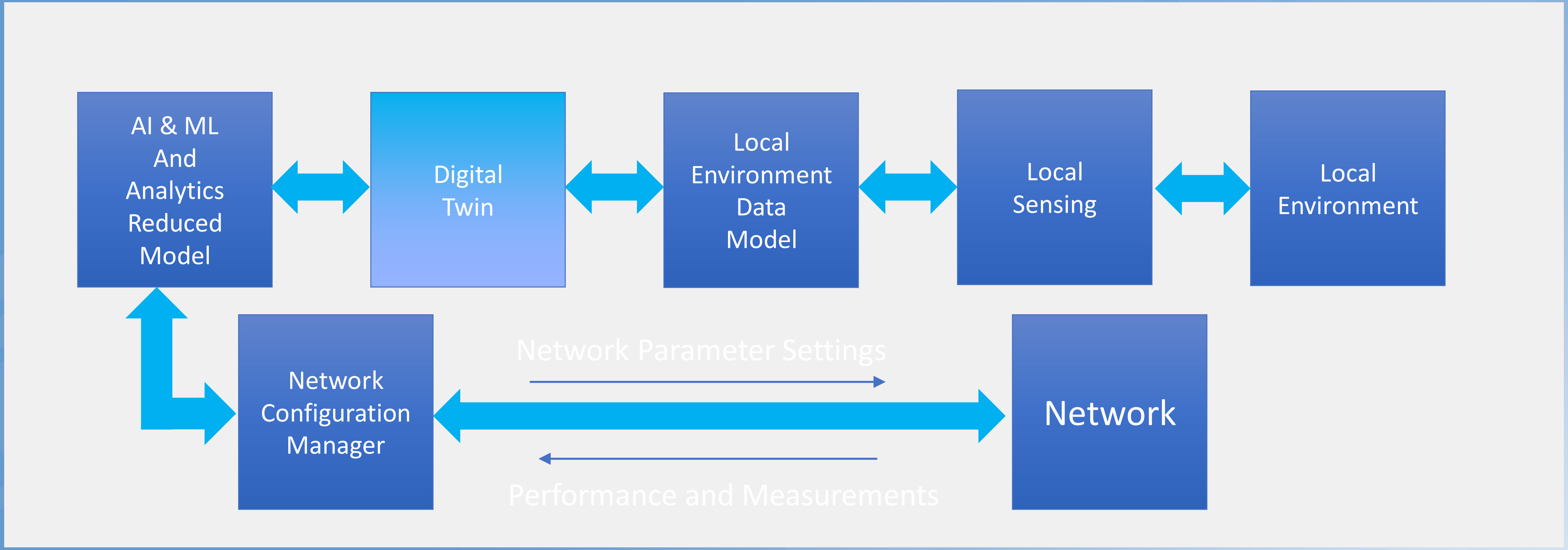
Reduced Data
Shared
With
Neighboring
Cells



Granular Local Digital Twin

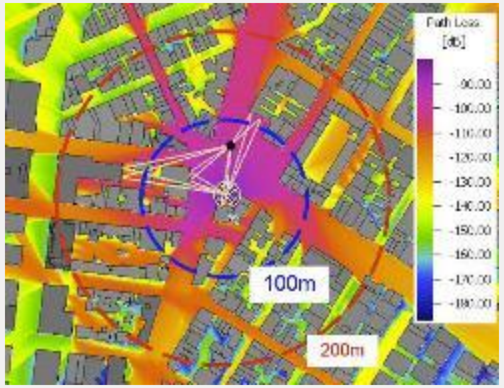
Digital Twins for Wireless Systems based on Local Sensing

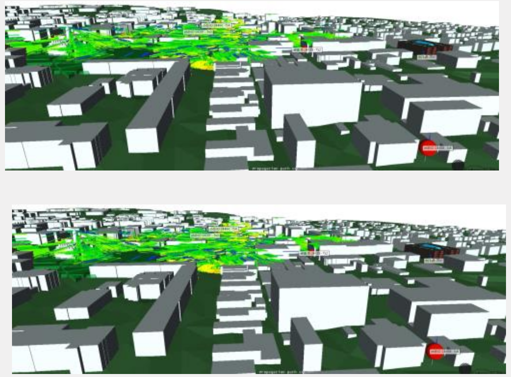
- Progression of approaches to Network Management

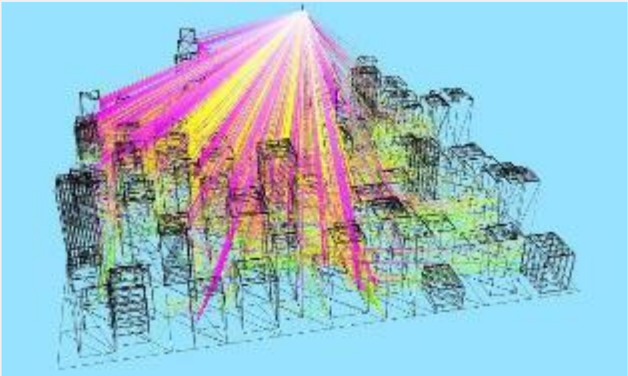


Digital Twins for Wireless Systems based on Local Sensing

- Progression of approaches to Network Management



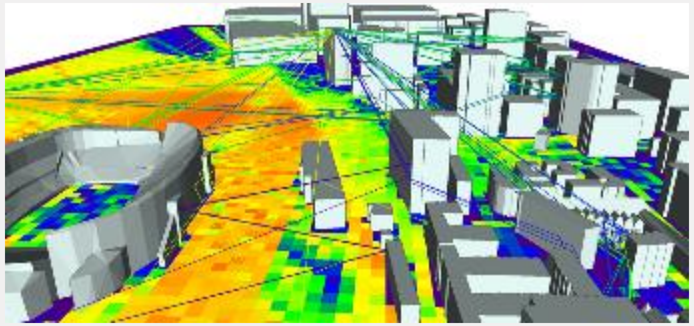




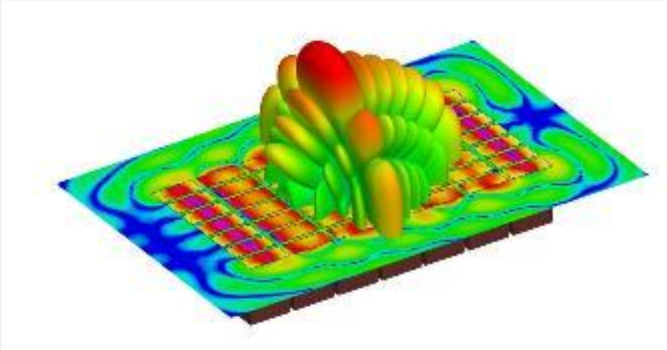
Many Techniques Available – but the problem is data and the temporal Variation in the Local Environment – that can be solved!!!

Digital Twins for Wireless Systems based on Local Sensing

- Progression of approaches to Network Management



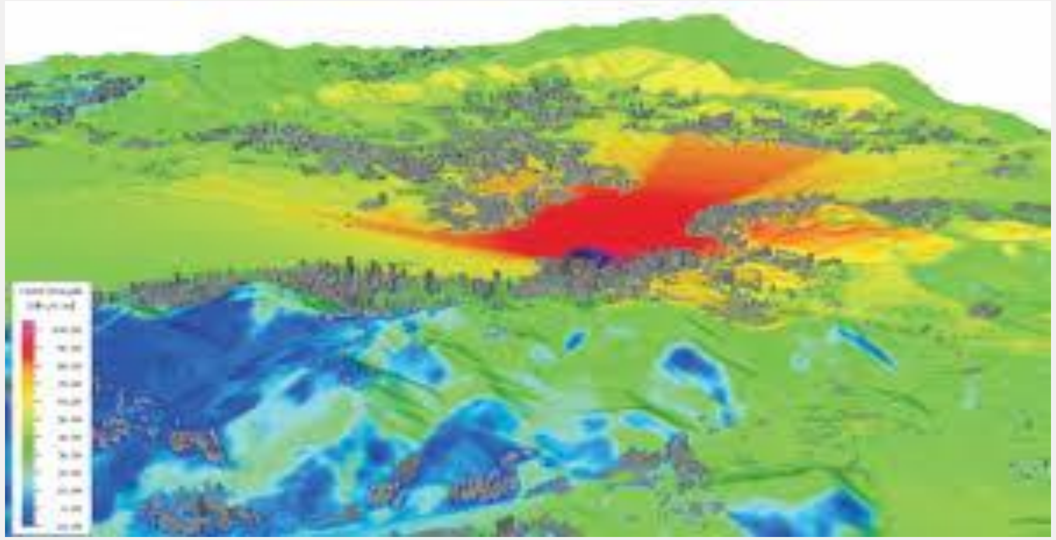
Large Scale Local Simulations

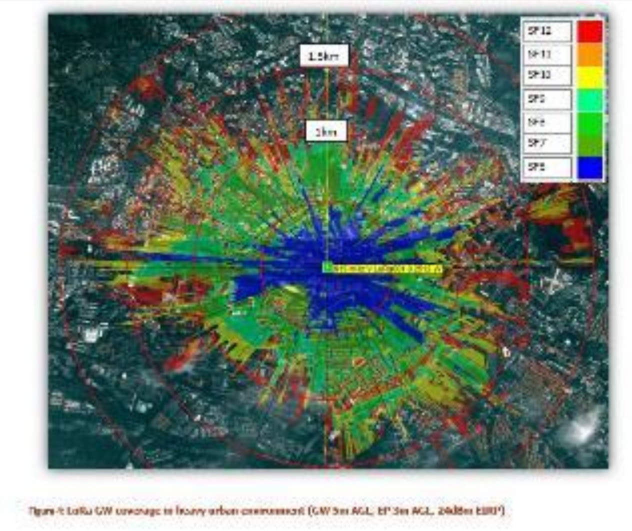


Individual Components

Digital Twins for Wireless Systems based on Local Sensing

- Progression of approaches to Network Management



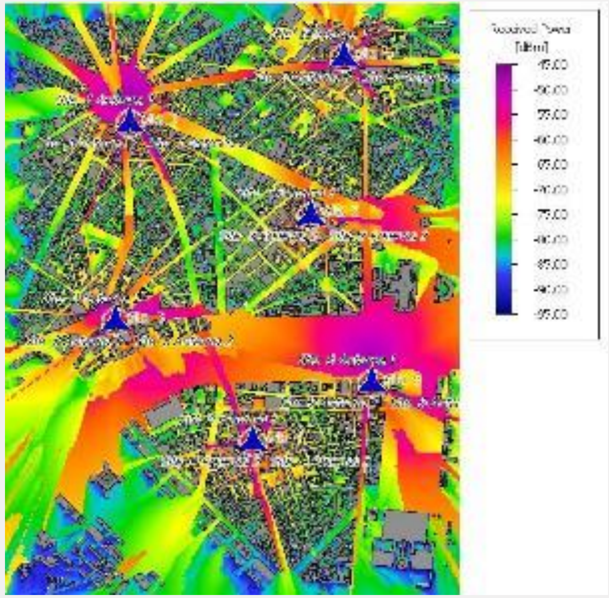


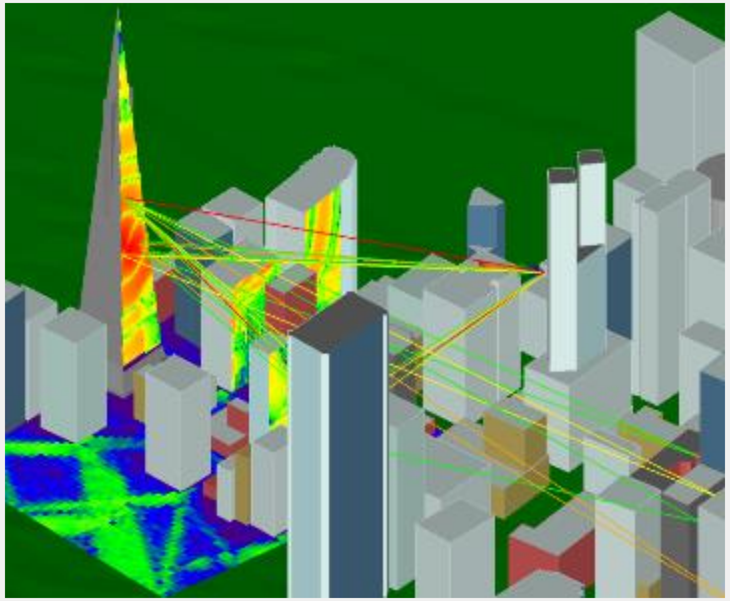
Large Scale/High Resolution Results – HPC Simulations

Digital Twins for Wireless Systems based on Local Sensing

- Progression of approaches to Network Management

Complex Environments





Digital Twins

Thank You!

- Use of AI/ML and Computing in Telecommunications Networks

- List of Speakers and Presenters

AIWG List of Participants and Presenters (*)

	Speaker	Affiliation	Date
01.	Acemoğlu, Daron	MIT Dept. of Economics and Sloan School	09/21/2022 (*)
02.	Baker, Amy	Mitre	08/10/2022 (Contributor)
03.	Barone, Marco Leto	ITI Council EU	05/11/2022 (*)
04.	Baxter, Kathy	Salesforce	07/21/2022 (*)
05.	Belliappa, Gautham	Deloitte	11/10/2022 (*)
06.	Black, Aeva	Microsoft, Office of the CTO and Open-Source Initiative	11/03/2022 (Panel Moderator)
07.	Blackburn, Chris	Mitre	08/10/2022 (Contributor)
08.	Bowman, Mic	Intel Labs	08/03/2022 (*)
09.	Bowman, Michael	DISA	08/10/2022 (Contributor)
10.	Clancy, Charles	MITRE	06/15/2022 (*)
11.	Daisy, B.J.	Comcast	09/28/2022 (*)

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AIWG List of Participants and Presenters (*)

	Speaker	Affiliation	Date
12.	Damola, Ayodele	Ericsson	04/27/2022 (*)
13.	Davis, Randall	MIT EECS and CSAIL	05/25/2022 (*)
14.	Dohler, Mischa	Ericsson	10/26/2022 (*)
15.	Farshchian, Masoud	Mitre	08/10/2022 (*)
16.	Friday, Bob	Juniper	04/20/2022 (*)
17.	Kimmich, Sal	Sonatype and The Present Dev Podcast	11/03/2022 (Panelist)
18.	Lobrano, Guido	ITI Council EU	05/11/2022 (*)
19.	Mattson, Peter	MLCommons	09/14/2022 (*)
20.	Melodia, Tommaso	Northeastern University	07/13/2022 (*)
21.	Miche, Yoan	Nokia Bell Labs	07/20/2022 (*)
22.	Nafshi, Elad	Comcast	09/28/2022 (*)

AIWG List of Participants and Presenters (*)

	Speaker	Affiliation	Date
23.	Mike Regan	Telecommunications Industry Association	09/08/2022 (*)
24.	Rennier, Tony	Foundry Inc.	08/10/2022 (*)
25.	Russell, Stuart	EECS UC Berkeley	06/01/2022 (*)
26.	Sanneck, Henning	Nokia	07/20/2022 (*)
27.	Satyanarayanan, Mahadev	Carnegie Mellon University	10/05/2022 (*)
28.	Schirrmeister, Frank	Cadence	07/27/2022 (*)
29.	Stantchev, George	Naval Research Laboratory	11/09/2022 (*)
30.	Tabassi, Elham	NIST Information Technology Laboratory	09/22/2022 (*)
31.	Tarkowski, Alek	Open Future and Creative Commons	11/03/2022 (Panelist)
32.	Vasseur, Jean-Phillipe (JP)	Cisco	07/06/2022 (*)

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AIWG List of Participants and Presenters (*)

	Speaker	Affiliation	Date
33.	Villa, Luis	Tidelift, TechGC, and Wikimedia	11/03/2022 (Panelist)
34.	West, Nathan	DeepSig	08/24/2022 (*)
35.	Yoo, Taesang	Qualcomm	06/22/2022 (*)
36.	Zebrowitz, Harris	Mitre	08/10/2022 (Contributor)

FCC TAC AIWG Presentation: September 21st, 2022

Daron Acemoğlu, Institute Professor, Department of Economics and the Sloan School, MIT

Talk Title: **“AI, Jobs, and Democracy”**

Biography: Prof. **Daron Acemoğlu** , Department of Economics and Sloan School, MIT

Daron Acemoglu is Elizabeth and James Killian Professor of Economics in the Department of Economics at the Massachusetts Institute of Technology. He has received a BA in economics at the University of York, 1989, M.Sc. in mathematical economics and econometrics at the London School of Economics, 1990, and Ph.D. in economics at the London School of Economics in 1992.

He is an elected fellow of the National Academy of Sciences (United States), the Science Academy (Turkey), the American Academy of Arts and Sciences, the Econometric Society, the European Economic Association, and the Society of Labor Economists. He has received numerous awards and fellowships, including the inaugural T. W. Shultz Prize from the University of Chicago in 2004, and the inaugural Sherwin Rosen Award for outstanding contribution to labor economics in 2004, Distinguished Science Award from the Turkish Sciences Association in 2006, the John von Neumann Award, Rajk College, Budapest in 2007.

He was the recipient of the John Bates Clark Medal in 2005, awarded every two years to the best economist in the United States under the age of 40 by the American Economic Association, and the Erwin Plein Nemmers prize awarded every two years for work of lasting significance in economics. He holds Honorary Doctorates from the University of Utrecht, Bosporus University, and the University of Athens.

Daron Acemoglu’s areas of research include political economy, economic development and growth, human capital theory, growth theory, innovation, search theory, network economics and learning. His recent research focuses on the political, economic and social causes of differences in economic development across societies; the factors affecting the institutional and political evolution of nations; and how technology impacts growth and distribution of resources and is itself determined by economic and social incentives. In addition to scholarly articles, Daron Acemoglu has published four books: *Economic Origins of Dictatorship and Democracy* (joint with James A. Robinson), which was awarded the Woodrow Wilson and the William Riker prizes, *Introduction to Modern Economic Growth, Why Nations Fail: The Origins of Power, Prosperity, and Poverty* (joint with James A. Robinson), which was a New York Times bestseller in 2012; and *Principles of Economics* (joint with David Laibson and John List).

http://economics.mit.edu/faculty/acemoglu/index.htm

https://mitsloan.mit.edu/faculty/directory/daron-acemoglu

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FCC TAC AIWG Presentation: May 12th, 2022

Marco Leto Barone Policy Manager – Europe at ITI - The Information Technology Industry Council

Talk Title: **“The European Union’s Artificial Intelligence (AI) Act”**

Biography: Marco Leto Barone, Policy Manager – Europe at ITI

Marco joined ITI as a Policy Fellow in March 2019 and now works as a Manager of Policy on ITI’s Brussels team. Before joining ITI, Marco worked on tech policy as a Blue book trainee at the European Commission’s DG CNECT in Luxembourg. Prior to that, he interned at the Brussels office of the consultancy firm Brunswick Group, where he focused on EU public affairs, technology, consumer issues and financial services. Marco has a background in EU Affairs, and he studied at the University of Groningen in the Netherlands, at the University of Deusto in Spain and at the University of Bologna in Italy.

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FCC TAC AIWG Presentation: July 21st, 2022

Kathy Baxter
Principal Architect
Ethical AI Practice at Salesforce

Talk Title: **“Salesforce Ethical AI Maturity Model”**

Biography: Kathy Baxter, Principal Architect, Ethical AI Practice at Salesforce.

As a Principal Architect of Ethical AI Practice at Salesforce, Kathy Baxter develops research-informed best practice to educate Salesforce employees, customers, and the industry on the development of responsible AI. She collaborates and partners with external AI and ethics experts to continuously evolve Salesforce policies, practices, and products. She is also a member of Singapore’s Advisory Council on the Ethical Use of AI and Data.

Prior to Salesforce, she worked at Google, eBay, and Oracle in User Experience Research. She received her MS in Engineering Psychology and BS in Applied Psychology from the Georgia Institute of Technology. She is the co-author of "Understanding Your Users: A Practical Guide to User Research Methodologies." You can read about the Ethics AI Practice Team's current research at salesforceairesearch.com/trusted-ai and follow her on Twitter at @baxterkb.

https://www.linkedin.com/in/kathykbaxter/

https://www.salesforce.com/in/blog/authors/kathy-baxter

FCC TAC AIWG Presentation: November 10th, 2022

Goutham Belliappa, Managing Director AI and Data Engineering, Deloitte Consulting LLP

Talk Title: **"Safe Use of AI and ML: Security/Reliability, Implications of an increasingly SDN/NFV World and with a particular emphasis on 5G"**

Biography: Goutham Belliappa, Managing Director AI and Data Engineering, Deloitte Consulting LLP

Goutham has a 20-year track record of Value Creation & Risk Mitigation with Data and AI by modernizing ecosystems in Telecommunications, Media, Technology and other sectors. He has helped clients realize over $2B in value by transforming Network Operations, Security, Labor, Sales, Marketing, Field Operations, Call Center, and Technology functions to be data driven. Goutham is known for his ability to help seamlessly Data and AI into Business Process & Policy enhancements. As a thinker, inventor, thought leader, speaker, and author on AI, Cognitive, Big Data, Business Intelligence, Analytics, and Cloud based Business Analytics, Goutham has delivered projects, presentations and written several published articles and helped clients create industry leading innovations that have resulted in patents with Goutham named on several of them.

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FCC TAC AIWG Presentation: August 24th , 2022

Aeva Black, Open-Source Hacker, Azure Office of the CTO, Microsoft, and Board Member Open-Source

Initiative (OSI)

Panel Moderator - Title: **"AI/ML Safe Uses – Open-Source Discussion"**

Biography: Aeva Black, Open-Source Hacker, Azure Office of the CTO, Microsoft, and Board Member Open-Source Initiative (OSI).

Aeva Black Is An Incurably Queer Geek, Open-Source Hacker, And A Dot-Com Veteran With A 20+ Year Career Spanning Several Startups And Fortune 500 Companies, Including HPE, IBM, And Microsoft. Their Areas Of Expertise Include Open-Source Strategy And Community Management, Containers, Databases, Bare Metal Orchestration, And Security. Aeva Currently Works In Azure's Office Of The CTO And Hold Seats On The Board Of The Open-Source Initiative, On The OpenSSF's Technical Advisory Council, And A Shadow Seat On The Board Of The Cloud Native Computing Foundation. In A Previous Life, Aeva Was The Founding Member And Technical Lead Of The OpenStack Ironic Project, And Held Seats On The OpenStack Technical Committee, The Kubernetes Code Of Conduct Committee, And On The Board Of The Consent Academy. Aeva Is A Frequent Keynote Speaker At Open-Source Conferences Around The World, Advocating To Make Technology More Ethical And Inclusive, And A Lifelong Student Of The Buddha Dharma. They Are Also An Aspiring Writer Whose Recent Works Include Contributing To "Transcending: An Anthology Of Trans Buddhist Voices" (2019) and Being The Technical Editor For "Trust In Computer Systems And The Cloud" (2021).

https://www.linkedin.com/in/aevaonline/

https://swampup.jfrog.com/speaker/aeva-black/

https://github.com/AevaOnline

FCC TAC AIWG Presentation: August 3rd , 2022

Mic Bowman, Senior Principal Engineer, Trusted Distributed Systems, Intel Labs, Boise ID

Talk Title: **“Blockchain and AI: A few random thoughts”**

Biography: Mic Bowman, Senior Principal Engineer, Intel Labs

Mic Bowman is a principal engineer in Intel Labs and leads the Virtual World Infrastructure research project. His team develops technologies that enable “order of magnitude” scalability improvements in virtual environments opening the door to new levels of immersiveness and interaction among players.

Bowman received his BS from the University of Montana, and his MS and PhD in Computer Science from the University of Arizona. He joined Intel Labs in 1999 to work on Internet services for search. While at Intel, He developed personal information retrieval applications, context-based communication systems, and middleware services for mobile applications. In addition, he led the team that built and deployed the first version of Planet Lab, a global testbed for networking research (awarded Scientific Americans Top 50 technologies in 2003). Prior to joining Intel, he worked at Transarc Corp. where he led research teams at that developed distributed search services for the Web, distributed file systems, and naming systems.

https://www.linkedin.com/in/mic-bowman-7276703/

https://www.intel.com/content/www/us/en/research/researchers/mic-bowman.html

FCC TAC AIWG Presentation: June 15th , 2022

Charles Clancy, Senior Vice President, General Manager, MITRE Labs, Chief Futurist

Talk Title: **"Why AI Must be a Fundamental Building Block of NextG"**

Biography: Charles Clancy, General Manager, MITRE Labs

Charles Clancy is senior vice president, general manager of MITRE Labs, and chief futurist. He is responsible for sparking innovative disruption, accelerating risk-taking and discovery, and delivering real-time technology capabilities and execution through the company's laboratories, solution platforms, and MITRE Fellows program. He leads technical innovation to anticipate and meet the future demands of government sponsors and industry and academic partners.

Clancy is an internationally recognized expert on topics at the intersection of wireless, cybersecurity, and artificial intelligence.

Before joining MITRE in 2019 as vice president for intelligence programs, Clancy served as the Bradley Distinguished Professor in Cybersecurity at Virginia Tech and executive director at the Hume Center for National Security and Technology. There, he led Virginia Tech's research and experiential learning programs in defense and intelligence.

He started his career at the National Security Agency, filling a variety of research, engineering, and operations roles, with a focus on wireless communications. He has co-authored more than 250 patents and academic publications, as well as six books. He co-founded several venture-backed security startup companies that apply commercial innovation to national security challenges.

Clancy is an IEEE Fellow and sits on the AFCEA International Board of Directors' Executive Committee, the AFCEA Intelligence Committee, the Intelligence and National Security Alliance Advisory Committee, the Systems Engineering Research Center Advisory Board, the Alliance for Telecommunications Industry Solutions Next G Alliance, and the Center for New American Security Task Force on Artificial Intelligence and National Security. He also serves on advisory boards at Howard University, Norfolk State University, North Carolina A&T State University, and Virginia Tech. In 2021, *WashingtonExec* magazine named Clancy one of the nation's Top Climate Executives to Watch.

Clancy holds a bachelor's degree in computer engineering from the Rose-Hulman Institute of Technology, a master's degree in electrical engineering from the University of Illinois at Urbana-Champaign, and a doctorate in computer science from the University of Maryland, College Park.

https://www.linkedin.com/in/clancytc/

https://www.mitre.org/about/leadership/executive/charles-clancy

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FCC TAC AIWG Presentation: September 28th , 2022

BJ Daisey
Senior Vice President, Emerging Experiences, Comcast

Talk Title: **"Leveraging Infostructure, AI/ML and Digital Experience: Bringing Digital Experience to Life"**

Biography: B.J. Daisey, Senior Vice President, Emerging Experiences, Comcast

BJ Daisey is a 23-year Comcaster who brings vast leadership experience from Technical Operations to Digital Product Experience – having led various experience, technical, and product teams across the country.

During his tenure with Comcast, BJ has led teams in six states, three Divisions, including roles at Comcast HQ bringing a broad and diverse knowledge of business and processes. BJ currently leads a team responsible for accelerating innovation and building transformative, personalized, proactive, cross-product digital experiences at scale. In addition, BJ and team have direct oversight of the platform that powers the Xfinity Assistant – Comcast's always-on virtual assistant that lets you get personalized, guided help as well as the product strategy for MDU product solutions. His role involves close collaboration with various stakeholders, providing product strategy and platform capabilities to support company-wide business needs and driving an exceptional customer experience.

With over 20 years of telecommunications, technology, and service industry experience, BJ offers a fresh perspective and strategic direction for operations and product teams and is a true "servant leader" who leads by example, inspiring excellence and leading effectively with one shared goal – make decisions through the eyes of the customer.

BJ is a graduate of Comcast's Highly Technical Leadership (HTLM) executive leadership program and a member of SCTE, WICT, and Comcasts Young Professionals' network (YPN). BJ also served on the board of the Boys and Girls Club of America in Sacramento, California. While BJ's passion at work is centered around technology and operational leadership, when not working, BJ is an avid sports fan, enjoys trying new recipes in the kitchen, and most of all spending time with his family.

https://www.linkedin.com/in/bj-daisey-8397034/

FCC TAC AIWG Presentation: April 27th, 2022

Talk Title: **"Leveraging AI/ML in Radio Access Networks (RAN)"**

Ayodele Damola
Director
AI/ML Strategy at
Ericsson
Plano TX

Biography: Ayodele Damola is the Director of AI/ML Strategy at Ericsson

Ayodele has 17+ years of experience in the telecommunications industry. He works in the MANA CTO Office focusing on driving the AI/ML strategy for North America looking into key market and technology trends in AI/ML and identifying business opportunities and threats.

Previously Ayodele worked in Ericsson Research in Kista, Sweden. He is an inventor with 18 granted US patents.

He holds a Master of Science degree in Computer Networks from the Royal Institute of Technology (KTH) Sweden and has completed professional development programs at Harvard and McGill universities.

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FCC TAC AIWG Presentation: May 25th, 2022

Professor Randall Davis, CSAIL (Computer Science and Artificial Intelligence Laboratory, MIT

Talk Title: **“Artificial Intelligence: What it Can and Can’t Do (Yet)”**

Biography: Prof. Randall Davis, CSAIL, MIT

Randall Davis received his undergraduate degree from Dartmouth, graduating summa cum laude, Phi Beta Kappa in 1970, and received a PhD from Stanford in artificial intelligence in 1976. He joined the faculty of the Electrical Engineering and Computer Science Department at MIT in 1978 where he held an Esther and Harold Edgerton Endowed Chair (1979-1981).

He has been a Full Professor in the Department since 1989. He has served as Associate Director of MIT's Artificial Intelligence Laboratory (1993-1998), as a Research Director of CSAIL from 2003-2007, and as Associate Director of CSAIL from 2012-2014.

Dr. Davis has been a seminal contributor to the fields of knowledge-based systems and human-computer interaction, publishing some more than 100 articles and playing a central role in the development of several systems. He and his research group are developing advanced tools that permit natural multi-modal interaction with computers by creating software that understands users as they sketch, gesture, and talk.

He is the co-author of *Knowledge-Based Systems in AI*. In 1990 he was named a Founding Fellow of the Association for the Advancement of AI and in 1995 was elected to a two-year term as its President. From 1995-1998 he served on the Scientific Advisory Board of the U. S. Air Force, earning the USAF Decoration for Exceptional Civilian Service.

Dr. Davis has also been active in the area of intellectual property and software. In 1990 he served as expert to the Court in Computer Associates v. Altai, a case that produced the abstraction, filtration, comparison test now widely used in software copyright cases.

From 1998 to 2000 he served as the chairman of the U.S. National Academy of Sciences study on intellectual property rights and the information infrastructure entitled The Digital Dilemma: Intellectual Property in the Information Age, published by the National Academy Press in February 2000.

https://www.csail.mit.edu/person/randall-davis

FEDERAL COMMUNICATIONS COMMISSION · USA ·

FCC TAC AIWG Presentation: October 26th, 2022

Mischa Dohler, Chief Architect, Ericsson Inc., Silicon Valley

Talk Title: **"Primer on AI, AI in 5G/6G Networks, and Stanford Human-Centric AI Takeaways"**

Biography: Mischa Dohler, Chief Architect, Ericsson Inc., Silicon Valley

Mischa Dohler is the Chief Architect at Ericsson Inc. in Silicon Valley, working on cutting-edge topics of 6G, Metaverse, XR, Quantum and Blockchain. He serves on the Technical Advisory Committee of the FCC and on the Spectrum Advisory Board of Ofcom.

He is a Fellow of the IEEE, the Royal Academy of Engineering, the Royal Society of Arts (RSA), the Institution of Engineering and Technology (IET); and a Distinguished Member of Harvard Square Leaders Excellence. He is a serial entrepreneur with 5 companies; composer & pianist with 5 albums on Spotify/iTunes; and fluent in several languages. He has had ample coverage by national and international press and media and is featured on Amazon Prime.

He is a frequent keynote, panel and tutorial speaker, and has received numerous awards. He has pioneered several research fields, contributed to numerous wireless broadband, IoT/M2M and cyber security standards, holds a dozen patents, organized and chaired numerous conferences, was the Editor-in-Chief of two journals, has more than 300 highly-cited publications, and authored several books. He is a Top-1% Cited Innovator across all science fields globally.

He was Professor in Wireless Communications at King's College London and Director of the Centre for Telecommunications Research from 2013-2021, driving cross-disciplinary research and innovation in technology, sciences and arts. He is the Cofounder and former CTO of the IoT-pioneering company Worldsensing; cofounder and former CTO of the AI-driven satellite company SiriusInsight.AI, and cofounder of the sustainability company Movingbeans. He also worked as a Senior Researcher at Orange/France Telecom from 2005-2008.

https://www.linkedin.com/in/mischadohler/

https://mischadohler.com/about/

https://en.wikipedia.org/wiki/Mischa_Dohler

FCC TAC AIWG Presentation: August 10th , 2022

Masoud Farschian, Lead Signal Processing Engineer, Mitre

Talk Title: **“Machine Learning Based Enhanced Clutter Model”**

Biography: Masoud Farschian, Lead Signal Processing Engineer, Mitre

Masoud Farshchian obtained his Bachelor of Science in Electrical Engineering and minor in mathematics from Rutgers University in the year 2000. From 2000 to 2001, he worked as a systems engineer in Motorola Corporation. In 2001, he entered graduate school in Rensselaer Polytechnic Institute and obtained a master’s in electrical engineering in 2003, a master’s in applied mathematics in 2005 and his Ph.D. in Electrical Engineering in 2007. He has a combined 15 years of experience in radar and wireless communications including 5 years in the Radar Division of the Naval Research Laboratory, and 2 years in the John Hopkins Applied Physics Laboratory. His general interest is in the field of signal processing and machine learning with recent specific focus on sensor-to-sensor and sensor-to-communications spectrum sharing, electronic protection, geolocation, propagation modeling and anomaly detection. He has also been active in research and development of maritime detection and classification radars, inverse synthetic aperture radars, bi-static radars, sea and bird radar clutter modeling, image and video processing, sparse signal processing, and wireless communications performance modeling. Since June2021, he is a teleworker for the MITRE Corporation based in Englewood Cliffs, New Jersey.

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FCC TAC AIWG Presentation: April 20th, 2022

Bob Friday
Chief AI Officer
Juniper

Talk Title: **"AI Operations for the Future of Networking"**

- **Biography:** Bob is the CTO and co-founder of Mist Systems, a Juniper Company. He is currently Junipers' Chief AI Officer.

  Bob started his career in wireless at Metricom (Ricochet wireless network) developing and deploying wireless mesh networks across the country to connect the first generation of Internet browsers. After Metricom, Bob co-founded Airespace, a start-up focused on helping enterprises manage the flood of employees bringing unlicensed Wi-Fi technology into their businesses. Following Cisco's acquisition of Airespace in 2005, Bob became the VP/CTO of Cisco enterprise mobility and drove mobility strategy and investments in the wireless business (e.g., Navini, Cognio, ThinkSmart, Phunware, Wilocity, Meraki). He also drove industry standards such as Hot Spot 2.0 and market efforts such as Cisco's Connected Mobile Experience. He holds more than 15 patents.

FCC TAC AIWG Presentation: August 24th , 2022

Sal Kimmich, Open-Source Developer Advocate Sonatype, and Host of the Present Dev Podcast.

Panelist - Title: **"AI/ML Safe Uses – Open-Source Discussion"**

Biography: Sal Kimmich, Open-Source Developer Advocate Sonatype, and Host of the Present Dev Podcast.

Sal is a developer advocate for open source at Sonatype and passionate about helping engineers, ethical hackers and digital enthusiasts understand the complexity of modern software development. With over a decade of experience as building cloud-native machine learning pipelines in the healthcare and tech for good sectors, their work is now focused on filling the cracks in the open-source software supply chain to build a better digital future for all of us. By day, you'll find Sal working with site reliability engineers, DevOps and cybersecurity specialists to implement best tools and practices to remove toil from developer workflows. By night, you'll find Sal mentoring the next generation of engineers in cloud computing from around the globe, helping them to make the world a better place through the clever use of math and tech policy.

https://www.linkedin.com/in/salkimmich/

https://blog.sonatype.com/meet-an-open-source-contributor-sal-kimmich

https://github.com/Salkimmich

FCC TAC AIWG Presentation: May 12th, 2022

Guido Lobrano
Senior VP and Director General for Europe at ITI - The Information Technology Industry Council

Talk Title: **"The European Union's Artificial Intelligence (AI) Act"**

Biography: Guido Lobrano is the Senior Vice President of Policy, Director General for Europe at ITI

Guido Lobrano is ITI's Senior Vice President of Policy and Director General for Europe, leading ITI's work on the European Union's activities impacting technology and innovation. Guido is based in Brussels, Belgium, where he opened ITI's first office in Europe. He coordinates ITI's work on EU initiatives in areas such as privacy, cybersecurity, artificial intelligence and data, competition policy and platform issues, and supports the work on digital trade and taxation.

Before joining ITI in October 2017, Guido was deputy director for legal affairs, internal market and digital economy at BusinessEurope, the confederation of European industry. He was in charge of digital and tech policy, as well antitrust and state aid legislation. He also coordinated the team responsible for single market policy.

He led the association's advocacy on Europe's i2010 Strategy and the Digital Agenda for Europe (2012), as well as the 2015 Digital Single Market (DSM) and Digitizing European Industry strategies. He was in charge of privacy and data issues, e-commerce, sharing economy and platforms among others. He covered key legal and policy debates from a cross-sectoral industry perspective, including the 2008-2009 EU Telecoms Review, collective redress (EU-level class action schemes), the process leading to the General Data Protection Regulation (GDPR), the transition from the EU-US Safe Harbor to Privacy Shield.

Guido began his professional career working in law firms in the United States, France, Italy and Belgium, on international and EU law. He is a frequent speaker on a variety of topics, particularly technology and competition policies. He received his law degree in Italy at the University of Sassari and an Erasmus diploma from the University of Vienna.

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FCC TAC AIWG Presentation: August 24th , 2022

Peter Mattson, President, MLCommons, and Senior Staff Engineer at Google

Talk Title: **"MLCommons – An Introduction for the FCC"**

Biography: Peter Mattson, President, MLCommons and Senior Staff Engineer at Google

Peter Mattson co-founded and is President of MLCommons and co-founded and was General Chair of the MLPerf consortium that preceded it. Previously, he founded the Programming Systems and Applications Group at NVIDIA Research, was VP of software infrastructure for Stream Processors Inc (SPI) and was a managing engineer at Reservoir Labs. His research focuses on understanding machine learning models and data through quantitative metrics and analysis. Peter holds a PhD and MS from Stanford University and a BS from the University of Washington.

https://www.linkedin.com/in/peter-mattson-33b8863/

https://mlcommons.org/en/leadership/

FCC TAC AIWG Presentation: July 13th, 2022

Tommaso Melodia
Director, Institute for the Wireless Internet of Things, and William Lincoln Smith Professor at Northeastern University

Talk Title: **“AI/ML-based Control and Orchestration in the Open RAN: Architectures, Algorithms, and Testbeds”**

Biography: Tommaso Melodia,

- Tommaso Melodia is the William Lincoln Smith Chair Professor with the Department of Electrical and Computer Engineering at Northeastern University in Boston. He is also the Founding Director of the Institute for the Wireless Internet of Things and the Director of Research for the PAWR Project Office. He received his Laurea (integrated BS and MS) from the University of Rome - La Sapienza and his Ph.D. in Electrical and Computer Engineering from the Georgia Institute of Technology in 2007. He is an IEEE Fellow and recipient of the National Science Foundation CAREER award. He was named a College of Engineering Faculty Fellow in 2017 and received the Søren Buus Outstanding Research Award in 2018 - the highest research award in the College of Engineering at Northeastern University. Prof. Melodia has served as Associate Editor fo IEEE Transactions on Wireless Communications, IEEE Transactions on Mobile Computing, Elsevier Computer Networks, among others. He has served as Technical Program Committee Chair for IEEE Infocom 2018, General Chair for IEEE SECON 2019, ACM Nanocom 2019, and ACM WUWnet 2014. Prof. Melodia is the Director of Research for the Platforms for Advanced Wireless Research (PAWR) Project Office, a $100M public-private partnership to establish 4 city-scale platforms for wireless research to advance the US wireless ecosystem in years to come. The PAWR Project Office is co-lead by Northeastern University and US Ignite and is overseeing the overall deployment and operation of the PAWR Program. Prof. Melodia’s research on modeling, optimization, and experimental evaluation of Internet-of-Things and wireless networked systems has been funded by the National Science Foundation, the Air Force Research Laboratory the Office of Naval Research, DARPA, and the Army Research Laboratory.

https://www.linkedin.com/in/tommasomelodia/

https://ece.northeastern.edu/wineslab/tmelodia.php

FCC TAC AIWG Presentation: July 20th, 2022

Yoav Miche, Head of Network Security Research at Nokia Bell Labs, Finland

Talk Title: **“Trustworthy AI in 5G-A and 6G Networks: Security and Management”**

Biography: Yoav Miche PhD, Head of Network Security Research at Nokia Bell Labs

Yoan is currently the head of the Network Security research team in Nokia Bell Labs. He received a double M.Sc. degree in Telecoms and Signal/Image processing from the ENSIMAG and Gipsa Lab, France. He received a double degree Ph.D. in Applied Machine Learning (for watermarking and steganography) from Aalto University, Finland (then Helsinki University of Technology) and the INP Grenoble, France. He was a postdoctoral researcher on industry collaboration projects during 4 years at Aalto University, mainly focusing on applications of machine learning to (cyber)security problems. He joined Nokia Research (now Bell Labs) Finland in 2014 as a cybersecurity researcher and took the lead of the cybersecurity research team in 2018. His topics of predilection include neural networks, anomaly detection, data mining, network security, and he is still fascinated by watermarking and steganography technologies. He was Associate Editor for Elsevier's Neurocomputing from 2012 to 2021, and now serves as a member of the Advisory Board for the journal. He is also on the editorial board (and one of the co-founders) of the Machine Learning and Knowledge Extraction (MAKE) journal. He has been on the Advisory and Stakeholder Boards of several EU projects, recently including the SHERPA project (on the Ethics of AI/ML) and the SAPPAN project (on the sharing and automation of security knowledge).

https://www.linkedin.com/in/yoan-miche-5842533b/?originalSubdomain=fi

https://www.bell-labs.com/about/researcher-profiles/yoanmiche/#gref

FCC TAC AIWG Presentation: September 28th , 2022

Elad Nafshi, Executive Vice President, Chief Network Officer, Comcast Cable

Talk Title: **“Leveraging Infostructure, AI/ML and Digital Experience: A Brilliant Network Comcast’s Path to 10G”**

Biography: Elad Nafshi, Executive Vice President, Chief Network Officer, Comcast Cable

Elad Nafshi serves as Executive Vice President, Chief Network Officer for Comcast Cable. In this role, he leads the unified core and access network teams that drive innovation, reliability, scalability, and development across our network capabilities. Elad drives strategy for the nation’s largest gigabit Internet network and is a global leader in 10G technology, which will allow Comcast to deliver multigigabit upload and download speeds to tens of millions of Americans.

Elad joined Comcast in 2005 and has held several network, product development and management roles at Comcast since that time. He has led a number of high-profile initiatives around Next Generation Access Network, Cloud TV, Cloud DVR Interactive Television, Addressable Advertising, Digital Set-Top-Boxes, On-Screen Guides and other key programs.

Prior to joining Comcast, Elad led the product management and development group of RCN Corporation, a regional high speed internet service, digital cable TV, and home phone service provider, where he enabled the then-startup to capture share and consumer awareness against much larger competitors.

Elad graduated from The Buchmann School of Law at Tel Aviv University in Israel with a focus on corporate and international law. He also holds a master's in business from the William E. Simon Graduate School of Business Administration at the University of Rochester in New York, where he specialized in electronic commerce and finance.

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FCC TAC AIWG Presentation: September 28th , 2022

Michael Regan, Vice President, Business Performance Standards, Telecommunications Industry Association (TIA)

Talk Title: **"Conceptual Application of AI/ML to Certifiable QMS and Supply Chain Security Standards"**

Biography: Michael Regan, Vice President, Business Performance Standards, Telecommunications Industry Association (TIA)

Michael (Mike) Regan is responsible for the activities of the Telecommunication Industry Association's (TIA) QuEST Forum Community with a focus on business performance improvement standards and associated activities for the ICT industry.

Prior to joining TIA, Mike had a 30+ year career as an engineering and product development leader responsible for the delivery of complex communications and networking products. Mike has serviced the demanding needs of operators of business-critical production networks of premier public service providers, global cloud platforms, large enterprises and customer engagement centers.

Mike leverages his personal experiences in leading the initiatives of the TIA QuEST Forum by working with Forum participants, network operators, suppliers, government agencies and industry peers towards the development and adoption of new standards for the ICT industry with an emphasis on product quality, cyber security, supply chain security and secure software development.

https://tiaonline.org/staff-members/mike-regan/

FEDERAL COMMUNICATIONS COMMISSION · USA ·

FCC TAC AIWG Presentation: August 10th , 2022

Tony Rennier, CEO and Founder, Foundry Inc.

Talk Title: **"Machine Learning Based Enhanced Clutter Model"**

Biography: Tony Rennier, CEO and Founder, Foundry Inc.

Mr. Rennier is the founder and CEO of Foundry Inc., a spectrum engineering consulting firm that provides technical expertise, oversight, and guidance on technical issues related to spectrum sharing for spectrum communities of interest. He is currently the Chief Engineer for the AWS-3 Spectrum Sharing Test and Demonstration (SSTD) program which is operated by the Defense Information Systems Agency's Defense Spectrum Organization (DSO).

Before his work on SSTD, Mr. Rennier served as a lead technical contributor for DSO's Advanced Access Initiatives branch, working on several initiatives including Commercial Broadband Radio Service. As an information technology professional, he served as the Chief Architect for DSO's Global Electromagnetic Spectrum Information System program. Prior to his work in spectrum engineering, Mr. Rennier founded and ran two software products, services, and training firms.

Mr. Rennier is an active member of the IEEE Dynamic Spectrum Access Networks Standards Committee (DySPAN-SC). He is the current Chair of P1900.5, the Policy Language and Architectures for Managing Cognitive Radio for Dynamic Spectrum Access Applications working group.

His education includes a Bachelor of Electrical Engineering degree from Southern Illinois University, located in Edwardsville Illinois, and a Master of Electrical Engineering degree from the University of Illinois in Urbana Illinois.

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FEDERAL COMMUNICATIONS COMMISSION · USA ·

FCC TAC AIWG Presentation: June 8th , 2022

Professor Stuart Russell, Electrical Engineering and Computer Sciences, UC Berkeley

Talk Title: **“Artificial Intelligence and Machine Learning”**

Biography: Prof. Stuart Russell, EECS, UC Berkeley

Stuart Russell received his B.A. with first-class honors in physics from Oxford University in 1982 and his Ph.D. in computer science from Stanford in 1986. He then joined the faculty of the University of California at Berkeley, where he is Professor (and formerly Chair) of Electrical Engineering and Computer Sciences and holder of the Smith-Zadeh Chair in Engineering. He is also an Adjunct Professor of Neurological Surgery at UC San Francisco and Vice-Chair of the World Economic Forum's Council on AI and Robotics.

Russell is a recipient of the Presidential Young Investigator Award of the National Science Foundation, the IJCAI Computers and Thought Award, the World Technology Award (Policy category), the Mitchell Prize of the American Statistical Association and the International Society for Bayesian Analysis, the ACM Karlstrom Outstanding Educator Award, and the AAAI/EAAI Outstanding Educator Award. In 1998, he gave the Forsythe Memorial Lectures at Stanford University and from 2012 to 2014 he held the Chaire Blaise Pascal in Paris. He is a Fellow of the American Association for Artificial Intelligence, the Association for Computing Machinery, and the American Association for the Advancement of Science.

His research covers a wide range of topics in artificial intelligence including machine learning, probabilistic reasoning, knowledge representation, planning, real-time decision making, multitarget tracking, computer vision, computational physiology, global seismic monitoring, and philosophical foundations. His books include "The Use of Knowledge in Analogy and Induction", "Do the Right Thing: Studies in Limited Rationality" (with Eric Wefald), and "Artificial Intelligence: A Modern Approach" (with Peter Norvig). His current concerns include the threat of autonomous weapons and the long-term future of artificial intelligence and its relation to humanity.

https://www2.eecs.berkeley.edu/Faculty/Homepages/russell.html

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FCC TAC AIWG Presentation: July 20th, 2022

Henning Sanneck, Manager, Network Automation Research, NOKIA Standards, Munich, Germany

Talk Title: **"Trustworthy AI in 5G-A and 6G Networks: Security and Management"**

Biography: Dr. Henning Sanneck, Manager, Network Automation Research

Henning Sanneck is Manager, Network Automation Research in the Standards unit of Nokia Strategy & Technology, Munich, Germany. He received his Dr.-Ing. (PhD) degree in Electrical Engineering from the Technical University of Berlin with a thesis on Voice over IP QoS in 2000. Then, Henning joined Siemens - Mobile Networks as a Senior Research Engineer, becoming an Innovation Project Manager in Radio Network Management in 2003. In 2007, at the formation of Nokia Siemens Networks, he started to lead a line team driving Self Organizing Networks (SON) concepts, IPR and demos for LTE using policy-based management technologies. Since 2009, Henning and his team have been working on applying and adapting analytics and machine learning technologies to Radio Network Management (in particular for anomaly detection and diagnosis) using network data- and simulation-based approaches. In 2014/15, as "Head of Cognitive Network Management" for Nokia Networks Research, he has also acted as the coordinator of the research & standardization work in that technical area which included the strategy development and technology transfer supervision. Henning's team has been continuously involved in nationally (BMBF) and internationally (EU) funded research projects.

His current research interests are in (Beyond) 5G Network Management and Orchestration, in particular configuration, healing and the operation of Cognitive Functions in virtualized, sliced radio access networks (across public and private deployment scenarios). Henning has published 80 papers and has 30 patents granted or published. He has been co-editor and -author of the book "LTE Self-Organizing Networks" (2011) and co-author of the book "Towards Cognitive Autonomous Networks" (2020).

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FCC TAC AIWG Presentation: August 10th , 2022

Mahadev Satyanarayanan, Carnegie Group University Professor of Computer Science, Carnegie Mellon University

Talk Title: **“The Seminal Role of Edge-Native Applications”**

Biography: Mahadev Satyanarayanan, Carnegie Group University Professor of Computer Science, Carnegie Mellon University

Satya’s multi-decade research career has focused on the challenges of performance, scalability, availability and trust in information systems that reach from the cloud to the mobile edge of the Internet. In the course of this work, he has pioneered many advances in distributed systems, mobile computing, pervasive computing, and the Internet of Things (IoT). Most recently, his seminal 2009 publication “The Case for VM-based Cloudlets in Mobile Computing” and the ensuing research has led to the emergence of Edge Computing. Satya is the Carnegie Group University Professor of Computer Science at Carnegie Mellon University. He received the PhD in Computer Science from Carnegie Mellon, after Bachelor's and Master's degrees from the Indian Institute of Technology, Madras. He is a Fellow of the ACM and the IEEE.

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http://www.cs.cmu.edu/~satya

https://en.wikipedia.org/wiki/Mahadev_Satyanarayanan

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FCC TAC AIWG Presentation: July 27th , 2022

Frank Schirrmeister, Senior Group Director, Solutions & Ecosystems, Cadence

Talk Title: **“Enabling AI/ML semiconductor and system design and the role of Ai/ML in increasing development productivity”**

Biography: Frank Schirrmeister, Senior Group Director, Solutions & Ecosystem, Cadence

Frank Schirrmeister is senior group director, solutions & ecosystem at Cadence, where he leads a team translating customer challenges in the hyperscale, communications, consumer, automotive, aerospace/defense, industrial, and healthcare vertical domains into specific requirements and solutions. His team focuses on cross-product technical solutions such as 5G, artificial intelligence, machine learning, safety, security, and digital twins, as well as partner collaborations.

Frank holds a Dipl.-Ing. in electrical engineering from the Technical University of Berlin, Germany. Prior to joining Cadence, Frank held senior engineering and product management positions in embedded software, semiconductor, and system development, both in Europe and the United States.

https://resources.pcb.cadence.com/authors/frank-schirrmeister

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FCC TAC AIWG Presentation: November 9th, 2022

George Stantchev, Senior Computer Scientist, Naval Research Laboratory (NRL)

Talk Title: **“Machine Learning for Cognitive Radio Networks”**

Biography: George Stantchev, Senior Computer Scientist, Naval Research Laboratory (NRL)

Dr. Stantchev is a Senior Computer Scientist at the Naval Research Laboratory (NRL). He received his Ph.D. in Applied Mathematics and Scientific Computation from the University of Maryland in 2003. Before joining NRL in 2011, he spend several years as postdoctoral research scientist at the University of Maryland’s Center for Scientific Computation and Mathematical Modeling (CSCAMM), as well as a research scientist at Leidos (formerly SAIC).

Dr. Stantchev has been leading or is actively involved in interdisciplinary research on a variety of topics, including signal processing, electromagnetic modeling and simulation, nonlinear device characterization, machine learning, neuromorphic computing, and decentralized autonomous multi-agent systems, among others. He has served as co-organizer of multiple workshops and symposia, as well as guest editor of special journal issues, on machine learning for cognitive radio communications. He is a recipient of the NRL Review Award (2014), and NRL’s Annual Alan Berman Publication Award (2016, 2019, and twice in 2022).

https://www.linkedin.com/in/george-stantchev-bb53608/

https://scholar.google.com/citations?user=SwgNy2sAAAAJ&hl=en

FCC TAC AIWG Presentation: September 22nd , 2022

Elham Tabassi, Chief of Staff, Information Technology Laboratory, NIST

Talk Title: **"NIST AI Risk Management Framework (RMF)"**

Biography: Elham Tabassi, Chief of Staff, Information Technology Laboratory, NIST

Elham Tabassi is the Chief of Staff in the Information Technology Laboratory (ITL) at the National Institute of Standards and Technology (NIST). ITL, one of six research Laboratories within NIST, supports NIST's mission, to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life. ITL conducts fundamental and applied research in computer science and engineering, mathematics, and statistics that cultivates trust in information technology and metrology by developing and disseminating standards, measurements, and testing for interoperability, security, usability, and reliability of information systems.

As a scientist she has been working on various computer vision research projects with applications in biometrics evaluation and standards since 1999. She is the principal architect of NIST Fingerprint Image Quality (NFIQ) which is now an international standard for measuring fingerprint image quality and has been deployed in many large-scale biometric applications worldwide. She received the Department of Commerce Gold Medal in 2003, the Department of Commerce Bronze Medal in 2007, and 2010, ANSI's 2012 Next Generation Award, and the Women in Biometrics Award in 2016 for her contributions to biometrics. She is a member of OSAC Friction Ridge subcommittee and co-chairs FIDO Biometrics Certification working group.

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https://www.nist.gov/people/elham-tabassi

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FCC TAC AIWG Presentation: August 24th , 2022

Alek Tarkowski, Co-Founder Open Future Foundation and Board Member of Creative Commons

Panelist - Title: **“AI/ML Safe Uses – Open-Source Discussion”**

Biography: Alek Tarkowski, Co-Founder Open Future Foundation and Board Member of Creative Commons.

Alek is the Director of Strategy at Open Future. He has over 15 years of experience with public interest advocacy, movement building and research into the intersection of society, culture and digital technologies. He is a sociologist by training and holds a PhD in sociology from the Polish Academy of Science. In 2010 he established Centrum Cyfrowe, one of the leading Polish organizations promoting openness and internet users’ rights. He led Centrum Cyfrowe for ten years as the Director and President of the Board. Before founding Centrum Cyfrowe, he was a strategic advisor to the Prime Minister of Poland.

He co-authored a range of Polish strategic documents, including the strategic report “Poland 2030”, the “Digital Poland” strategy and the Polish official long-term strategy for growth. He advised as well multiple public institutions and civil society organizations on digital strategies and projects. Co-author, with Mirek Filiciak, of a collection of essays titled “Two zero. Alphabet of new culture and other texts”. Lecturer at Artes Liberales Faculty at University of Warsaw and SWPS University of Social Sciences and Humanities. Member of the Advisory Board of the Commonwealth Center for Connected Learning, School of Ideas SWPS and CoderDojo Polska.

https://www.linkedin.com/in/alek-tarkowski/

https://creativecommons.org/author/atarkowski/

FCC TAC AIWG Presentation: July 6th , 2022

JP Vasseur, Vice-President, Head of Engineering, Predictive Networks, and Cisco Fellow

Talk Title: **“Use cases for AI/ML in Telecommunications and Lessons Learned on developing AI/ML technologies at Scale.”**

Biography: JP Vasseur, Cisco Fellow (VP), Head of Engineering, Predictive Networks

JP Vasseur, PhD is a Cisco Fellow and lead of an engineering team developing products where he has been working on several networking technologies such as IP/MPLS, Quality of Service, Traffic Engineering, network recovery, PCE, “Internet of Things” (as the Chief Architect), Security, Wireless Networks since he joined Cisco in 1998. From 1992 to 1998, he worked for Service Providers in large multi-protocol environments, with a key focus on bringing cutting-edge innovation in shipping products.

JP has been an active member of the Internet Engineering Task Force (co-author of more than 35 IETF RFCs, funders and co-chair of several Working Groups such as the PCE and ROLL WG), and in several SDOs.

Since 2010, JP has been leading world class engineering teams of advanced networking and Analytics/Machine Learning (Self Learning Networks, Cloud-based Machine Learning) with key applications such as Security, network cognitive and predictive analytics for Enterprise Networks (wireless, LAN, WAN). JP is a regular speaker at various international conferences, he is involved in various research projects and the member of a few Technical Program Committees. JP Vasseur is also Associate Professor at Telecom Paris.

He is the (co)inventor of more than 500 patents in the area of IP/MPLS, Security, The Internet of Things and Machines Learning / Analytics (#1 inventor at Cisco), with large impact in Internet Technologies.

He is the coauthor of “Network Recovery” (Morgan Kaufmann, July 2004), “Definitive MPLS Network Designs” (Cisco Press, March 2005) and "Interconnecting Smart Object with IP: The Next Internet (Morgan Kaufmann, July 2010 - http://www.thenextinternet.org/).

JP received a PhD in Networking (Mines-Telecom Paris – France, a Master of Science in Computer Science (Steven - USA) and an engineering degree in computer Science (France).

https://www.linkedin.com/in/jp-vasseur-phd/?originalSubdomain=fr

https://www.youtube.com/watch?v=Jb8U1BrJlXo&ab_channel=TechFieldDay

https://newsroom.cisco.com/c/r/newsroom/en/us/a/y2019/m08/meet-cisco-s-top-inventor-jp-vasseur.html

FCC TAC AIWG Presentation: August 24th , 2022

Luis Villa, Co-founder and General Counsel Tidelift, and Founding Member

TechGC

Panelist - Title: **“AI/ML Safe Uses – Open-Source Discussion”**

Biography: Luis Villa, Co-founder and General Counsel Tidelift, and Founding Member TechGC.

Luis Villa is the co-founder and general counsel of Tidelift, a startup devoted to making open-source work better by supporting users and developers. Before Tidelift, he has had a varied career in open source, first in QA and engineering management, and then as an attorney at Mozilla, the Wikimedia Foundation, and Greenberg Traurig. At Columbia Law School, he was Editor-in-Chief of the Science and Technology Law Review and a Kent and Stone Scholar.

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https://lu.is/

https://en.wikipedia.org/wiki/Luis_Villa

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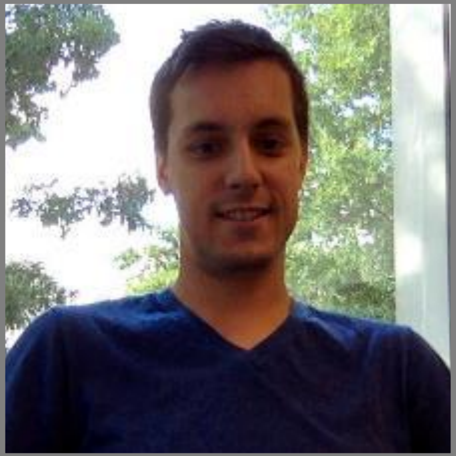
FCC TAC AIWG Presentation: August 24th , 2022



Nathan West, Director of Machine Learning at DeepSig Inc.

Talk Title: **"Benefits and Drawbacks of AI-native Spectrum Usage and Sharing"**

Biography: Nathan West, Director of Machine Learning, DeepSig Inc.

Nathan is a Principal Engineer at DeepSig responsible for transitioning deep learning models to broadly useable products solving wireless communications problems in novel ways. Prior to DeepSig he worked at the Naval Research Laboratory working on optimized software radio implementations on embedded platforms and cognitive radio.

https://www.linkedin.com/in/nathan-west

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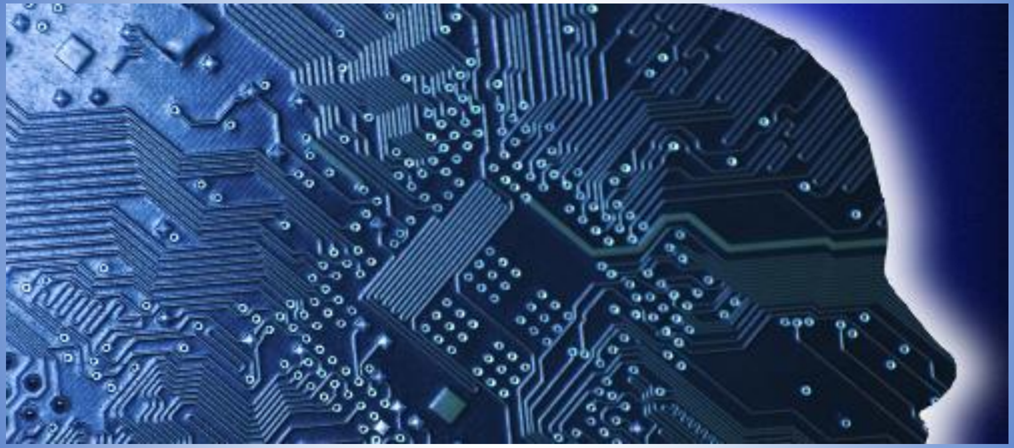
Bibliography

Artificial Intelligence
Machine Learning
Ethics and Social Impact



Bibliography

And Sources

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Sources

High Level Frameworks and Principles – ML Engineer

- AI & Machine Learning 8 principles for Responsible ML - The Institute for Ethical AI & Machine Learning has put together 8 principles for responsible machine learning that are to be adopted by individuals and delivery teams designing, building and operating machine learning systems.
- An Evaluation of Guidelines - The Ethics of Ethics - A research paper that analyses multiple Ethics principles
- Association for Computer Machinery's Code of Ethics and Professional Conduct - This is the code of ethics that has been put together in 1992 by the Association for Computer Machinery and updated in 2018. The Code is designed to inspire and guide the ethical conduct of all computing professionals, including current and aspiring practitioners, instructors, students, influencers, and anyone who uses computing technology in an impactful way. Additionally, the Code serves as a basis for remediation when violations occur. The Code includes principles formulated as statements of responsibility, based on the understanding that the public good is always the primary consideration.
- From What to How: An initial review of publicly available AI Ethics Tools, Methods and Research to translate principles into practices - A paper published by the UK Digital Catapult that aims to identify and present the gap between principles and their practical applications.

Sources

High Level Frameworks and Principles – ML Engineer

- European Commission's Guidelines for Trustworthy AI - The Ethics Guidelines for Trustworthy Artificial Intelligence (AI) is a document prepared by the High-Level Expert Group on Artificial Intelligence (AI HLEG). This independent expert group was set up by the European Commission in June 2018, as part of the AI strategy announced earlier that year.
- IEEE's Ethically Aligned Design - A Vision for Prioritizing Human Wellbeing with Artificial Intelligence and Autonomous Systems that encourages technologists to prioritize ethical considerations in the creation of autonomous and intelligent technologies.
- Montréal Declaration for a responsible development of artificial intelligence - ethical principles and values that promote the fundamental interests of people and group created as an initiative by Université de Montréal
- Oxford's Recommendations for AI Governance - A set of recommendations from Oxford's Future of Humanity institute which focus on the infrastructure and attributes required for efficient design, development, and research around the ongoing work building & implementing AI standards.
- PWC's Responsible AI - PWC has put together a survey and a set of principles that abstract some of the key areas they've identified for responsible AI.

Sources

High Level Frameworks and Principles – ML Engineer

•Singapore Data Protection Govt Commission's AI Governance Principles - The Singapore government's Personal Data Protection Commission has put together a set of guiding principles towards data protection and human involvement in automated systems and comes with a report that breaks down the guiding principles and motivations.

•Toronto Declaration Protecting the right to equality and non-discrimination in machine learning systems by access now.

•UK Government's Data Ethics Framework Principles - A resource put together by the Department for Digital, Culture, Media and Sport (DCMS) which outlines an overview of data ethics, together with a 7-principle framework.

•Algorithm charter for Aotearoa New Zealand - The Algorithm Charter for Aotearoa New Zealand is an evolving piece of work that needs to respond to emerging technologies and also be fit-for-purpose for government agencies.

•Montreal AI Ethics Institute State of AI Ethics June 2020 Report - A resource put together by the Montreal AI Ethics Institute that captures the most relevant research and reporting in the domain of AI ethics between March 2020 and June 2020.

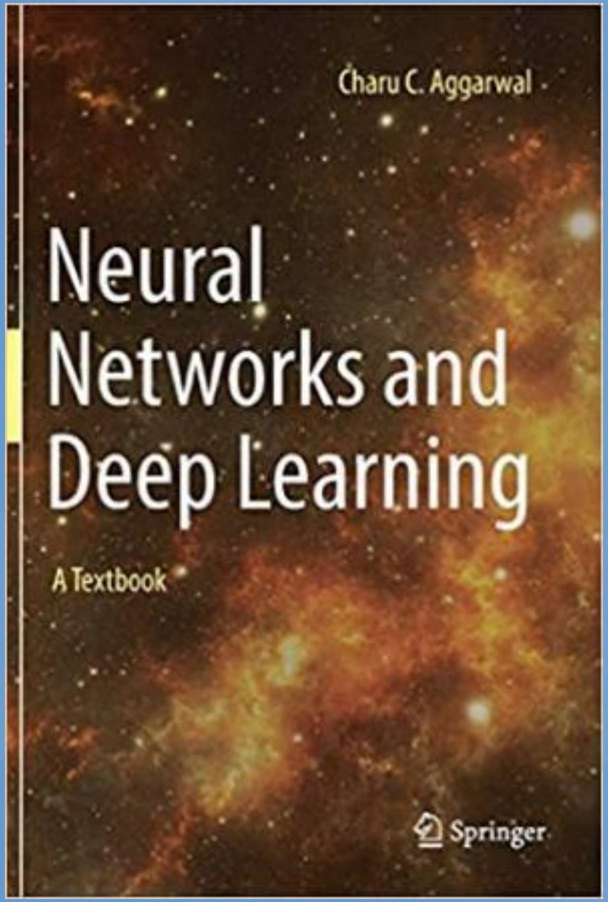
Sources

High Level Frameworks and Principles – ML Engineer

•Montreal AI Ethics Institute State of AI Ethics October 2020 Report - A resource put together by the Montreal AI Ethics Institute that captures the most relevant research and reporting in the domain of AI ethics between July 2020 and October 2020.
•Technical and Organizational Best Practices - A resource put together by Foundation for Best Practices in Machine Learning (FBPML) with technical guidelines (e.g., fairness and non-discrimination, monitoring and maintenance, data quality, product traceability, explainability) and organizational guidelines (e.g., data governance, product management, human resources management, compliance and auditing). Community contributions are welcome via the FBPML Wiki.
•Understanding artificial intelligence ethics and safety - A guide for the responsible design and implementation of AI systems in the public sector by David Leslie from the Alan Turing Institute.

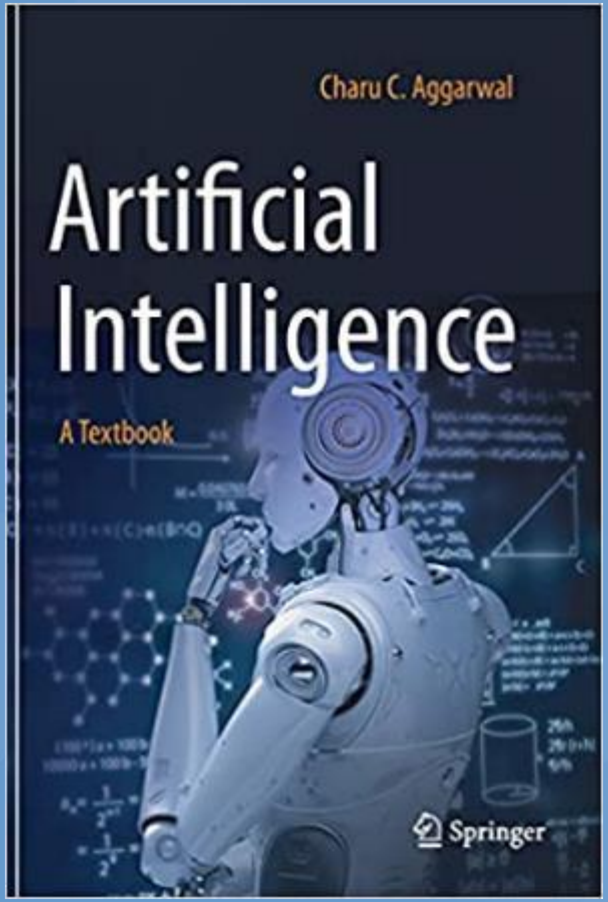
Source Link: https://github.com/EthicalML/awesome-artificial-intelligence-guidelines
Source Link: https://github.com/EthicalML/awesome-artificial-intelligence-guidelines#industry-standards-initiatives

Bibliography



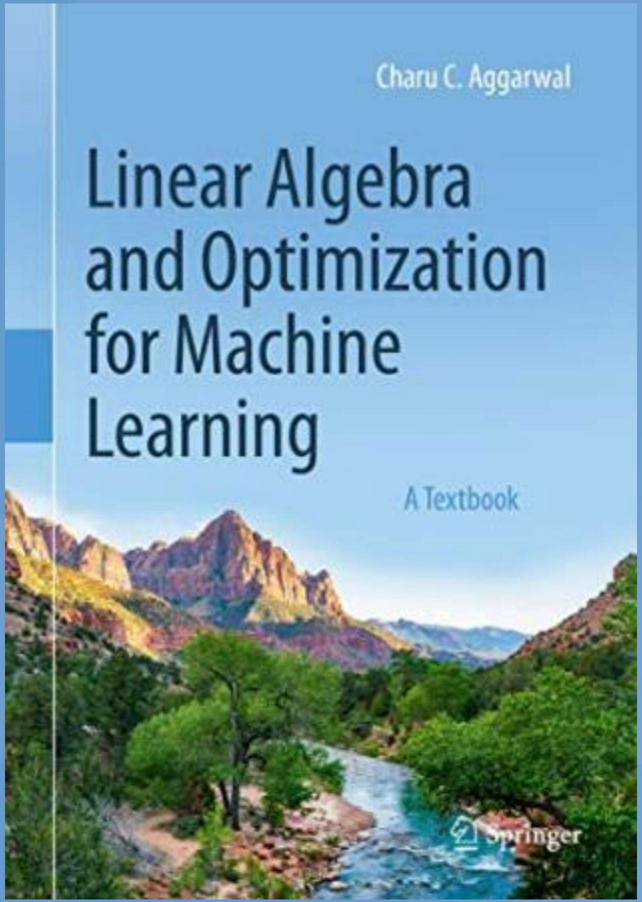
Aggarwal, Charu C.: **"Neural Networks and Deep Learning: A Textbook",** Springer, 1st Edition, 520 pages, September 13, 2018. [ISBN-13: 978-3319944623]

Bibliography



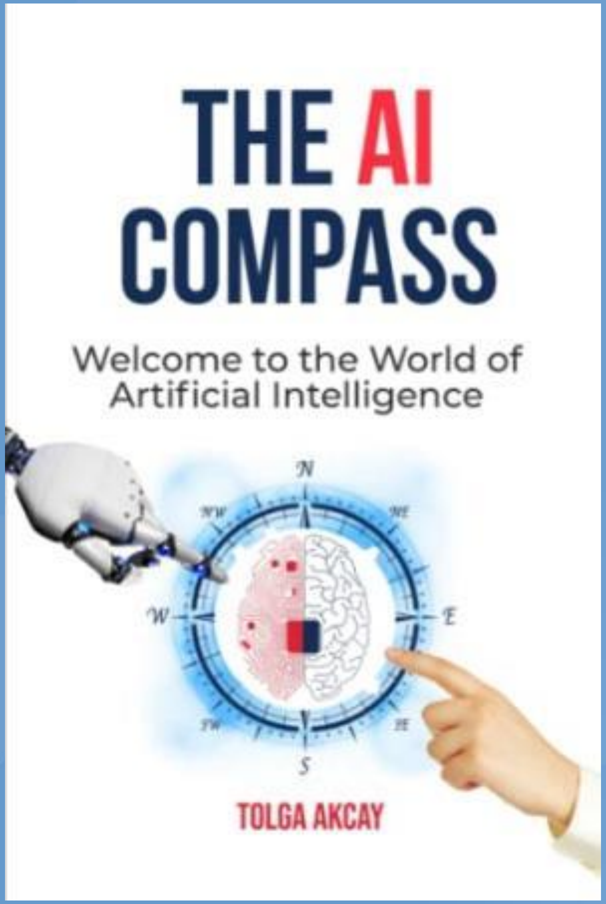
Aggarwal, Charu C.: “**Artificial Intelligence: A Textbook**”, Springer, 1st Edition, 503 pages, July 17, 2021. [ISBN-13: 978-3030723569]

Bibliography



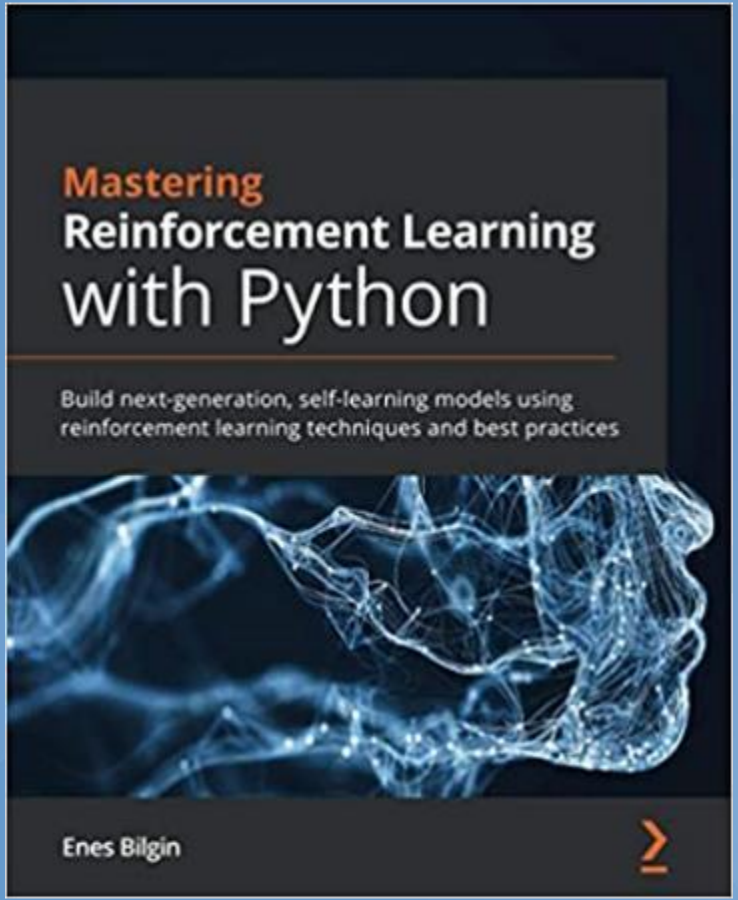
Aggarwal, Charu C.: **“Linear Algebra and Optimization for Machine Learning: A Textbook”**, Springer, 1st Edition, 516 pages, May 13, 2020. [ISBN-13: 978-3030403430]

Bibliography



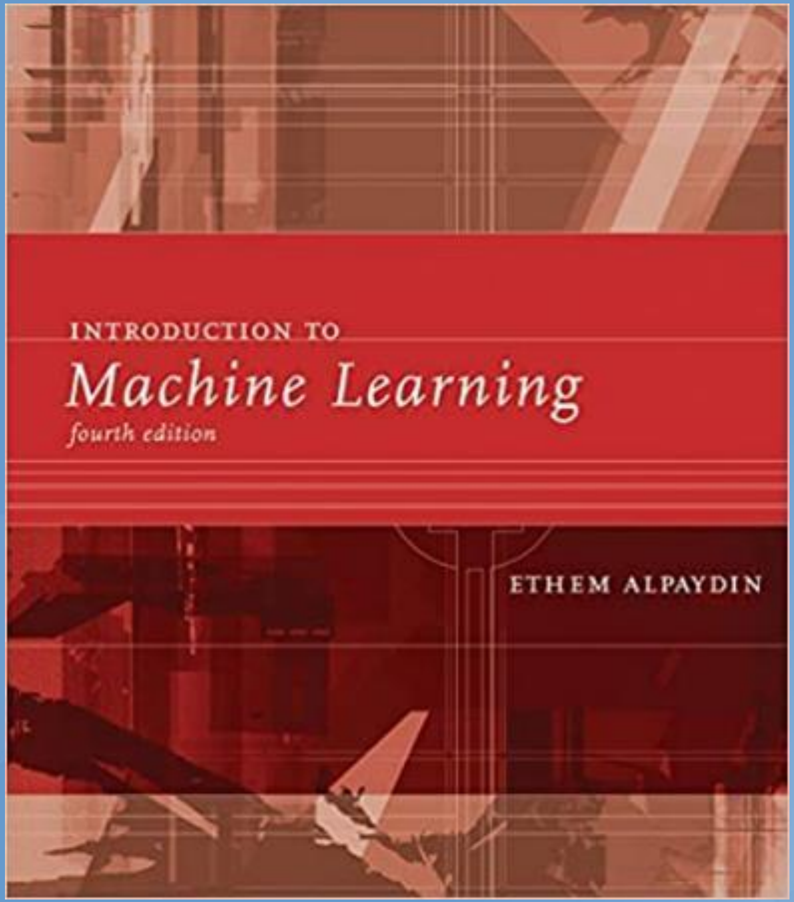
Akcay, Tolga: **“The AI Compass: Welcome to the World of Artificial Intelligence”**, Independently Published, 290 pages, January 1, 2022. [ISBN-13: 979-9784095817]

Bibliography



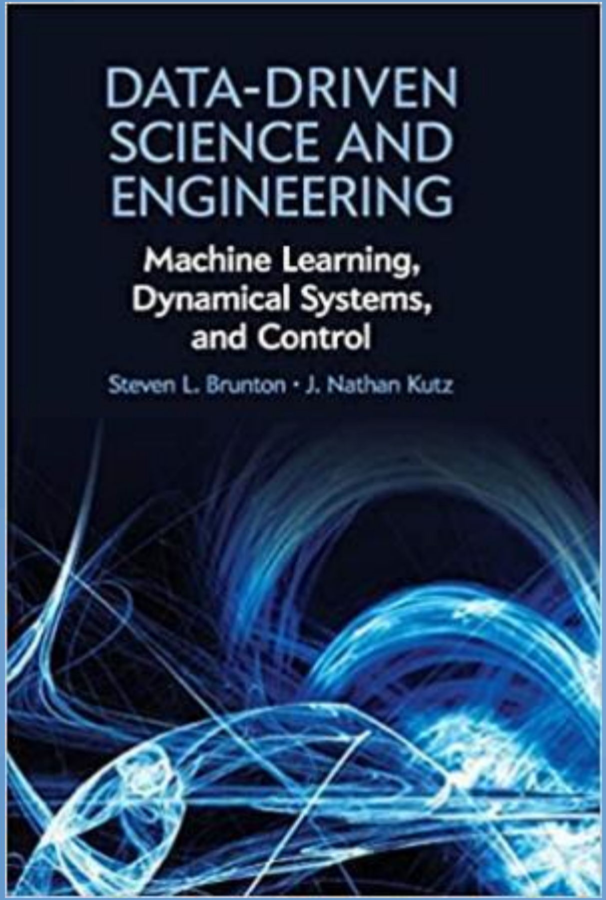
Bilgin, Ernes: “Mastering Reinforcement Learning with Python: Building next-generation models using reinforcement learning techniques and best practices”, Packt Publishing, 544 pages, December 8, 2020. [ISBN-13:978-1838644147]

Bibliography



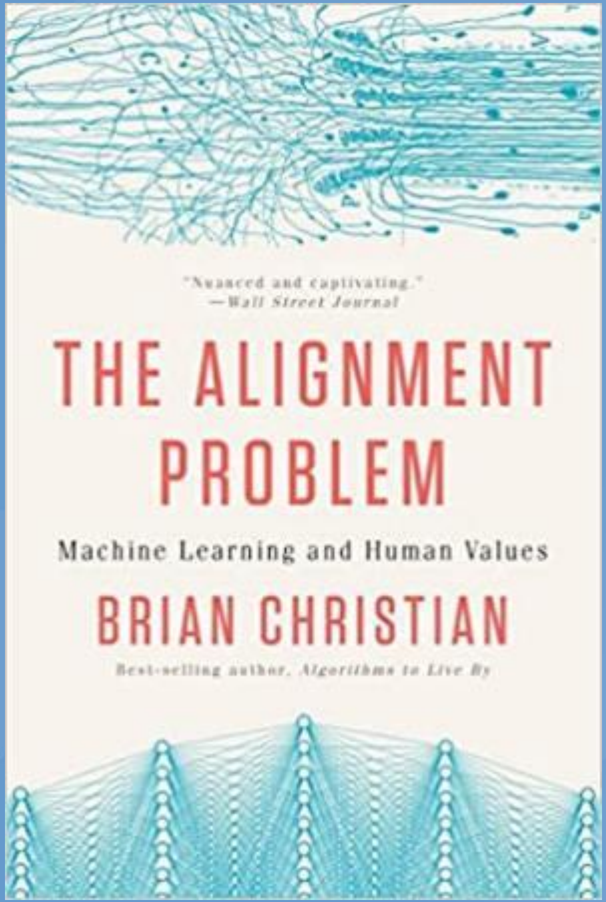
Alpaydin, Ethem: **“Introduction to Machine Learning”**, The MIT Press, Fourth Edition, 712 pages, March 24, 2020. [ISBN-13: 978-0262043793]

Bibliography



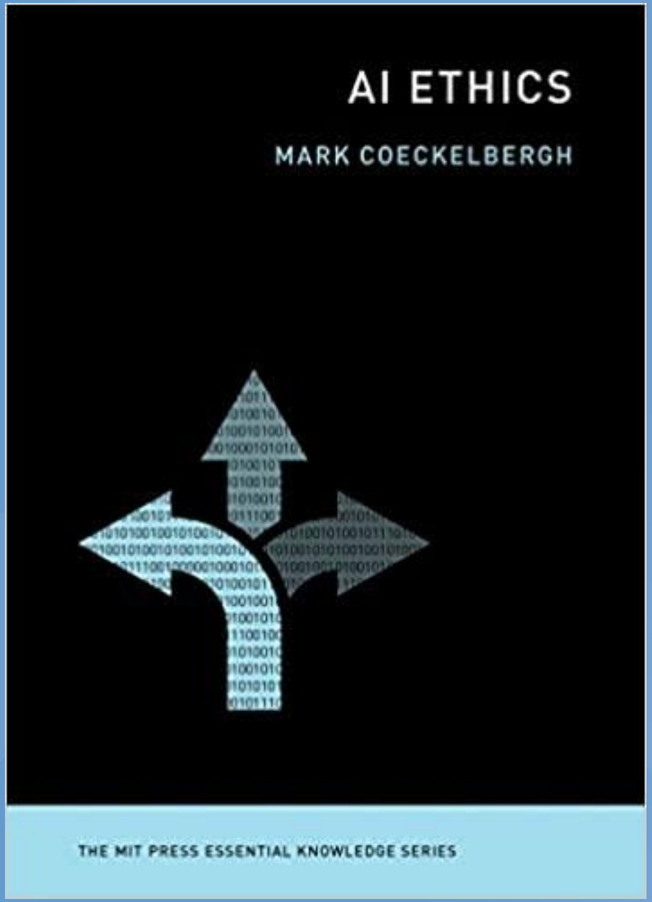
Brunton, Steven J. and Kutz, J. Nathan: "**Data-Driven Science and Engineering: Machine Learning, Dynamical Systems, and Control**", Cambridge University Press, 1st Edition, April 18, 2019. [ISBN-13: 978-1108422093]

Bibliography



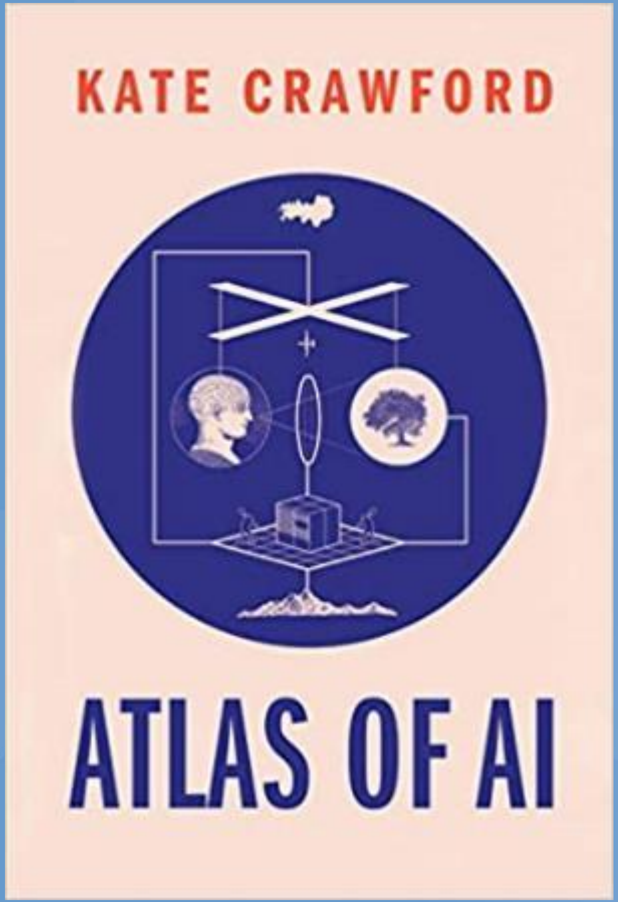
Christian, Brian: **"The Alignment Problem: Machine Learning and Human Values"**, W. W. Norton & Company, 496 pages, October 5, 2021. [ISBN-13: 978-0393868333]

Bibliography



Coeckelbergh, Mark: **"AI Ethics (The MIT Press Essential Knowledge Series)"**, The MIT Press, 248 pages, April 7, 2020. [ISBN-13: 978-0262538190]

Bibliography



Crawford, Kate: **“Atlas of AI”**, Yale University Press, 336 pages, April 6, 2021. [ISBN-13: 978-0300209570]

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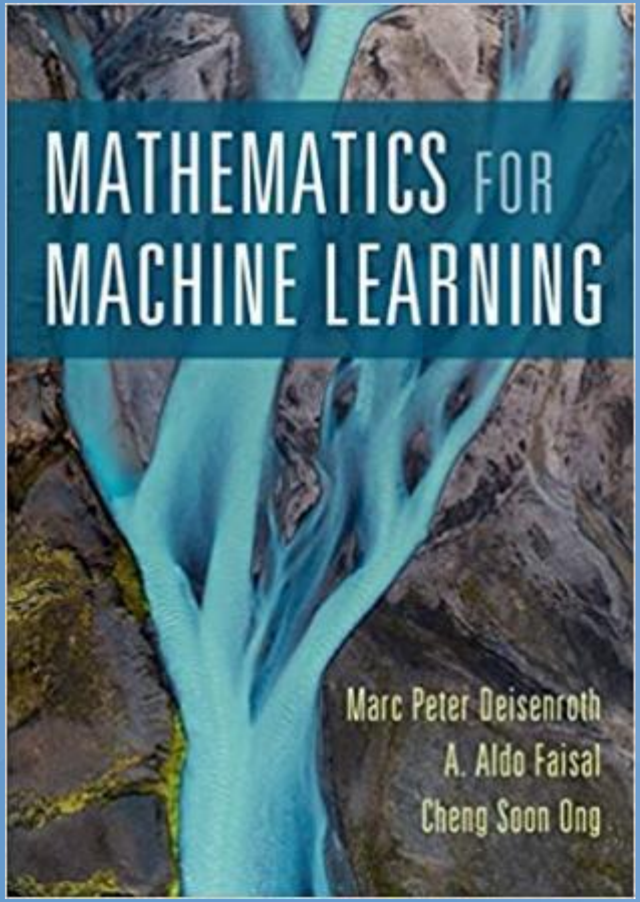
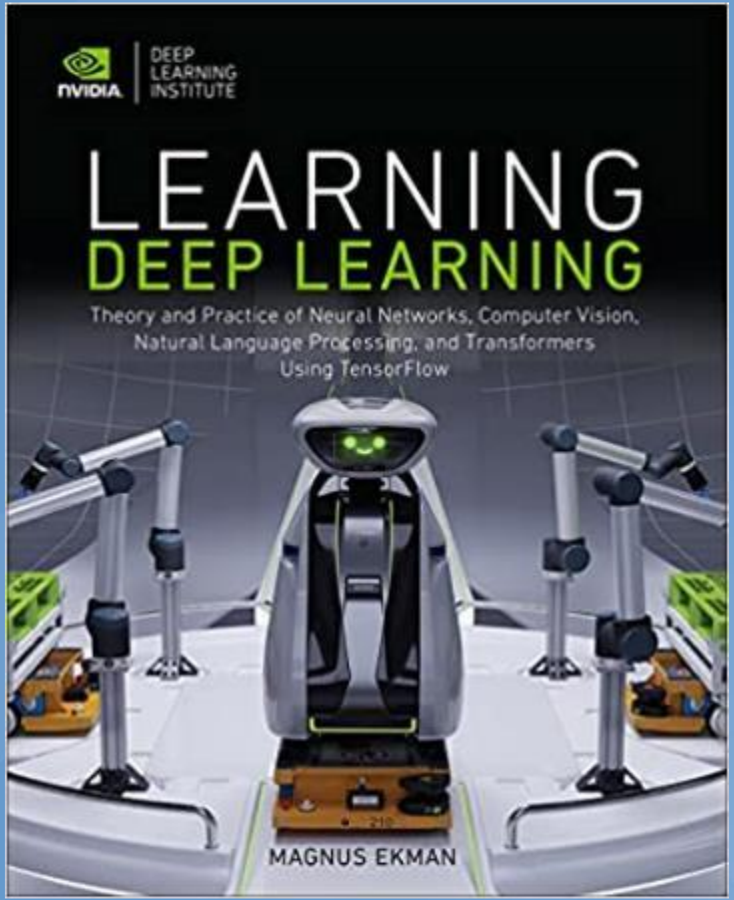
Bibliography



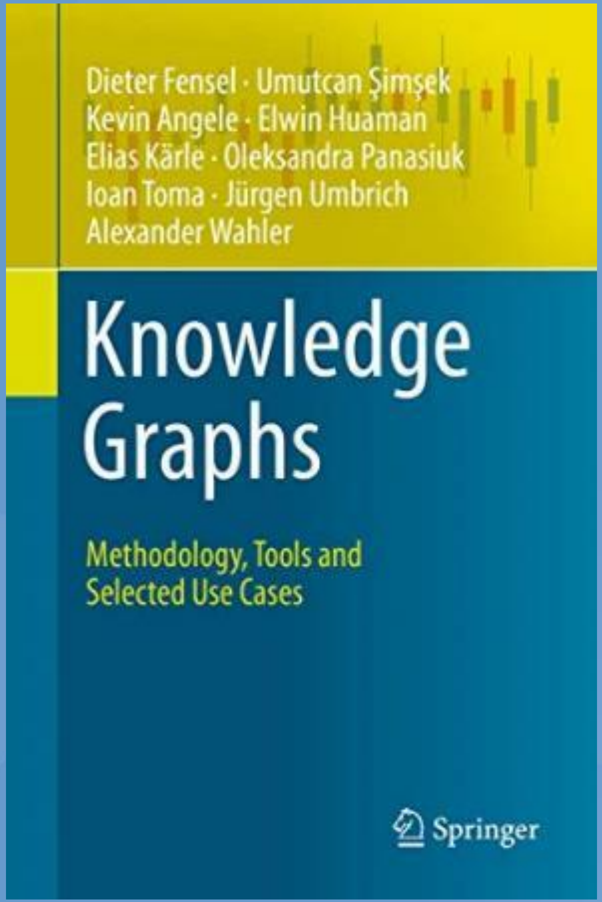
Deisenroth, Marc Peter; Faisal, A. Aldo; and Ong, Cheng Soon: **“Mathematics for Machine Learning”**, Cambridge University Press, 1st Edition, 398 pages, April 1, 2020. [ISBN-13: 978-1108455145]

Bibliography



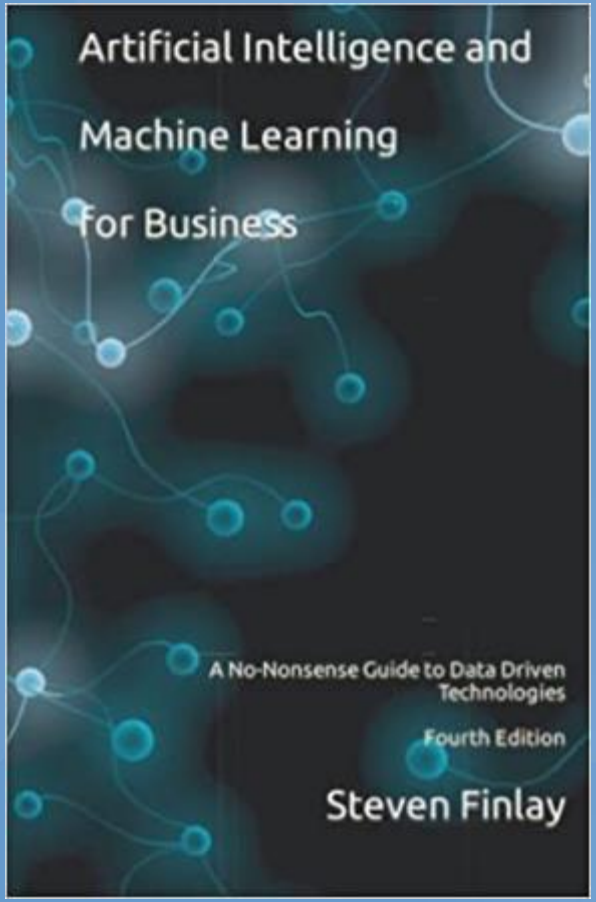
Ekman, Magnus: **“Learning Deep Learning: Theory and Practice of Neural Networks, Computer Vision, Natural Language Processing, and Transformers Using TensorFlow”**, Addison-Wesley Professional, 752 pages, August 17, 2021. [ISBN-13: 978-0137470358]

Bibliography



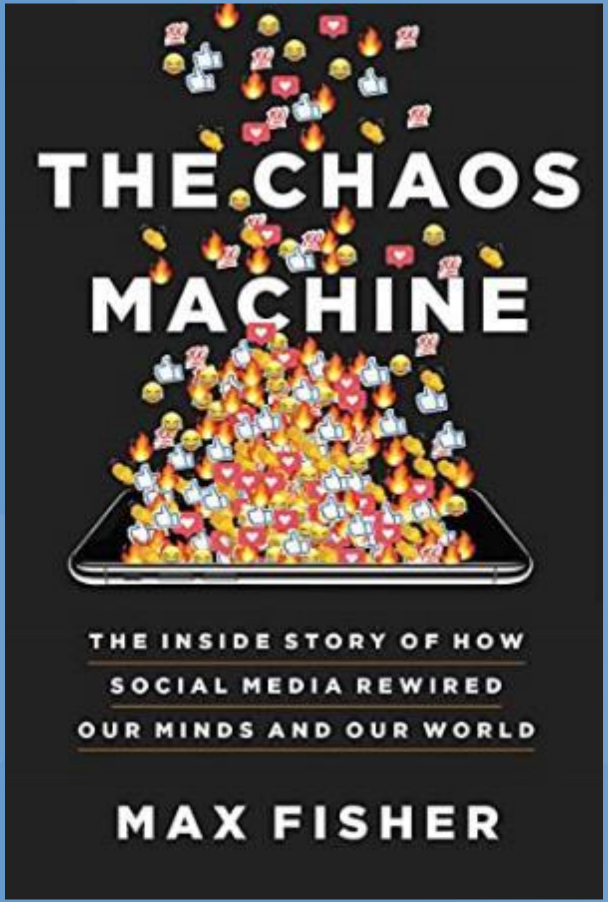
Fensel, Dieter; Şimşek,; Angele, Kevin; Hauman, Elwin; Kärle, Elias; Panasiuk, Oleksandra; Toma, Ioan; Umbrich , Jürgen; and Wahler, Alexander: "Knowledge Graphs: Methodology, Tools,, and Selected Use Cases" , Springer, 1st Edition, 164 pages, February 1, 2020. [ISBN-13: 978-3030374389]

Bibliography



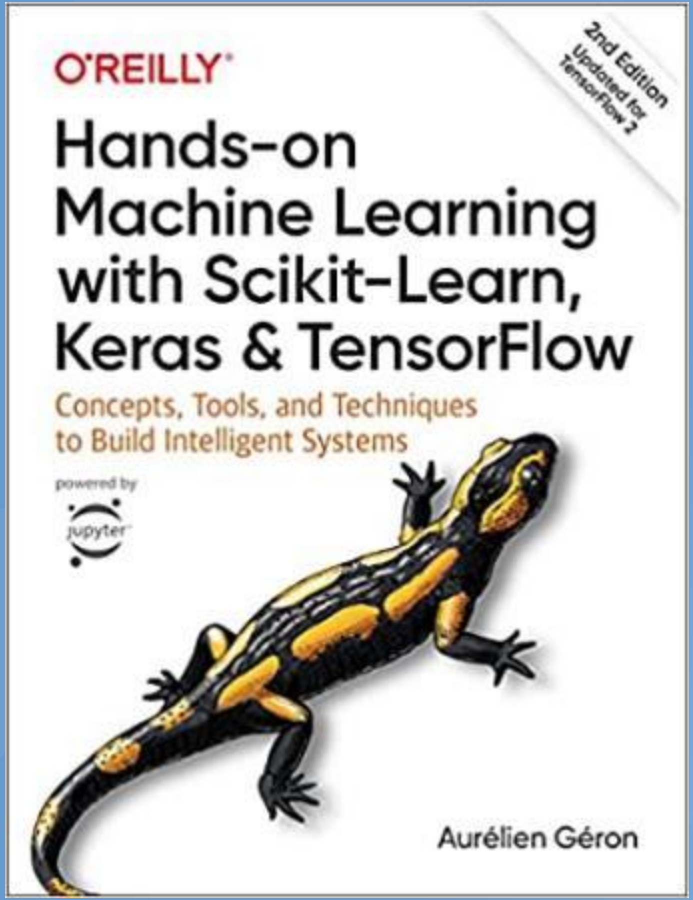
Finlay, Steven: **"Artificial Intelligence and Machine Learning for Business: A No-Nonsense Guide to Data Driven Technologies"**, Relativistic, Fourth Edition, 236 pages, May 23, 2021. [ISBN-13: 978-1838485726]

Bibliography



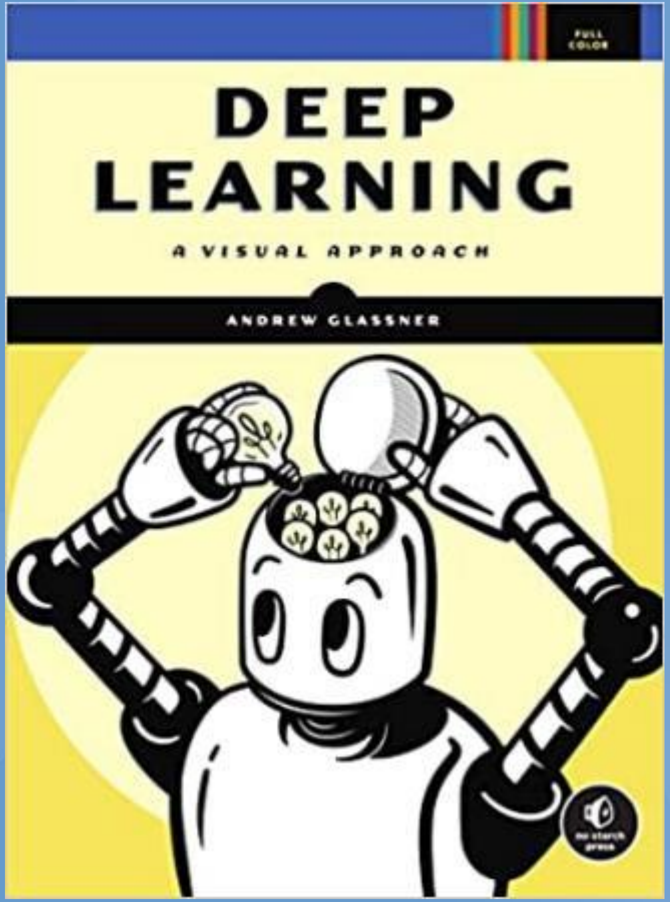
Fisher, Max: **“The Chaos Machine: The Inside Story of How Social Media Rewired Our Minds and Our World”** , Little Brown & Company, 400 pages, September 6, 2022. [ISBN-13: 978-0316703321]

Bibliography



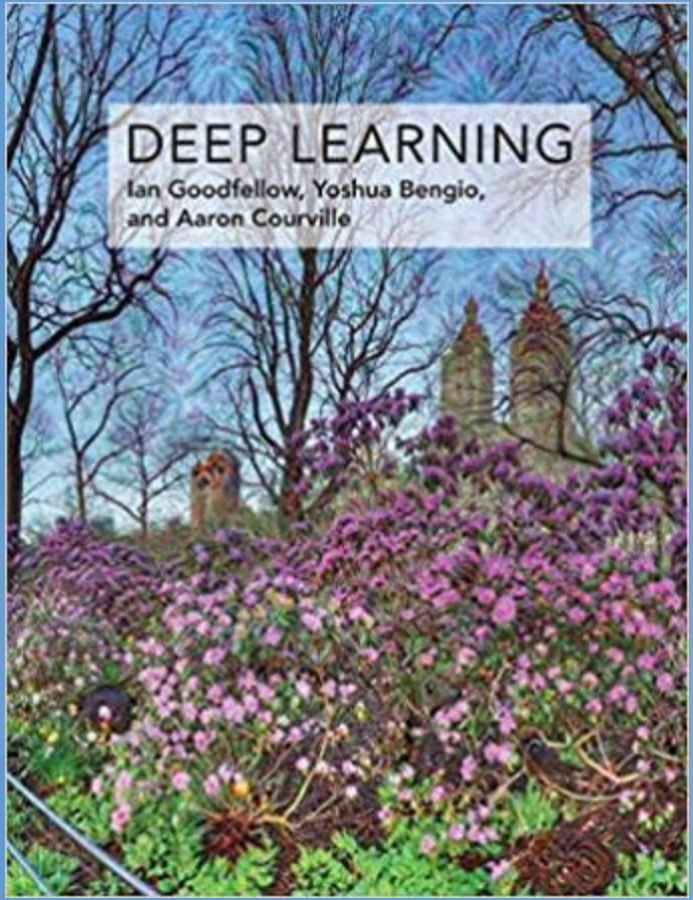
Géron, Aurélien: **"Hands-on Machine Learning with Scikit-Learn, Keras, & TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems"**, O'Reilly Media, 2nd Edition, 856 pages, October 15, 2019. [ISBN-13: 978-1492032649]

Bibliography



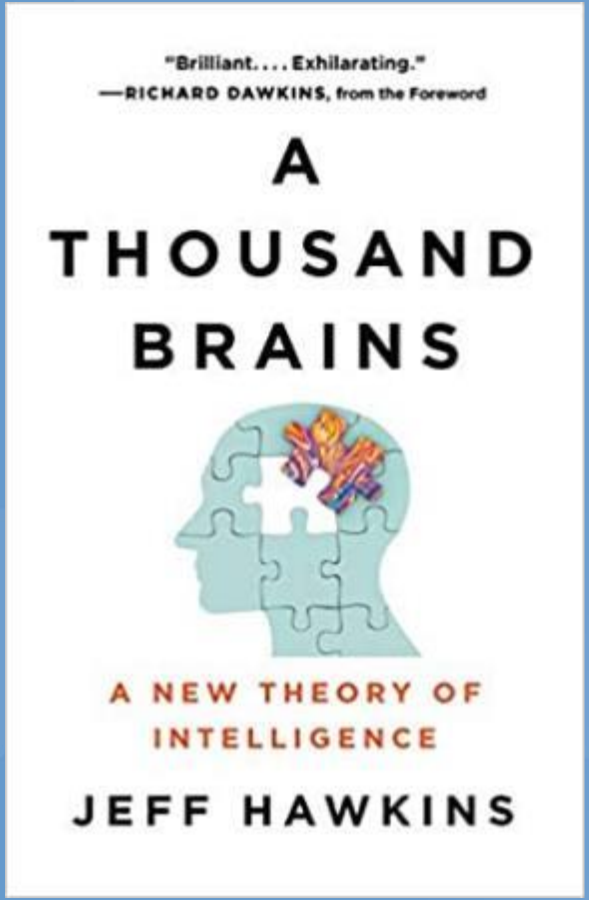
Glassner, Andrew: **“Deep Learning: A Visual Approach”,** No Starch Press, Illustrated Edition, 776 pages, June 29, 2021. [ISBN-13: 978-1718500723]

Bibliography



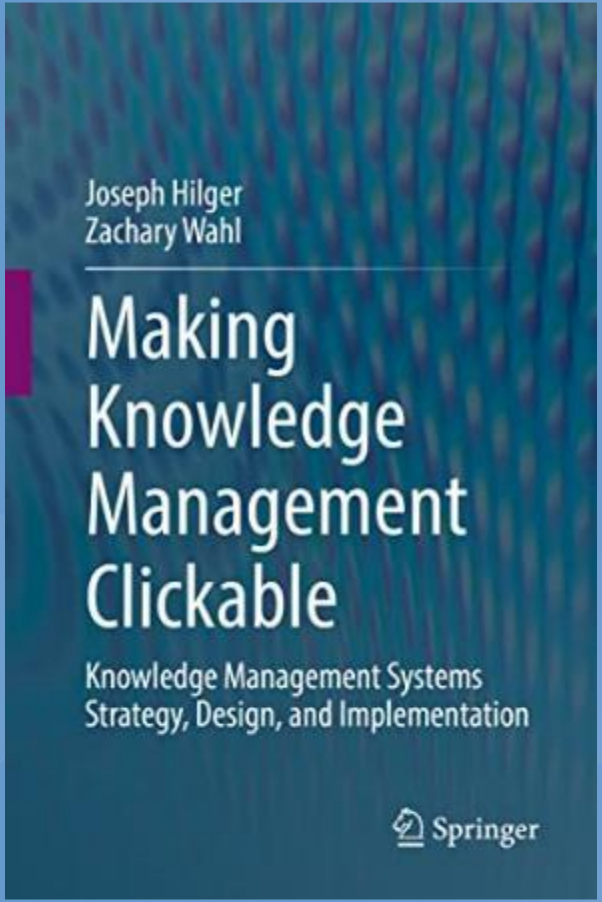
Goodfellow, Ian; Bengio, Yoshua; and Courville, Aaron: **“Deep Learning”**, The MIT Press, 800 pages, November 18, 2016. [ISBN-13: 978-0262035613]

Bibliography



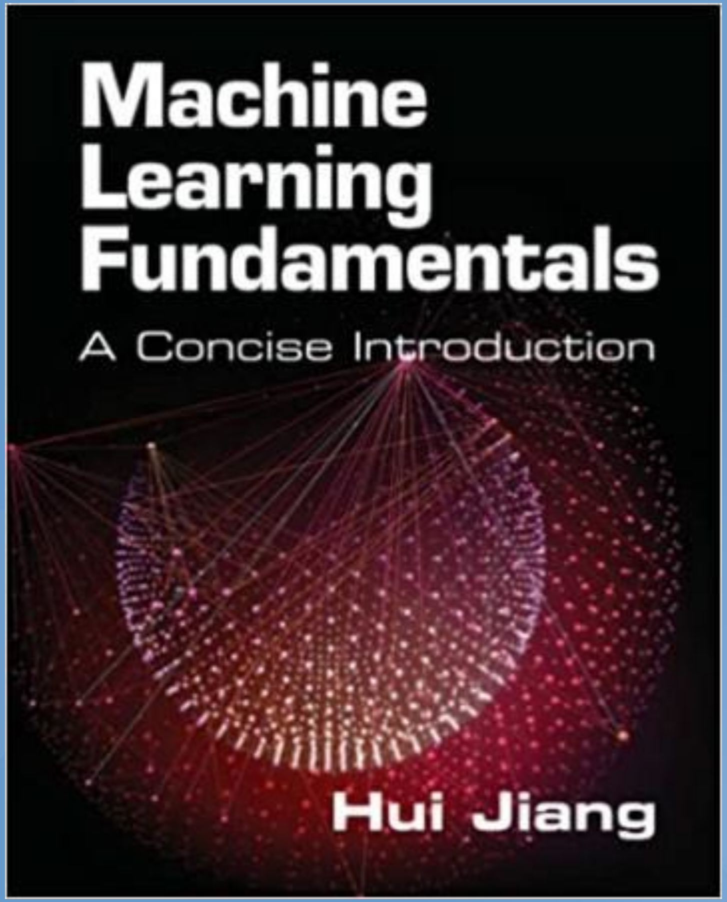
Hawkins, Jeff: **"A Thousand Brains: A New Theory of Intelligence"**, Basic Books, First Edition, 288 pages, March 2, 2021. [ISBN-13: 978-1541675810]

Bibliography



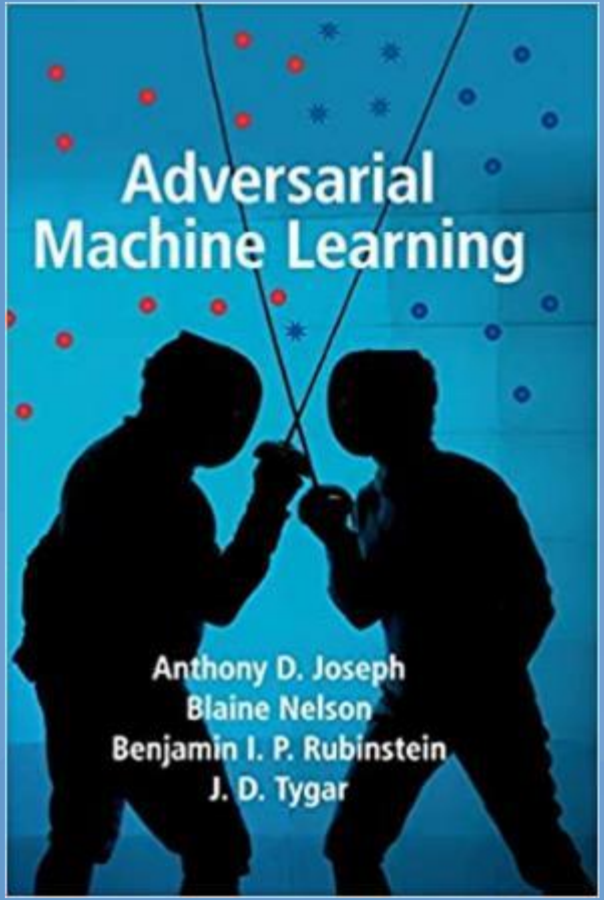
Hilger, Joseph; and Wahl, Zachary: **“Making Knowledge Management Clickable: Knowledge Management Systems – Strategy, Design, and Implementation”**, Springer 1st Edition, 336 pages, March 15, 2022. [ISBN-13: 978-3030923846]

Bibliography



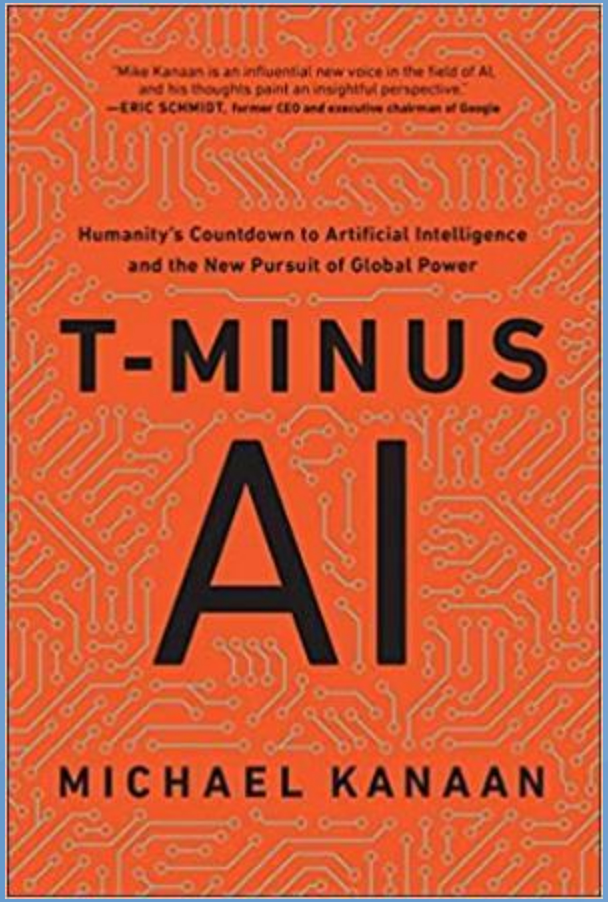
Jiang, Hui: **"Machine Learning Fundamentals: A Concise Introduction"**, Cambridge University Press, New Edition, 422 pages, November 25, 2021. [ISBN-13: 978-1108940023]

Bibliography



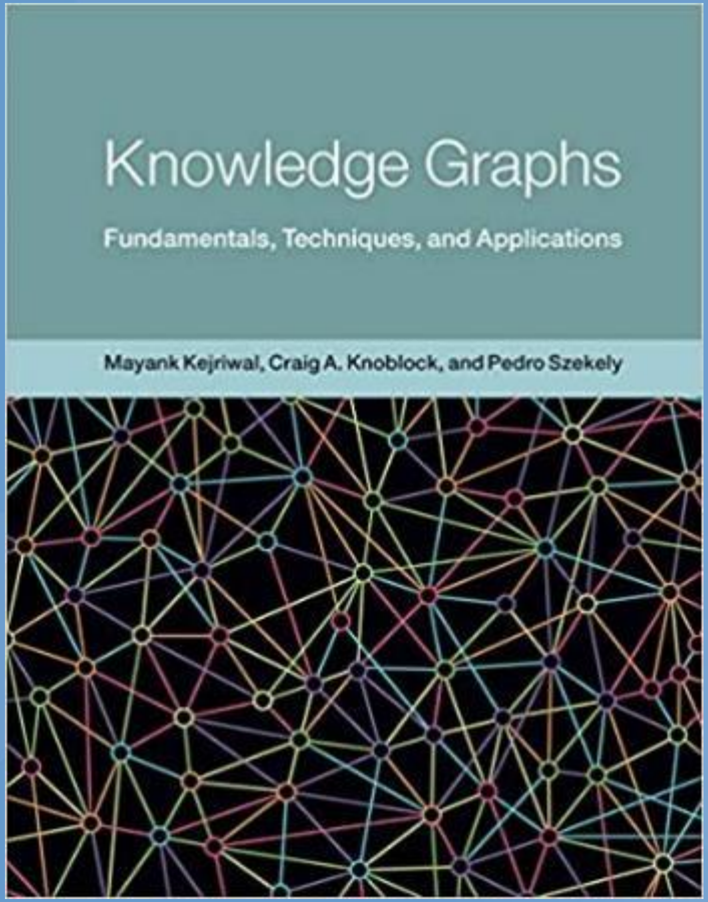
Joseph, Anthony D.; Nelson, Blaine; Rubinstein, Benjamin I. P.; and Tygar, J. D.: **“Adversarial Machine Learning”,** Cambridge University Press, 1st Edition, 338 pages, April 11, 2019. [ISBN-13: 978-1107043466]

Bibliography



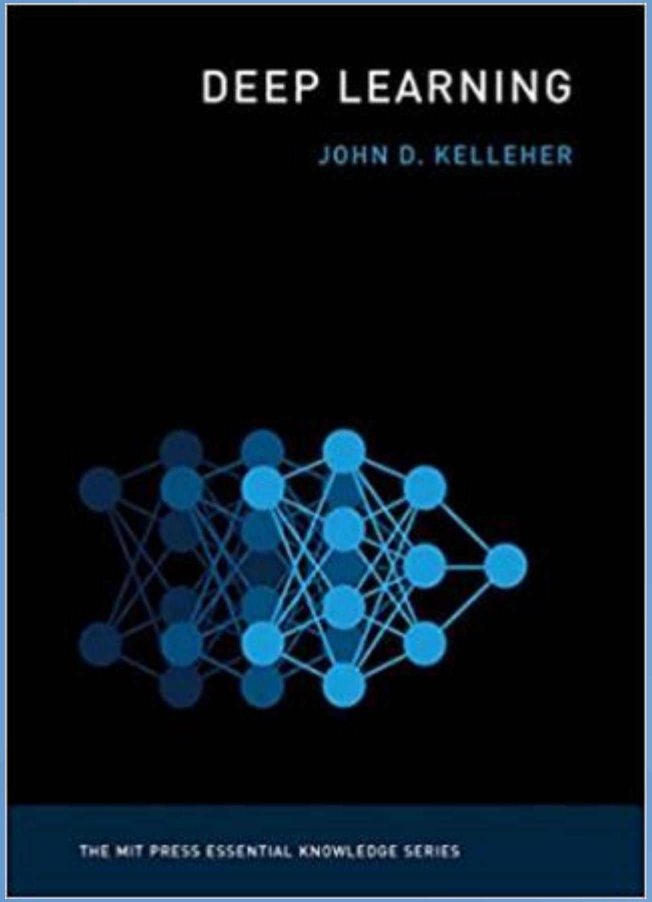
Kanaan, Michael: **"T-Minus AI: Humanity's Countdown to Artificial Intelligence and the New Pursuit of Global Power"**, BenBella Books, Illustrated Edition, 304 pages, August 25, 2020. [ISBN-13: 978-1948836944]

Bibliography



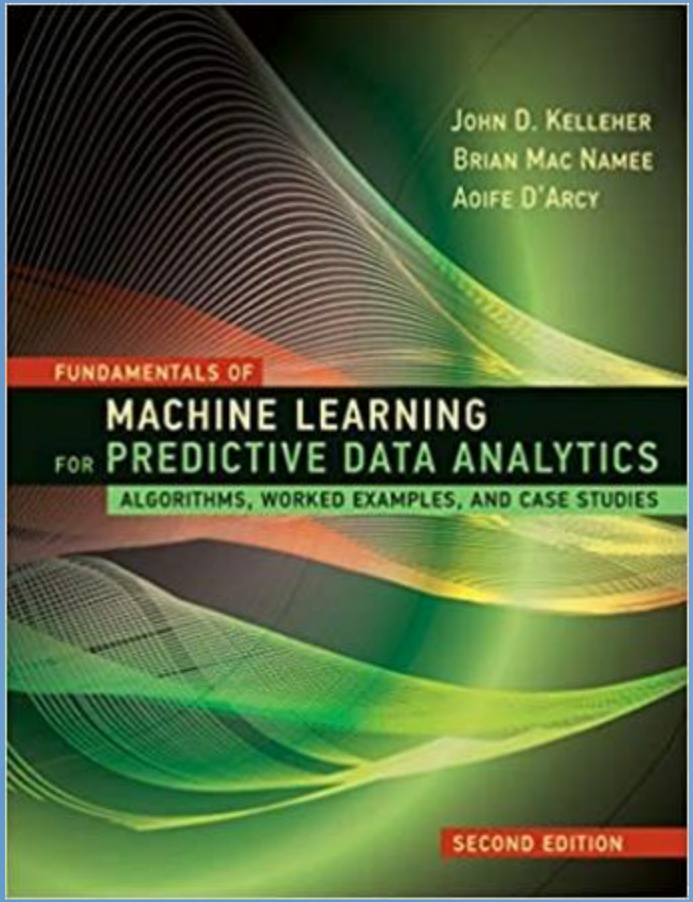
Kejriwal, Mayank; Knoblock, Craig A.; and Szekely, Pedro: **“Knowledge Graphs: Fundamentals, Techniques, and Applications”**, The MIT Press, 568 pages, March 30, 2021. [ISBN-13: 978-0262045094]

Bibliography



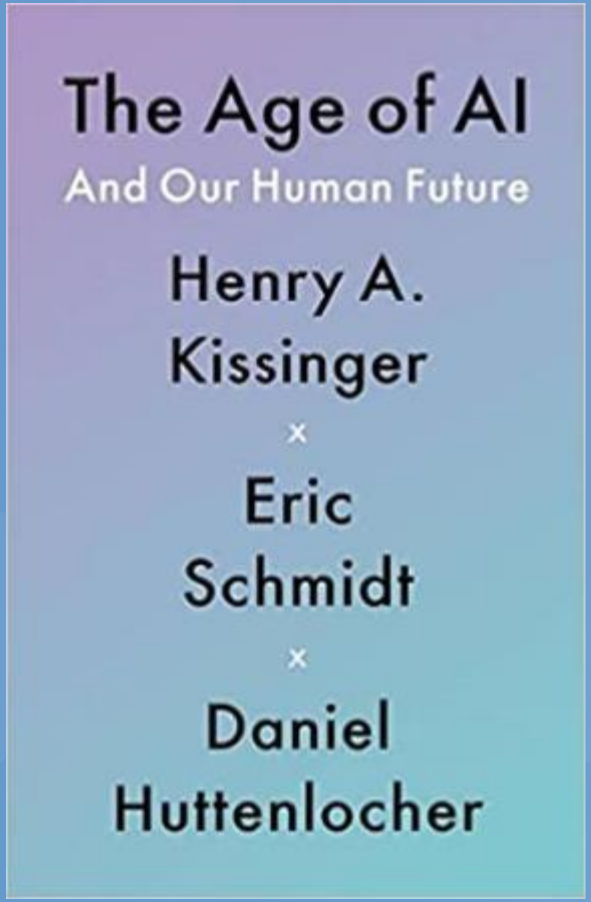
Kelleher, John D.: **“Deep Learning”**, The MIT Press, Illustrated Edition, 296 pages, September 10, 2019. [ISBN-13: 978-0262537551]

Bibliography



Kelleher, John D.; Namee, Brian Mac; and D'Arcy, Aoife: **"Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies"**, The MIT Press, 2nd Edition, 856 pages, October 20, 2020.

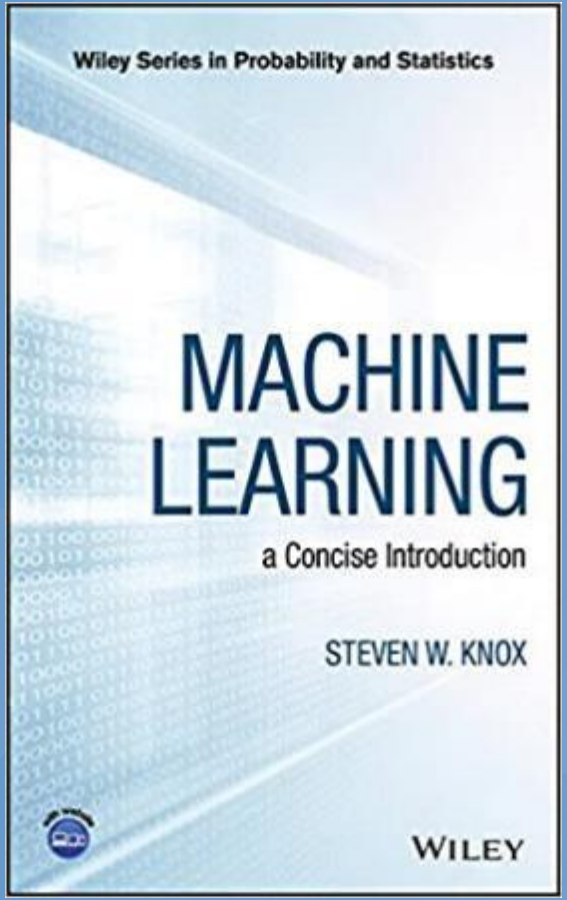
Bibliography



Kissinger, Henry A.; Schmidt, Eric; and Huttenlocher, Daniel: **"The Age of AI: And Our Human Future"**, Little, Brown and Company, First Edition, 272 pages, November 2, 2021. [ISBN-13: 978-0316273800]

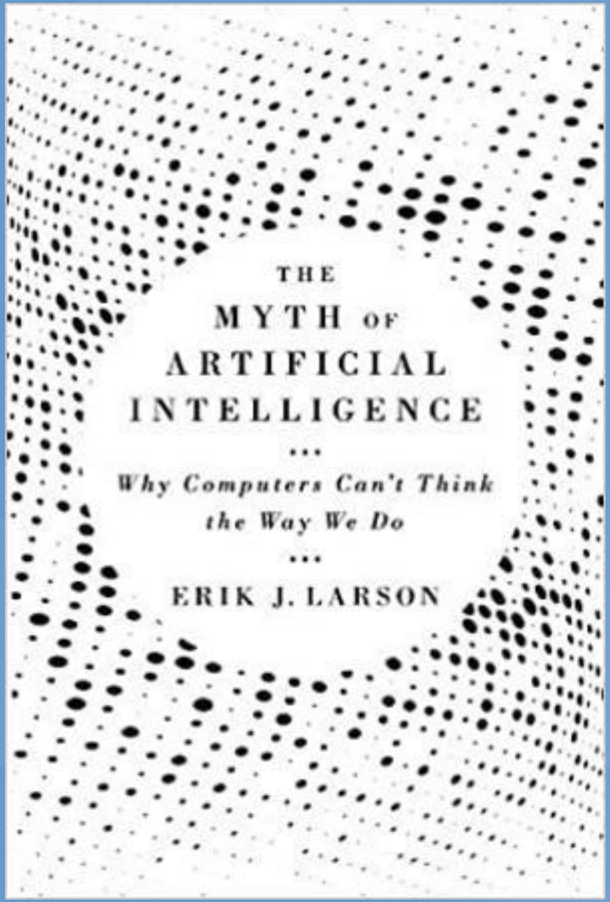
FEDERAL COMMUNICATIONS COMMISSION · USA ·

Bibliography



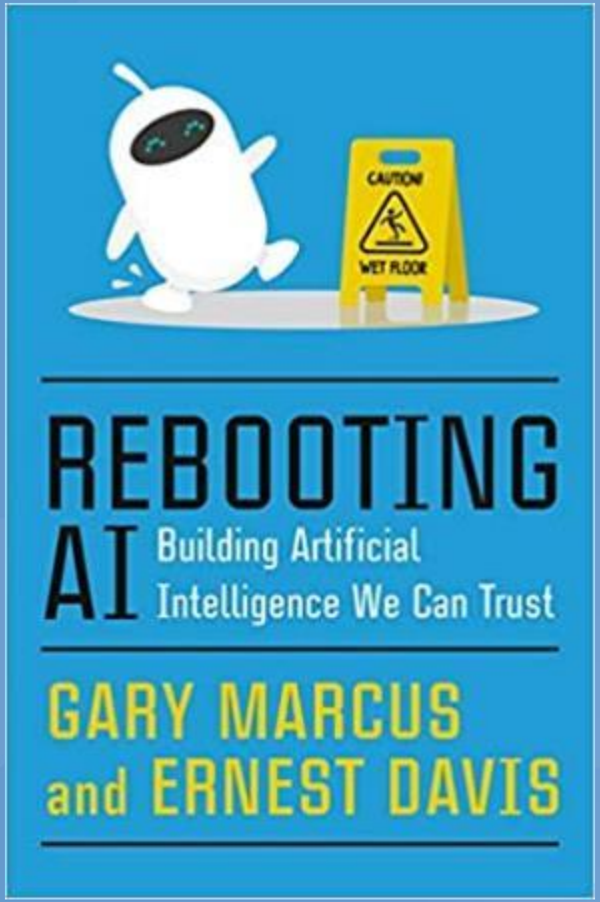
Knox, Steven W.: **"Machine Learning: A Concise Introduction"**, Wiley, 1st Edition, 352 pages, April 17, 2018. [ISBN-13: 978-1119439196]

Bibliography



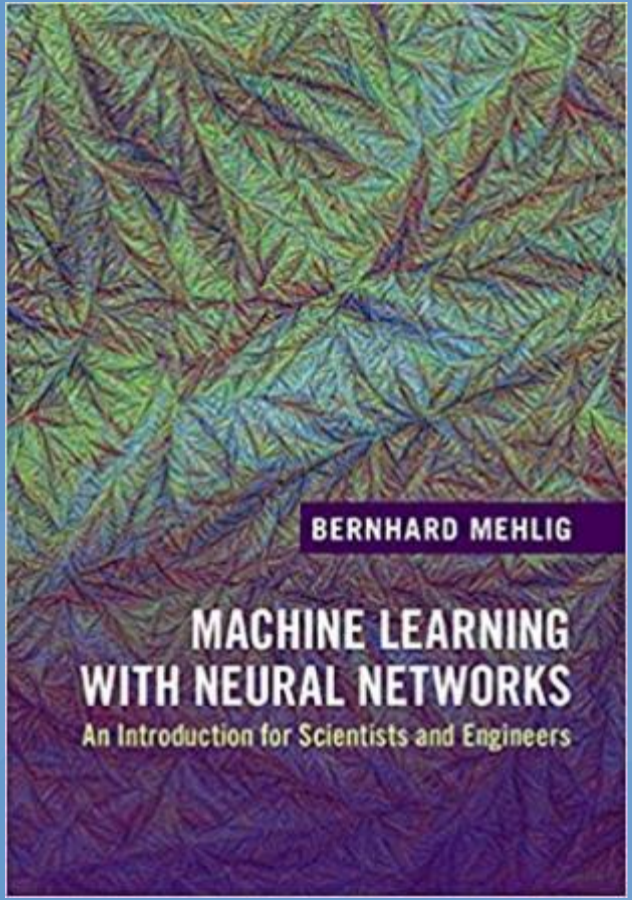
Larson, Erik J.: **"The Myth of Artificial Intelligence: Why Computers Can't Think the Way We Do"**, Belknap Press, An Imprint of Harvard University Press, 320 pages, April 6, 2021. [ISBN-13: 978-0674983519]

Bibliography



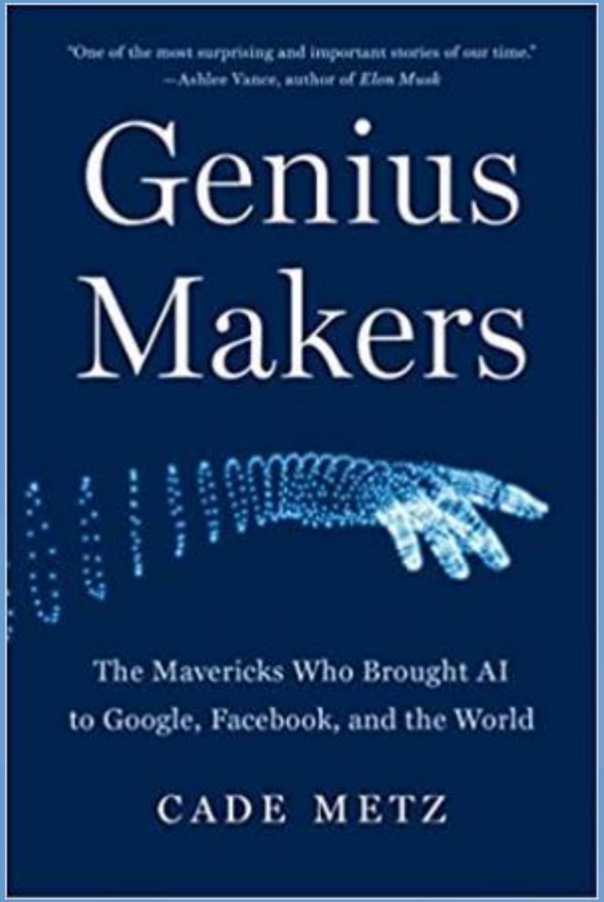
Marcus, Gary and Davis, Ernest: **“Rebooting AI: Building Artificial Intelligence we can Trust”**, Pantheon, 288 pages, September 10, 2019. [ISBN-13: 978-1524748258]

Bibliography



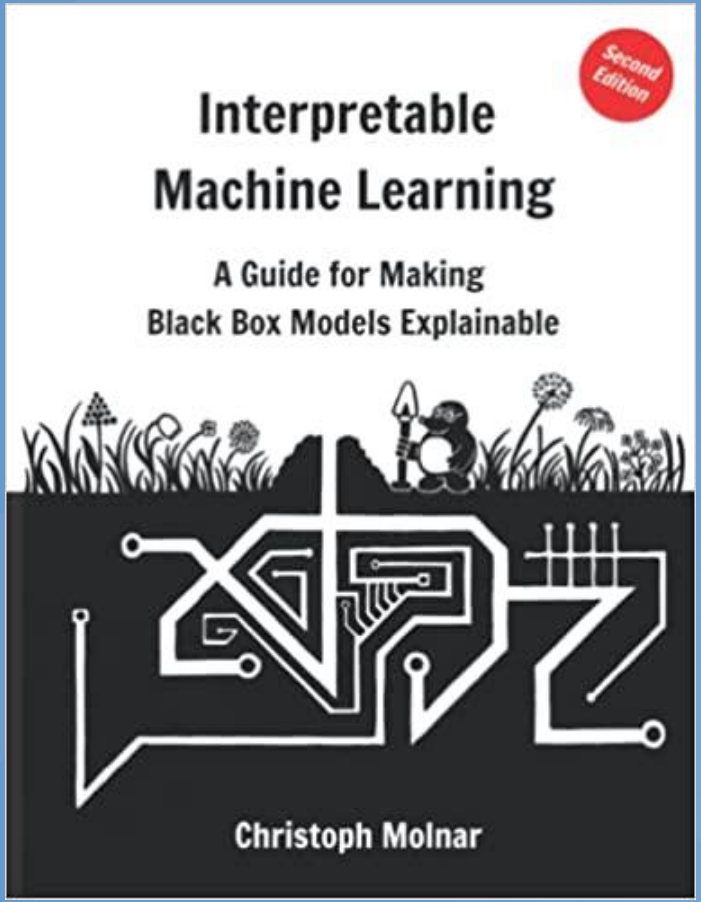
Mehlig, Bernard: **“Machine Learning With Neural Networks: An Introduction for Scientists and Engineers”**, Cambridge University Press, 260 pages, December 23, 2021. [ISBN-13: 978-1108494939]

Bibliography



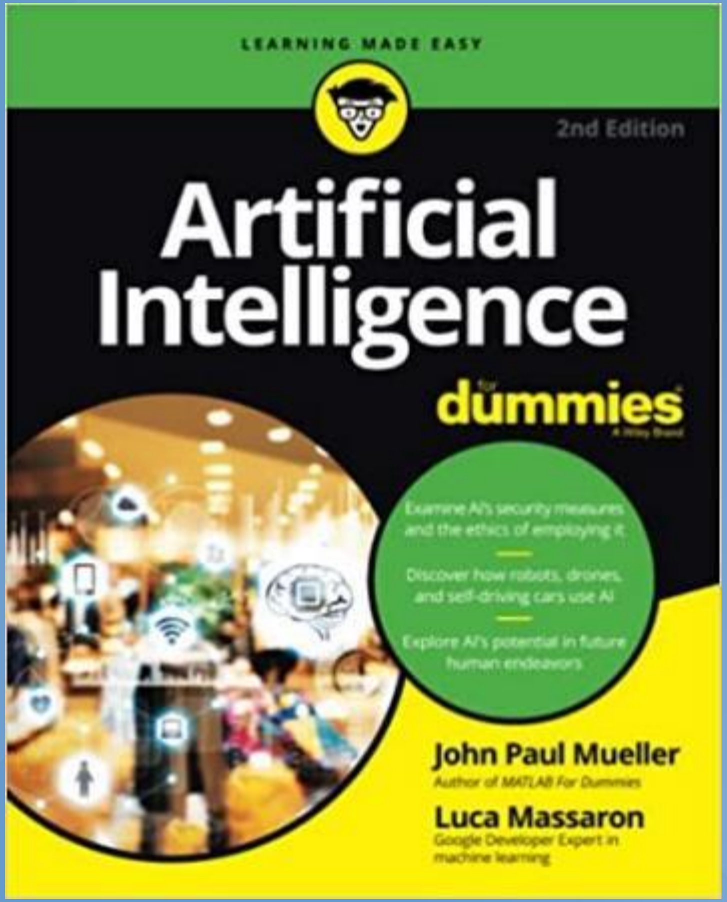
Metz, Cade: **"Genius Makers: The Mavericks Who Brought AI to Google, Facebook, and the World"**, Dutton, 384 pages, March 16, 2021. [ISBN-13: 978-1524742676]

Bibliography



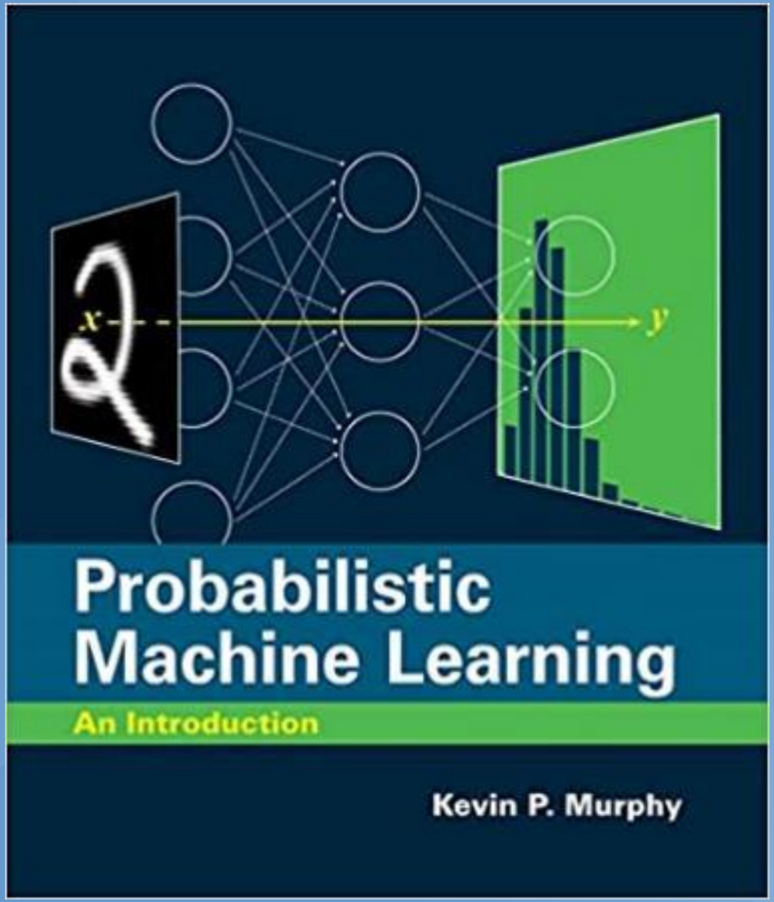
Molnar, Christoph: **“Interpretable Machine Learning: A Guide to Making Black Box Models Explainable”**, Independently Published, 329 pages, February 28, 2022. [ISBN-13: 979-8411463330]

Bibliography



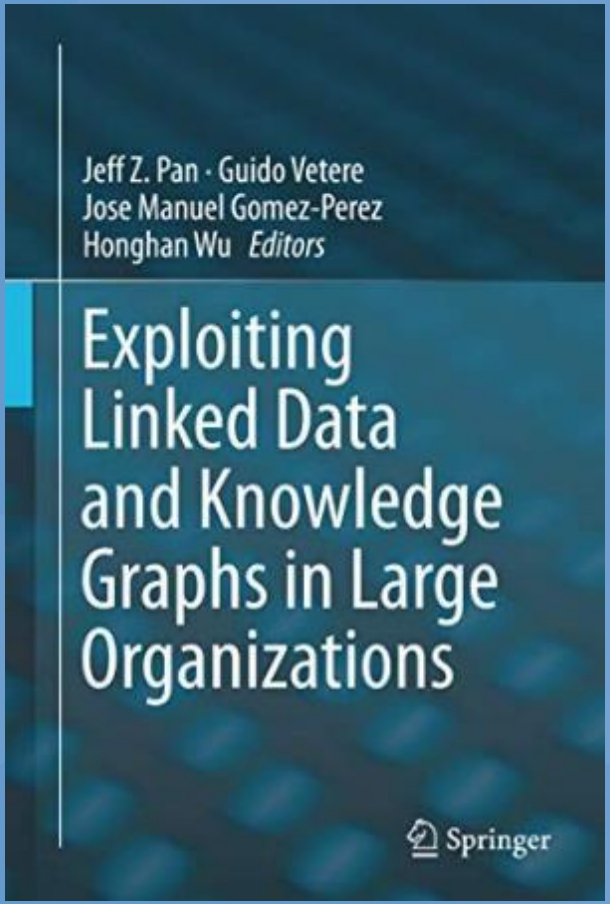
Mueller, John Paul; and Massaron, Luca: **"Artificial Intelligence for Dummies"**, For Dummies, 2nd Edition, 368 pages, November 10, 2021. [ISBN-13: 9781119796763]

Bibliography



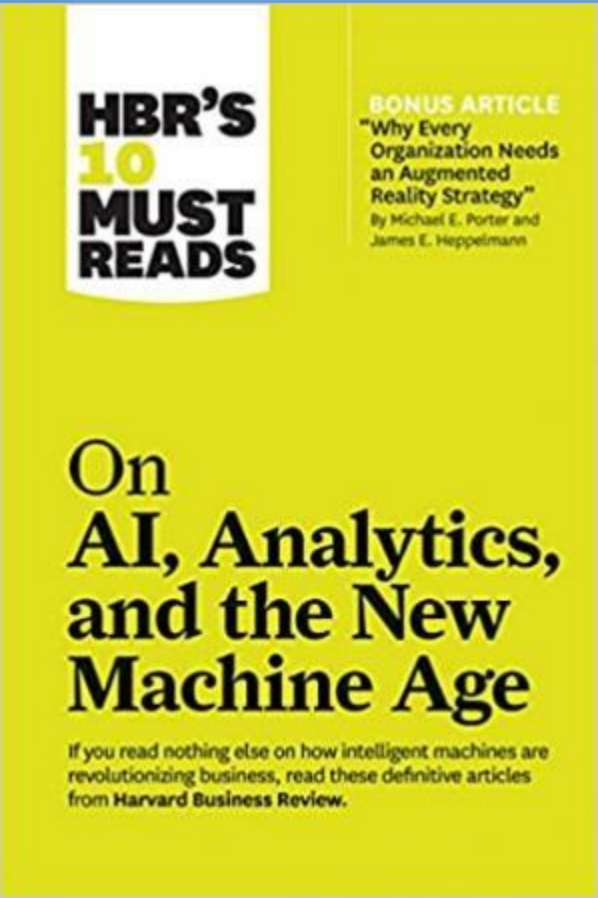
Murphy, Kevin P.: **"Probabilistic Machine Learning: An Introduction"**, The MIT Press, 864 pages, March 1, 2022. [ISBN-13: 978-0262046824]

Bibliography



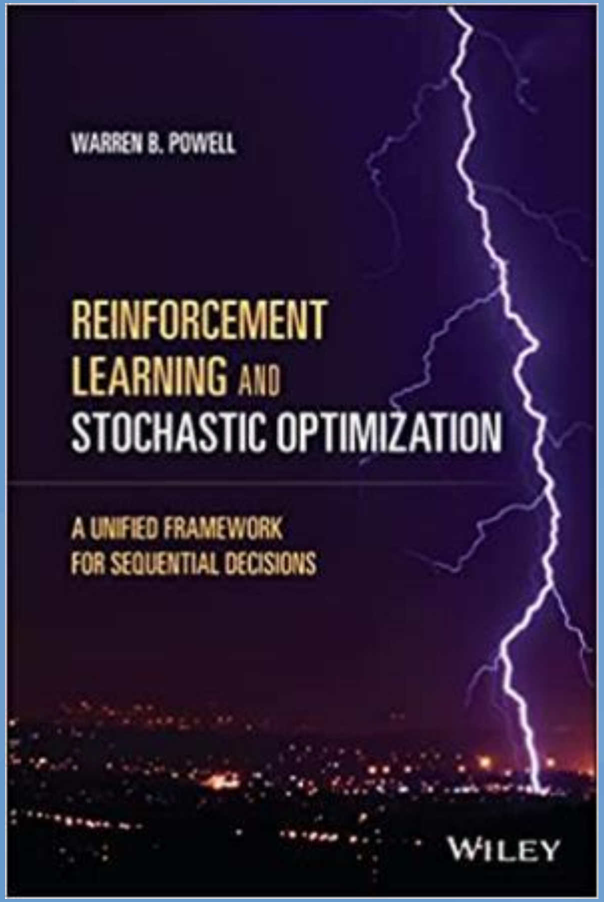
Pan, Jeff Z.; Vetere, Guido; Gomez-Perez, Jose Manuel; and Wu, Honghan; Editors: **"Exploiting Linked Data and Knowledge Graphs in Large Organizations"**, Springer, 1st Edition, 284 pages, February 9, 2017. [ISBN-13: 3319456522]

Bibliography



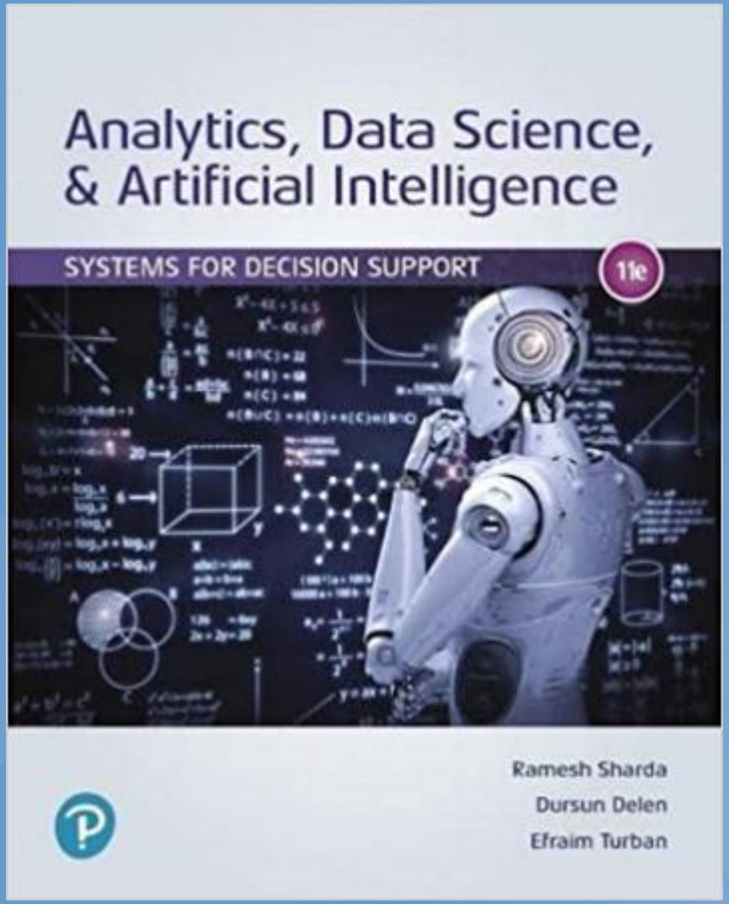
Porter, Michael E.; Davenport, Thomas H.; Daugherty, Paul; and Wilson, James H.: **"On AI, Analytics and the New Machine Age"**, Harvard Business Review Press, 192 pages, January 15, 2019. [ISBN-13: 978-1633696846]

Bibliography



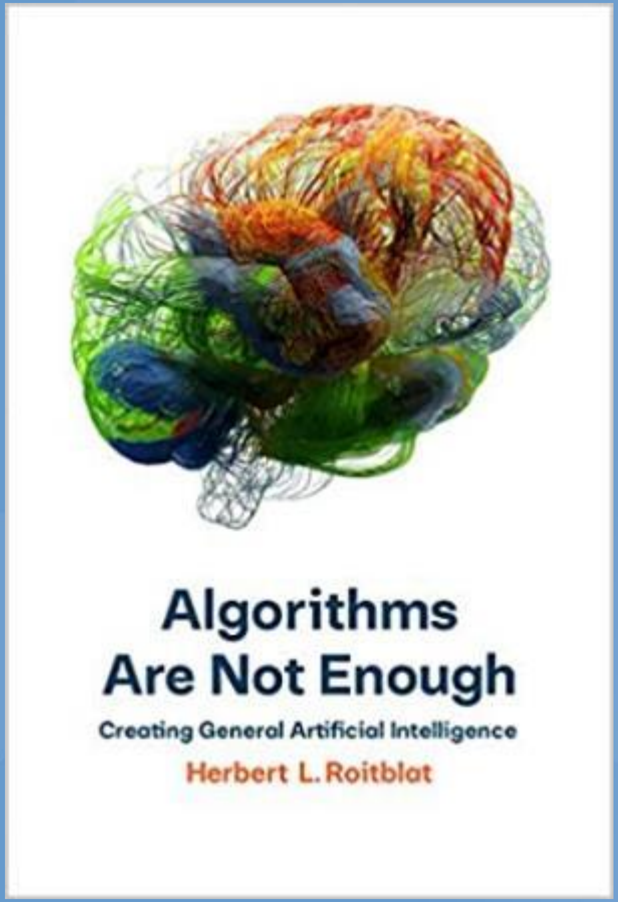
Powell, Warren B.: **“Reinforcement Learning and Stochastic Optimization: A Unified Framework for Sequential Decisions”**, Wiley, 1st Edition, March 15, 2022. [ISBN-13: 978-119815037]

Bibliography



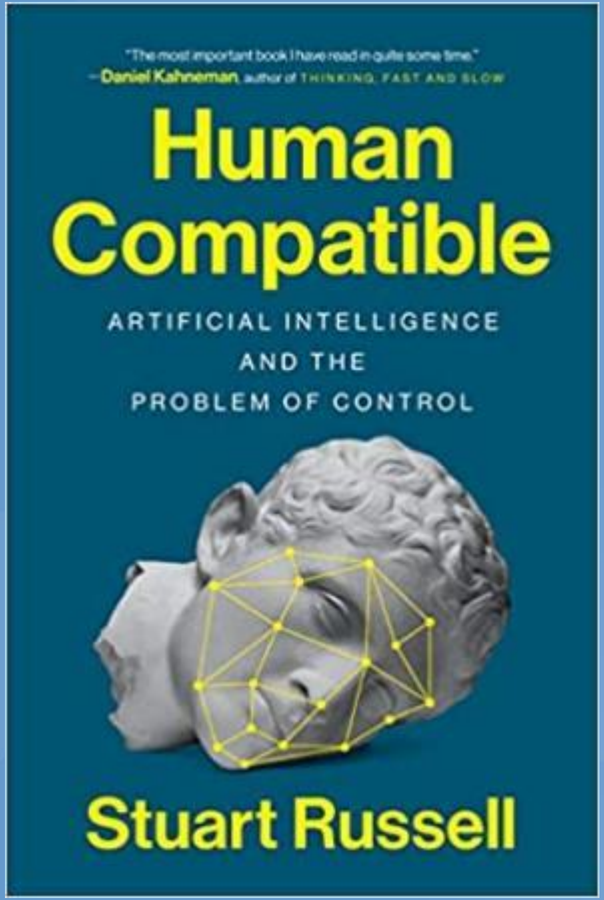
Sharda, Ramesh; Delen, Dursun; and Turban, Efraim: **“Analytics, Data Science, & Artificial Intelligence: Systems for Decision Support”**, Pearson, 11th Edition, 832 pages, February 11, 2019. [ISBN-13: 978-0135192016]

Bibliography



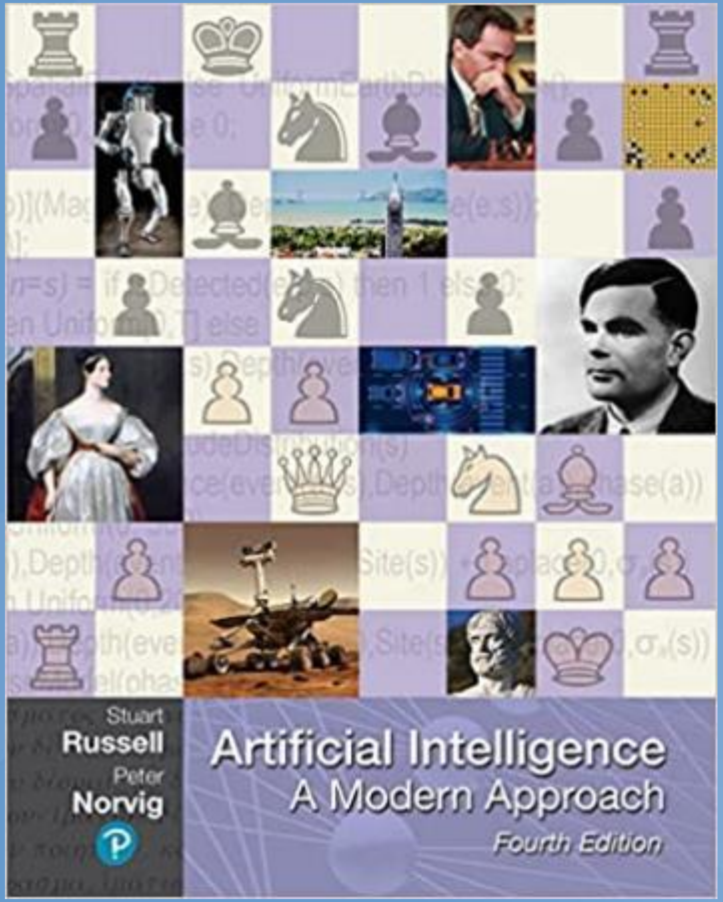
Roitblat, Herbert L.: **“Algorithms Are Not Enough: Creating General Artificial Intelligence”**, The MIT Press, 336 pages, October 13, 2020. [ISBN-13: 978-0262044127]

Bibliography



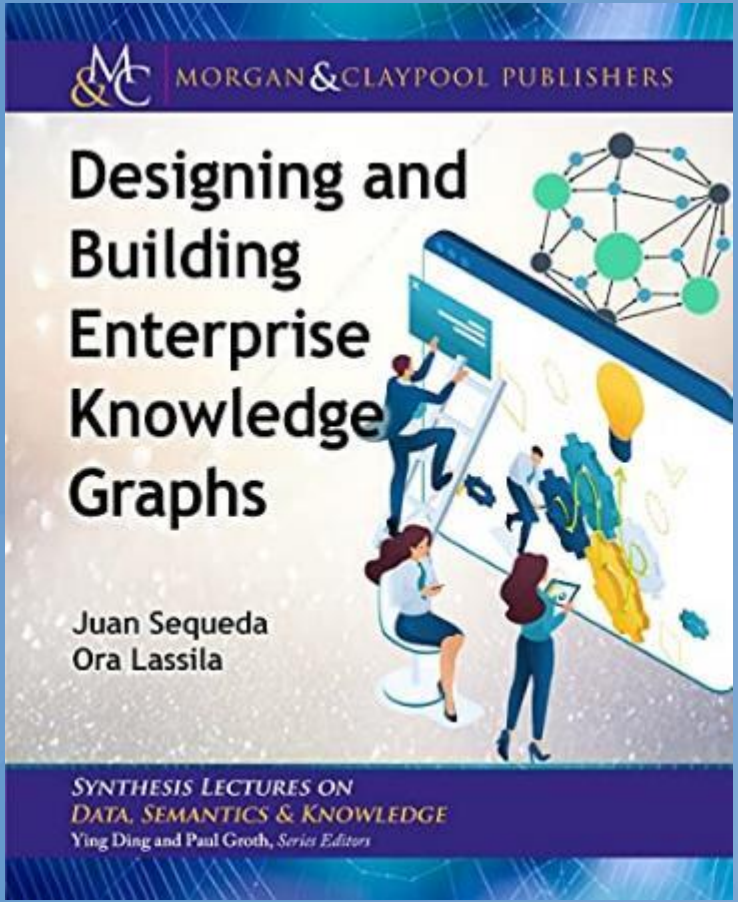
Russell, Stuart: **“Human Compatible: Artificial Intelligence and the Problem of Control”**, Viking, 352 pages, October 8, 2019. [ISBN-13: 978-0525558613]

Bibliography



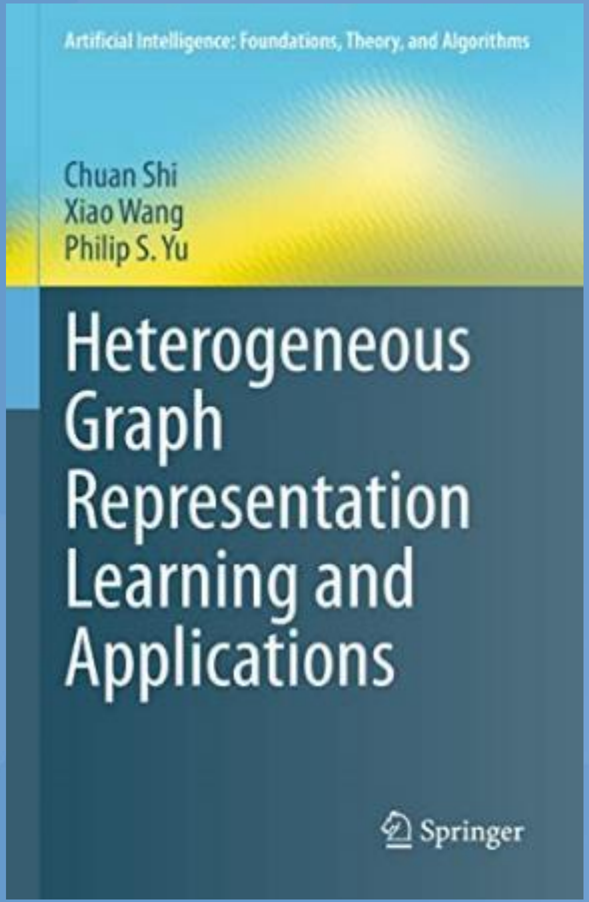
Russell, Stuart; and Norvig, Peter: **“Artificial Intelligence: A Modern Approach”**, Pearson, 4th Edition, 1136 pages, April 28, 2000. [ISBN-13: 978-0134610997]

Bibliography



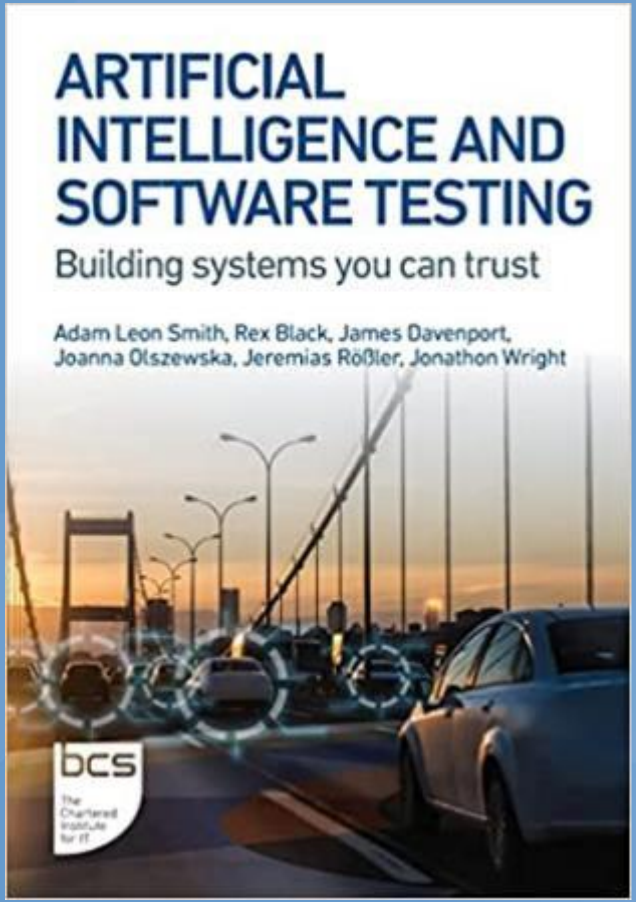
Sequeda, Juan; and Lassila, Ora: **"Designing and Building Enterprise Knowledge Graphs"**, Morgan and Claypool Publishers, 142 pages, 202. [ISBN-13: 978-1636391748]

Bibliography



Shi, Chuan; Wang, Xiao; and Yu, Philip S.: **"Heterogenous Graph Representation Learning and Applications: Artificial Intelligence – Foundations, Theory, and Algorithms"**, Springer, 1st Edition, 338 pages, January 31, 2022. [ISBN-13: 978-9811661655]

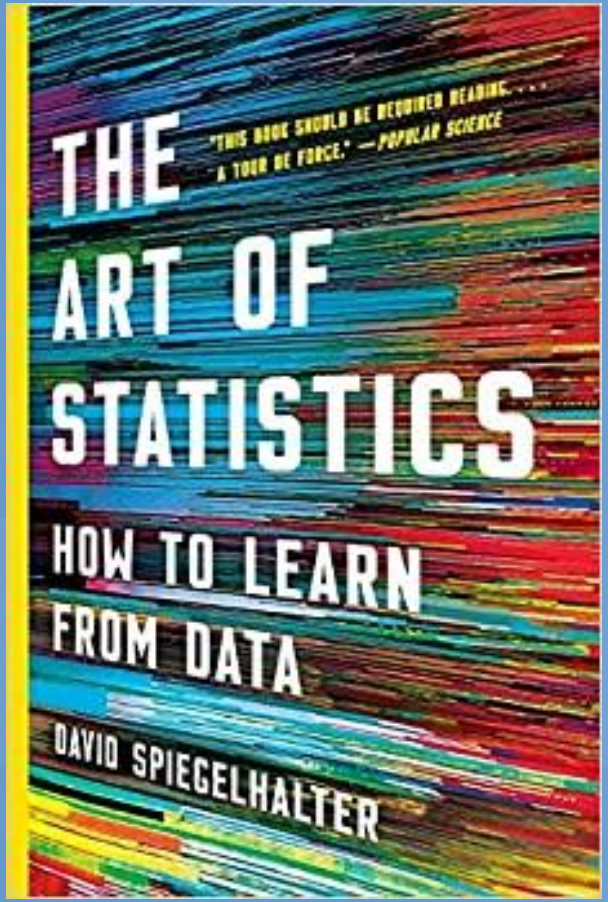
Bibliography



Smith, Adam Leon; Black, Rex; Davenport, James; Olszewska, Joanna; Rössler, Jeremias; and Wright, Jonathon: **"Artificial Intelligence and Software Testing: Building Systems you can Trust"**, BCS, The Chartered Institute for IT, 150 pages, March 10, 2022. [ISBN-13: 978-1780175768]

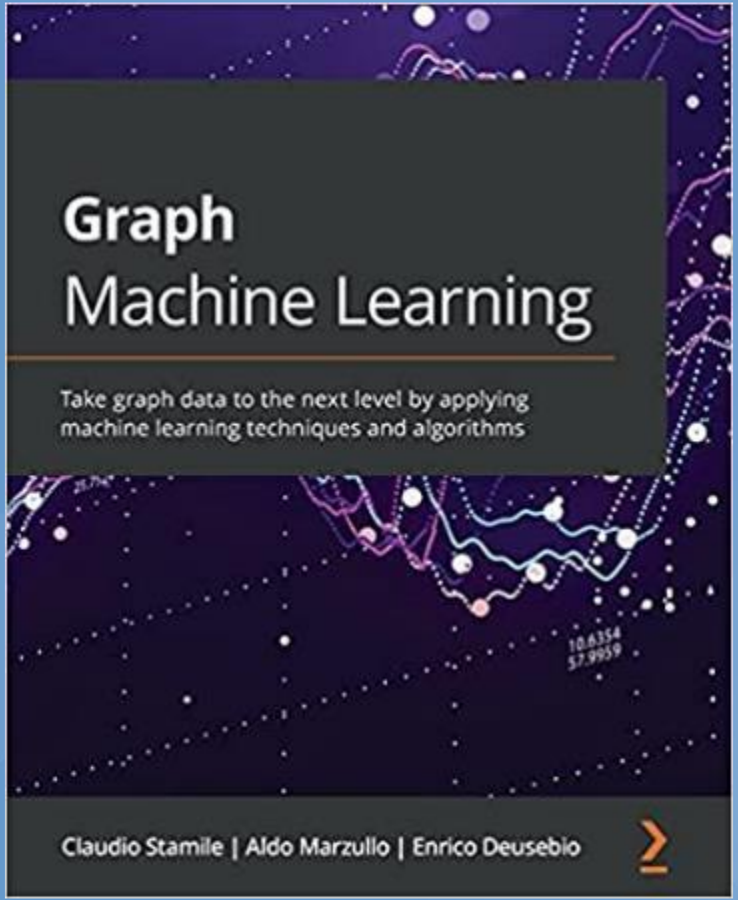
FEDERAL COMMUNICATIONS COMMISSION · USA ·

Bibliography



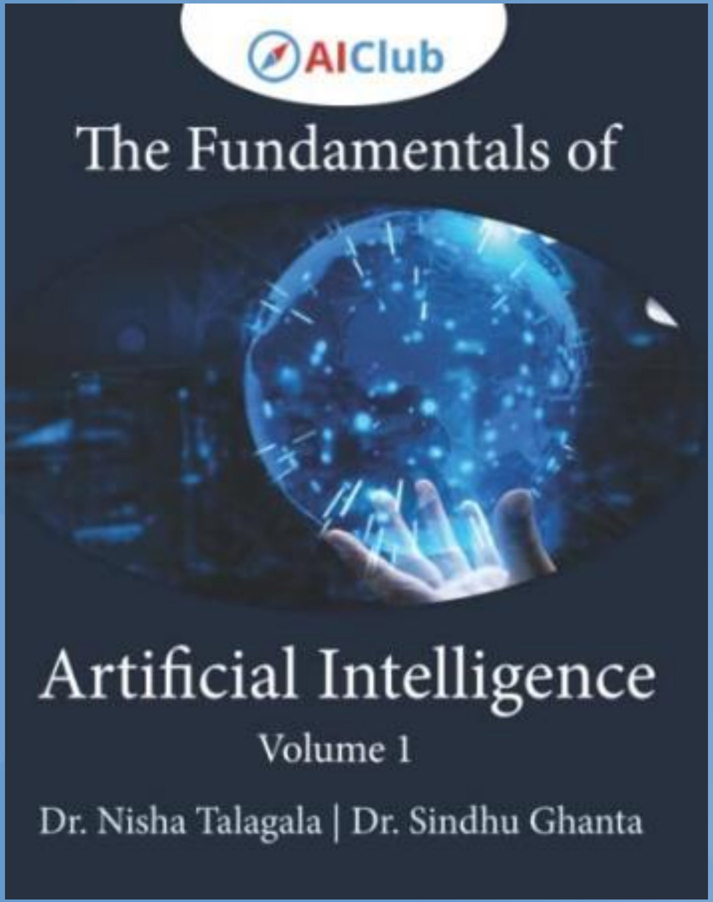
Spiegelhalter, David: **“The Art of Statistics: How to learn from data”**, Basic Books, Illustrated Edition, September 3, 2019. [ISBN-13: 978-1541618510]

Bibliography



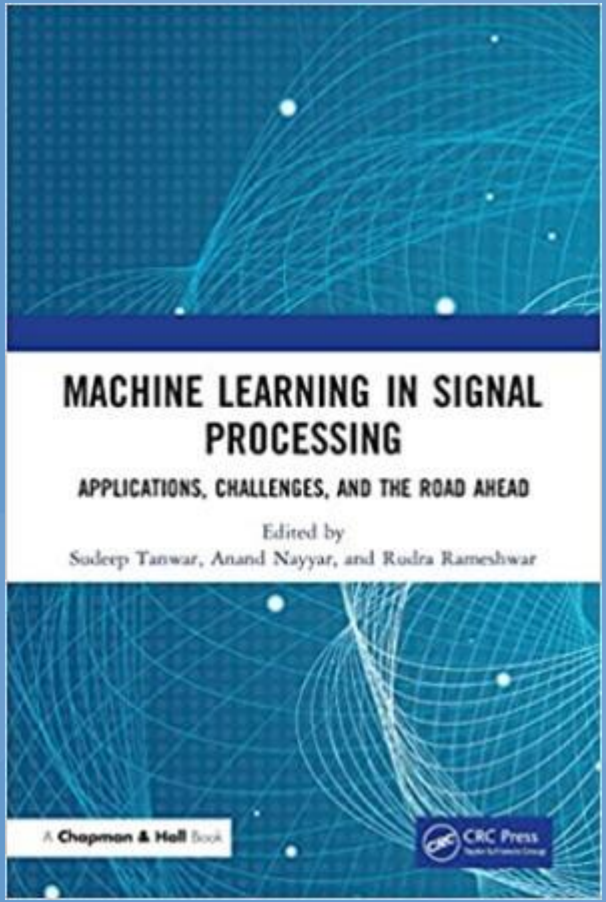
Stamile, Claudio; Marzullo, Aldo; and Deusebio, Enrico: **“Graph Machine Learning: Take graph data to the next level by machine learning techniques and algorithms”**, Packt Publishing, 338 pages, June 25, 202. [ISBN-13: 978-1800204492]

Bibliography



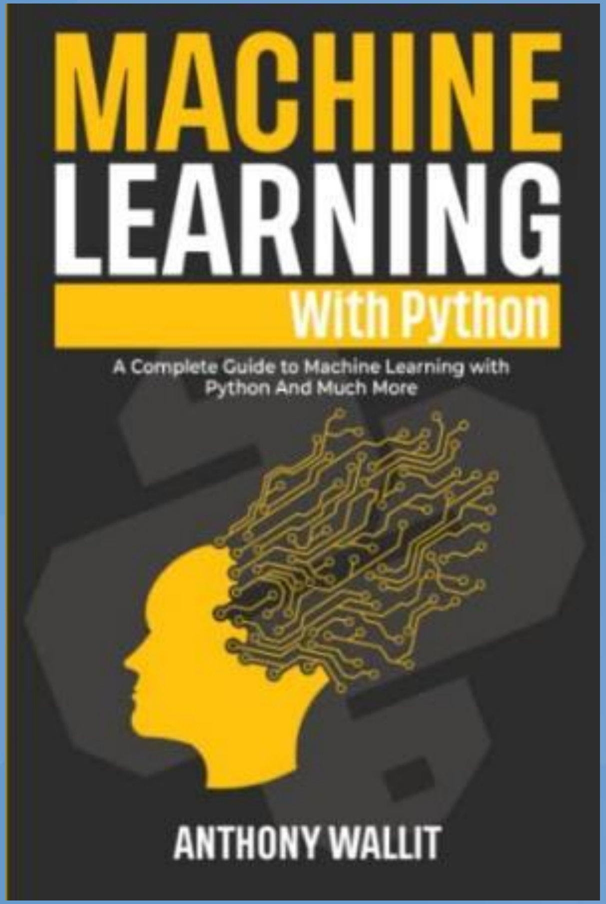
Talagala, Nisha; and Ghanta, Sindhu: **"Fundamentals of Artificial Intelligence: Volume 1 Introduction to Artificial Intelligence"**, Independently Published, 280 pages, May 11, 2022. [ISBN-13: 979-8413761205]

Bibliography



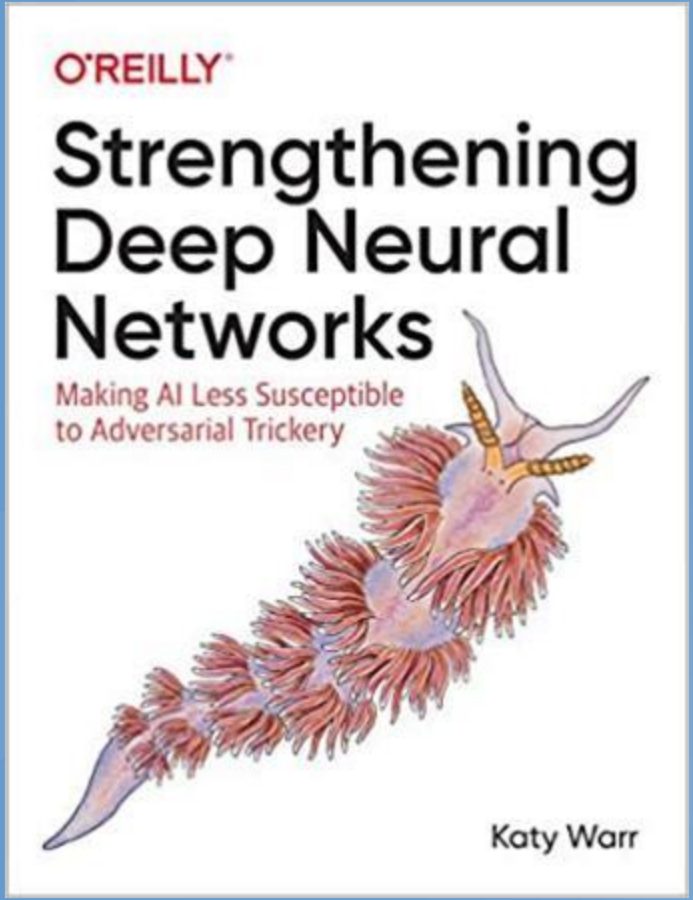
Tanwar, Sudeep; Nayyar, Anand; and Rameshwar, Rudra; Editors: **“Machine Learning In Signal Processing: Applications, Challenges, and the Road Ahead”**, Chapman and Hall, CRC Press, 1st Edition, 368 pages, December 10, 2021. [ISBN-13: 978-0367618902]

Bibliography



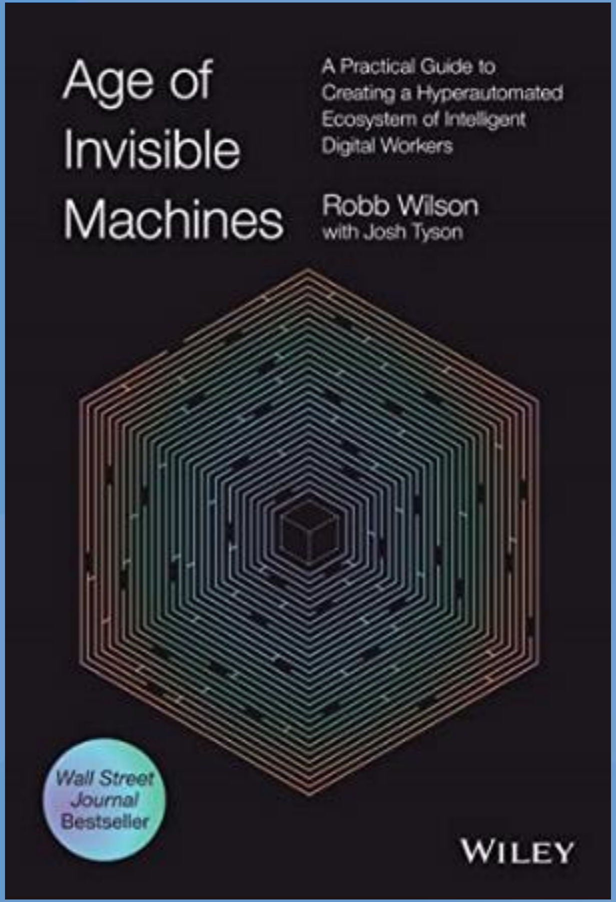
Wallit, Anthony: **"Machine Learning with Python: A Complete Guide to Mastering Machine Learning in Python and a Problem-Guide Solver to Creating Real-World Intelligent Systems"**, Independently Published, 196 pages, October 26, 2022. [ISBN-13: 979-8360472209]

Bibliography



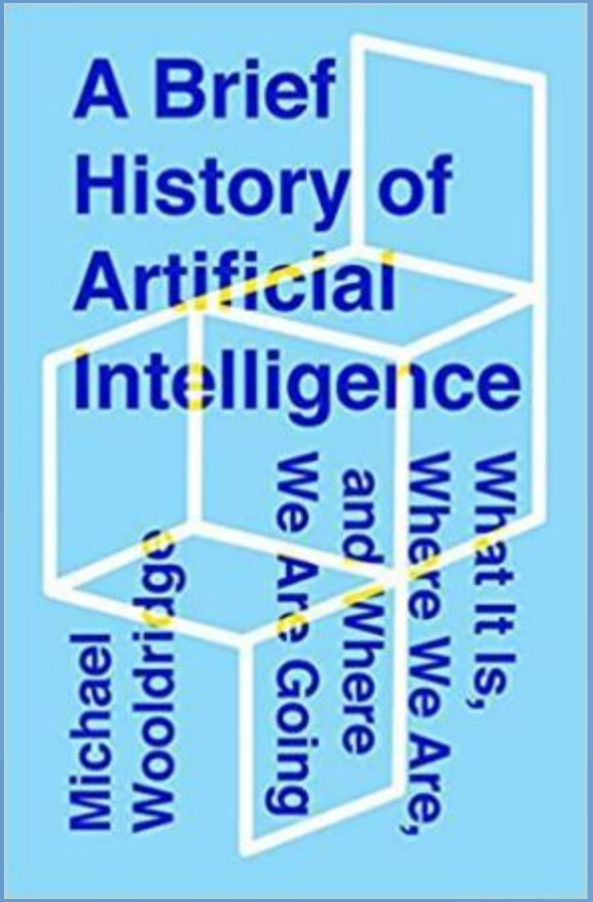
Warr, Katy: **"Strengthening Deep Neural Networks: Making AI Less Susceptible to Adversarial Trickery"**, O'Reilly Media, 1st Edition, 246 pages, August 20, 2019. [ISBN-13: 978-1492044956]

Bibliography



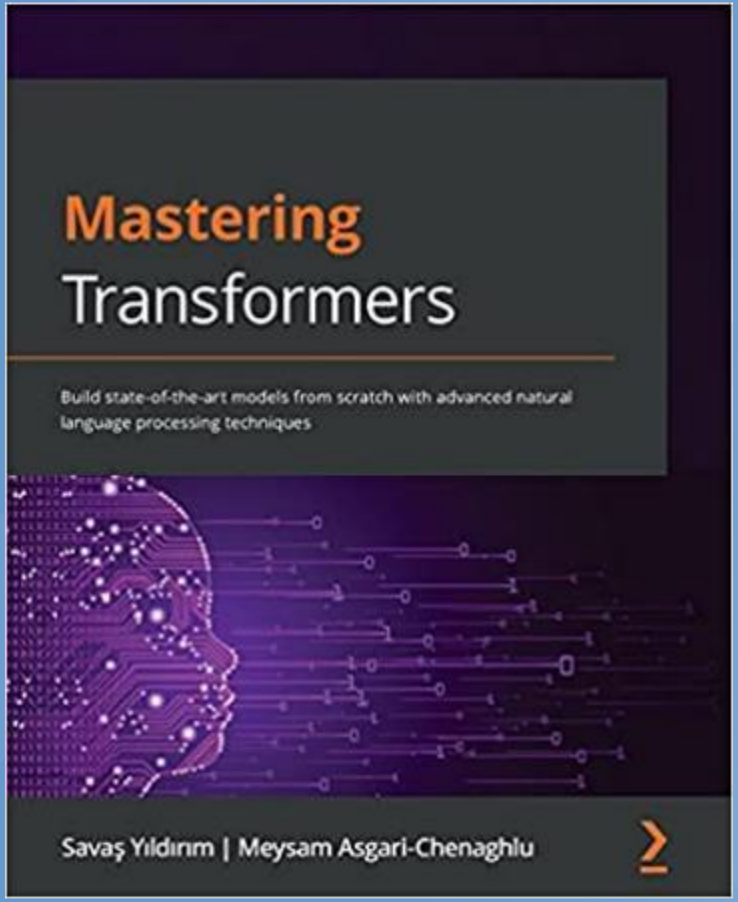
Wilson, Robb; with Tyson, Josh: **"The Age of Invisible Machines: A Practical Guide to Creating a Hyper-automated Ecosystem of Intelligent Digital Workers"**, Wiley, 1st Edition, 288 pages, September 27, 2022. [ISBN-13: 978-1119899921]

Bibliography



Wooldridge, Michael: **"A Brief History of Artificial Intelligence: What It Is, Where We Are, and Where We Are Going"**, Flatiron Books, 272 pages, January 19, 2021. [ISBN-13: 978-1250770745]

Bibliography



Yıldırım, Savaş; and Asgari-Chenaghlu, Meysam: "Mastering Transformers: Building state-of-the-art models from scratch with advanced natural language processing techniques", Packt Publishing, 374 pages, September 15, 2021. [ISBN-13: 978-1801077651]

FCC Technological Advisory Council Agenda – December 8, 2022

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	AI/ML WG Presentation
12:00pm – 1pm	Lunch Break
1pm – 1:45pm	Advanced Spectrum Sharing 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)

December 8, 2022

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2:30pm – 2:45pm	Closing Remarks
2:45pm	Adjourned

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: December 8th, 2022

2022 Spectrum Sharing Work Group Participants

Ames, Robert	VMware
Arefi, Reza	Intel
Badipour, Bahman	FCC
Balachandran, Kumar	Ericsson
Brake, Doug	NTIA
Brenner, Dean	Consultant
Chandra, Ranveer	Microsoft
Claudy, Lynn	NAB
Clegg, Andrew	Wireless Innovation Forum
Daly, Brian K.	AT&T
Doczkat, Martin	FCC
Drobot, Adam	Open Techworks
Etemad, Kamran	FCC
Flack, Matt	FCC
Ghosh, Monisha	Notre Dame

Golsahi, Navid	FCC
Guess, Lisa	Cradlepoint
Gurney, Dave	Motorola Solutions
Gyurek, Russ	Cisco
Ha, Michael	FCC
Hatfield , Dale N.	University of Colorado
Jindal, Manish	Charter
Lanning, Steve	Viasat
Lapin, Greg	ARRL
Mahdi, Kaniz	Deutsche Telecom
Manner, Jennifer	Echostar
Mansergh, Dan	Apple
Marcus, Michael	Northeastern U
Markwalter, Brian	CTA
Merrill, Lynn	NTCA

Mukhopadhyay, Amit	Nokia
Nasielski, Jack	Qualcomm
Noland, Madeleine	ATSC
Oros, Nick	FCC
Pavlak, Bob	FCC
Peha, Jon	CMU Metro21 Smart City Institute
Russell, Jesse	incNetworks
Sawanobori, Tom	CTIA
Schulzrinne, Henning	Columbia U
Scott, Andy	NCTA
Welsh, Patrick	Verizon

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Agenda

- Group Charter
- Summary of discussions and key recommendations by Topic Area
- Speakers
- 2023 Follow-on

Advanced Spectrum Sharing WG - 2022 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

Prefatory Remarks on Spectrum

- In general, radio spectrum is increasingly important to our social and economic welfare and to homeland security and national defense
- In the U.S., there are generally three spectrum management models. Each provides value and benefits various use cases. These models are:
    - Licensed- generally commercial services such as mobile communications
    - Unlicensed – generally used for Wi-Fi
    - Shared – example is CBRS, this is technology agnostic
- Incentives/disincentives affect the behavior of institutions and people and, while we do not always acknowledge and often face challenges in changing or managing them, they frequently dictate whether policy initiatives are successful; as in other situations, economic incentives are especially important in spectrum management as a means of encouraging spectrum sharing, along with technical parameters that improve spectrum sharing.

Topic 1: Potential Shared Spectrum Bands in 7 – 24 GHz and > 95 GHz - Discussion

- Presentations on both active and passive needs of spectrum users from Comsearch, Qualcomm and MIT Haystack Observatory.
- Created a catalog of federal and commercial allocations in 7 – 24 GHz.
  - Preliminary list of potential bands for new allocations, taking into consideration existing allocations and performance constraints.
- Summarized current uses (and uncertainties) of spectrum above 95 GHz
- Some of the following issues were discussed:
  - Which sub-bands are appropriate for sharing/clearing/etc.
  - Can we extend existing sharing techniques from sub-6 GHz to higher bands, or are new techniques needed?
  - Are specific types of secondary uses most compatible with a given sub-band? For example, what are the characteristics of secondary users, such as channelization, etc.
  - Global aspect of sub-bands
  - How/whether to consider adjacent band (even adjacent channel) compatibility issues?
  - How to consider future evolution (or flexibility) of incumbencies, adjacent bands, etc.?
  - What are the primary incumbent services in these bands?
  - What should be the coexistence mechanism(s): lightly licensed (i.e., CBRS GAA), licensed (i.e., 3.45 GHz; AWS); local area licensing (e.g. UK & Europe); and/or unlicensed (i.e., 6 GHz)?
  - How to share in some passive bands above 95 GHz?

Topic 1: Potential Shared Spectrum Bands in 7 – 24 GHz - Key Recommendations

- FCC and NTIA should work together to perform a detailed quantitative assessment similar to the one that was done in 2016 for select bands up to 3.5 GHz: https://www.ntia.doc.gov/report/2016/quantitative-assessments-spectrum-usage
- Public information about actual spectrum usage (not just allocations) should be collected in an online website, e.g. SpectrumWiki which should be kept updated. Classified information could be made available to stakeholders with security clearances in a process similar to how the National Spectrum Consortium is managing access for lower 3 GHz analyses.
- The working group's preliminary list of potential bands suitable for sharing, based on the limited information available at this time are listed below:
  - 10.7 – 13.25 GHz for sharing with non-federal satellite (there is a NOI on 12.7 – 13.25 GHz)
  - 14.0 - 14.75 GHz for sharing with space research and federal users (mobile and satellite uplink)
  - 17.8 – 18.6 GHz and 18.8 – 20.2 for sharing with federal satellite
- Potential sharing models in these bands may include the following options. Each provides value and benefits:
  - Contiguous exclusively licensed spectrum
  - Non-contiguous exclusively licensed spectrum
  - A mix of exclusively licensed and shared spectrum.
  - Non-exclusive licensed and non-licensed shared spectrum
  - Locally licensed (geo-fenced) shared spectrum
  - Private use shared spectrum
- Assess other bands (such as 7-8 GHz) once more information is available from NTIA on band use by federal agencies

Topic 1: Sharing above 95 GHz - Key Recommendations

- FCC should work with passive spectrum users to create and update listings of passive uses (such as the location and frequency bands of terrestrial observatories) and, in the case of satellite use, include ephemeris data so satellite overpasses can be predicted in advance to implement protections. Access to these data could enable new sharing options such as:
  - Minimizing high elevation angle sidelobe levels since low elevation paths are generally absorbed by atmosphere before they can reach satellites)
  - Techniques such as the use of MIMO-like antennas to produce a null on (Az, El) of NGSOs as they pass over could be used if ephemeris data were available
  - Dynamic routing: only links with acceptable impact on EESS(passive) NGSOs as they pass over

Topic 2: Best Practices for Spectrum Sharing - Discussion

- Presentations from Comsearch and WinnForum on lessons learnt from past spectrum sharing systems: TV White Spaces, CBRS and 6 GHz.

- Work product: White paper on "Recommendations to the Federal Communications Commission Based on Lessons Learned from CBRS".

- Some of the following issues were discussed:
  - We seem to be looking at each sharing framework anew each time. Can we identify commonalities for future shared spectrum systems, based on learning from TVWS and CBRS?
  - How band-specific should these sharing mechanisms be?
  - Can sharing mechanisms like low-power indoor devices without AFC be extended into new bands?
  - Are there robust methods of identifying if devices are "indoors"?
  - What are some of the considerations related to aggregate interference (its estimation and its actual impact)?
  - Challenges related to incumbent sensing
  - Improved propagation models for spectrum sharing
  - How do we react to reported cases of interference, how do we record & measure it, and how do we effect enforcement when necessary?
  - Can centralized spectrum management systems be "deputized" to enforce FCC rules?
  - How can we move to more dynamic operations (compared, for example, to CBRS)?

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Topic 2: Best Practices for Spectrum Sharing - Key Recommendations

- Based on lessons learned from CBRS:
  - Utilize an effective and time-efficient method for certifying and then re-certifying centralized spectrum management systems as they incorporate system enhancements, including better propagation models and other technical improvements, to improve sharing efficiency.
  - Explore simplifying the manner in which aggregate interference is taken into account for interference protection.
  - Avoid the required use of dedicated sensing networks similar to ESC as the sole enabler of shared spectrum. Consider other options such as IIC.
  - Undertake a study of modernizing the Commission's licensing databases, and making them more agile so as to more quickly respond to changing needs.
  - Set expectations clearly for all parties when it comes to shared spectrum, especially as it relates to secondary coexistence.
  - Proactively publish or reference dedicated information with respect to band encumbrances (both in-band and adjacent bands) and the possible impact to shared users of the band, prior to auction.
  - Consider how system virtualization impacts future shared spectrum frameworks, and whether modifications to the standard hardware certification process are needed.
  - Consider more concrete steps to facilitate coexistence at band edges when rule changes are made that can negatively impact one or more existing services.
  - Consider the extent to which regulatory certainty can be provided for the future status of a potentially shared spectrum band (for example, by establishing a long-term spectrum plan coordinated with NTIA) before the sharing framework is proposed and implemented.

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Topic 2: Best Practices for Spectrum Sharing - Key Recommendations

- FCC should continue and perhaps expand the practice of adopting varying power levels for shared use based on considerations such as geography, proximity to incumbents, protection of peer users, and whether a device is using a spectrum coordination system.
- The FCC should consider examining the local licensing model used in, for example, the UK, and the pros/cons of such models for applicability in the United States.

Topic 3: Receiver Standards and Technology Advances - Discussion

- Speakers from Google and Silicon Flatiron on receiver performance metrics.
- Some of the following issues were discussed:
  - What degree of interference is acceptable to an incumbent in a particular band, and should the responsibility of mitigation fall on the new entrant rather than the incumbent, even if the new entrant is adjacent channel?
  - Should we define a level of interference that the incumbent must be able to accept, i.e. define “harm thresholds”?
  - If yes, how do we account for legacy devices?
  - Smart antenna technologies are primarily being deployed to improve performance (throughput, coverage, density): how may they be better leveraged for spectrum sharing (i.e., directionality, including directionality of nulling)?
  - Do advanced filters play a role? Are there operational limitations to filters and their impact on the ability to share spectrum? What are the costs/benefits?
  - Is there an interplay between spectrum sharing and increased risk for security and resiliency, both for the incumbent and the secondary user?

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Topic 3: Receiver Standards and Technology Advances - Discussion

- There is an open Notice of Inquiry (NOI) on Receiver Standards. The comments and reply comments in the proceeding were discussed in detail within the group. However, we do not have any key recommendations for this topic area since the record on this topic is quite complete in most aspects.

Topic 4: Interference Modeling - Discussion

- Speakers from FCC (OET) presented on the use of Kriging to develop models for predicting coverage.

- Some of the following issues were discussed:
  - The need for better modeling of potential sources of interference.
  - Spatial interference rejection potential of Massive MIMO arrays.
  - Propagation models focused on interference modeling rather than coverage
  - How to avoid multiple "worst-case" assumptions (i.e., application of joint statistics)?
  - In a broader sense, how should we deal with statistics of interference, rather than static/deterministic interference calculations? "Risk-informed analysis"
  - How to adapt interference modeling based on real-world measurements and sharing experience?
  - How can potential interference scenarios be tested at-scale prior to rulemaking?
  - Testbeds, in academia (e.g. PAWR), industry and government labs like ITS.
  - Industry-accepted interference models for accurate simulations.
  - Lab testing
  - Timely testing with all stakeholders engaged can avoid last-minute delays caused by interference concerns.

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Topic 4: Interference Modeling - Key Recommendations

- The FCC should continue exploring evaluating the development of propagation and interference models using real-world signal strength data, e.g. from crowdsourced measurements and use tools such as Kriging and AI/ML, to predict performance and interference.

- The FCC should investigate how the data sets they are collecting through their speed test app could be made available to researchers to facilitate the further development of propagation and interference models.

Topic 5: Economic Incentives of Shared Spectrum - Discussion

- Speakers from Silicon Flatirons and Clemson University presented to the group.

- The following issues were discussed in depth:
  - Impacts to legacy systems: is it more economically efficient to pay for legacy systems to upgrade? Is this a viable option in all cases? Most cases? Few cases?
  - What are the components of legacy systems that need to be addressed? (Front-end filter, pre-amps, IF filters, etc.)
  - Impacts to incumbents
  - Impacts to the new entrants
  - Nobel Prize winning economist Ronald Coase developed the Coase Theorem which provides a theoretical means for resolving conflicting property right claims in a way that the maximizes economic output, or, to state it in spectrum terms, ensures that the economic gain from the increased interference to incumbent spectrum users more than offsets the economic harm it produces.

Topic 5: Economic Incentives of Shared Spectrum - Key Recommendations

- The FCC and NTIA should focus increased attention on promoting economic incentives for entities to voluntarily share spectrum.
- The FCC and NTIA should examine pathways to gather information from incumbent spectrum users to facilitate better analyses of spectrum value and sharing constraints.
- The FCC and NTIA should continue to facilitate the use of voluntary, market-based approaches to spectrum sharing or leasing, by removing unnecessary impediments to such transactions as appropriate.
- It is recommended that the FCC continue to facilitate or emulate Coasian bargaining.
- It is recommended that the FCC determine a metric or metrics to assess the comparative spectrum utilization between exclusive use and shared use.
    - Include relocation impacts (both drawbacks and benefits), incumbent disruption of shared use, auction revenue impacts, etc.

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Topic 5: Economic Incentives of Shared Spectrum - Future Work

- Critically review proposals (academic and otherwise) for reducing the friction in spectrum markets and encouraging innovation, competition and investment by, for example, (a) providing information on the spectrum environment both current and future, (b) establishing a new, more efficient “depreciating license” as proposed by Nobel Prize winning economist Paul Milgrom and colleagues, (c) adopting the proposal by Mark Bykowsky and William Sharkey that suggests Interference Limits and market forces can promote the efficient co-existence of radio systems and
  - Based on the reviews, develop strategies for moving the most promising proposals toward adoption in the Commission’s rules and policies.
  - Investigate technical approaches that maximize spectrum value.

Speakers

- March 22, 2022: Mark Gibson, Comsearch, Overview of Shared Spectrum, 7/8 GHz
  - Topic 1, Topic 2
- March 29, 2022: Preston Marshall, Google, Receiver Expectations
  - Topic 3
- April 05, 2022: Tingfang Ji, Qualcomm, 6G in 12.75 GHz
  - Topic 1
- April 26, 2022: Pierre de Vries, Silicon Flatirons, Harm Claim Thresholds
  - Topic 3, Topic 5
- May 10, 2022: Phil Erickson, MIT Haystack Observatory, Passive Sharing
  - Topic 1
- July 12, 2022: Bob Baxley, Zylinium, Dynamic Spectrum sharing
  - Topic 2
- August 02, 2022: Thomas Hazlett, Clemson University, Economics of Spectrum Sharing
  - Topic 5
- August 30, 2022: Mark Gibson, Comsearch, Lessons learnt from 6 GHz AFC
  - Topic 2
- November 08, 2022: Chrys Chrysanthou and Barbara Pavon, FCC OET, Using Kriging to Predict Wireless Coverage.
  - Topic 4

Follow-on Work

Follow-on Work

- The Advanced Spectrum Sharing WG spent most of its 2022 session gathering information from SMEs and having substantive discussions on the complex topic of spectrum sharing in new bands.
- We have not had sufficient time to reach consensus on additional important topics under each major topic area and develop additional work products like white papers. We propose to continue working on the 5 major topic areas identified and explore new ones.
  - The group would like to revisit the 2015 TAC White Paper, “Basic Principles for Assessing Compatibility of New Spectrum Allocations,”
  - https://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting121015/Principles-White-Paper-Release-1.1.pdf
  - Investigate new sharing schemes which could be better suited to new bands and use-cases.
- We recommend that the FCC consider extending the work of the group through the 2023 session under its current charter.

Thank You

FCC Technological Advisory Council Agenda – December 8, 2022

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	AI/ML WG Presentation
12:00pm – 1pm	Lunch Break
1pm – 1:45pm	Advanced Spectrum Sharing 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: Michael Ha, Martin Doczkat, Kamran Etemad, Nicholas Oros, Sean Yun

Date: December 8, 2022

Outline for FCC TAC Formal Readout December 8 2022

- WG participants
- Charter
- Invited SMEs overview
- 6G Standards, Roadmap and Advisements
- 6G Technology Ecosystem Observations
- Recommendations/Advisements Summary
- 2023 6G Working Group (proposed) Focus Areas

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2022 6G Working Group Team Members

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

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6G WG - 2022 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?

Bottom Line Up Front

- **6G Development Timeline**
  - 5G Deployments are still nascent and potential impact still needs to be realized.
  - 5G Advanced Evolution to continue for future 3GPP Releases (18,19)
  - 6G Fundamental research is underway with Federal and Industry Investments
  - ITU defined IMT-2030 and twinning with WRC23 will set 6G radio performance requirements
  - 6G is an undefined formal term not adopted by any SDO or Consortia.

- **Spectrum Needs**
  - Mid Band: >500MHz in 7-24 GHz, enhancements to existing sharing mechanisms needed?
  - Sub THz: 100-1000 GHz for highly demanding use cases: Immersive comms, cobots
    - Policy is nascent
    - To achieve 1 Tbps, 50GHz spectrum is required in the 300 GHz-1 THz domain
  - Heterogeneity of access: Space,Aerial,Terrestrial Integrated Networks requires coordination

- **O-RAN and Open RAN Security**
  - Focus on demonstrating multi-vendor interoperability in disaggregated O-RAN Networks
  - Federal incentives need to align with subsystem integration and demonstrate performance parity with legacy networks
  - Securing the Open Fronthaul interface real time system from targeted attacks

- **6G Use Cases and Application Verticals**
  - Focus on application centric view with Multi-sensory and Immersive Communication use cases are quickly emerging
  - Emergence of Key Value Metrics (KVI) beyond traditional metrics for 5G
  - Focus on energy efficiency, sustainability, inclusion and deployment economics

- **mmWave and Sub-THz**
  - Opportunity: joint comms and sensing, large transmission bandwidth, indoor and personal area network deployment
  - Challenge: High mid-band value for deployment scenarios, very high path loss
  - Focus on highly directional systems

6G WG Advisements

- ITU-R performance requirements analysis and WRC 23 proceedings will have profound impact on development of 6G component technologies and architecture. Continue monitoring these forums and report out key contributions as part of 2023 TAC agenda.
- The 5G->5G Advanced journey within 3GPP continues to take shape with future Rel 18, 19 study items adopting native AI/ML, comms and sensing and metaverse service applications.
- Consolidation and convergence of 6G roadmaps and technology areas from various consortia and alliances will be key to keep abreast of Industry consensus.
- Open RAN technology development and deployment acceleration needs to monitored continuously to understand to understand evolution towards secure, interoperable deployments
- 6G spectrum needs across mid band and higher frequency bands will be tightly coupled with use cases required to support with respect to latency, capacity, reliability, energy efficiency, positioning/sensing accuracy as well as spectrum sharing potential with incumbent services

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Working Group SME Presenters

SME Speakers

Organization	Topic	Speaker	Summary
AT&T	ITU-R process for IMT	Marc Grant (ATT)	• Described IMT terrestrial component radio interface development process • Shared Draft timeline "IMT towards 2030 and beyond" • ITU WRC and ITU-R Study process are interrelated and collaborate to be globally harmonized
NEXT G ALLIANCE An ATIS Initiative	6G Roadmap Overview	Mike Nawrocki Amitava Ghosh Douglas Castor (NextGAlliance)	• Described Initiative to advance North American mobile technology leadership over the next decade through private sector-led efforts. • 6G Technology Roadmap focused AI-native distributed cloud and communication systems to meet application requirements with key focus on resiliency, energy efficiency, and sustainability.
Institute for the Wireless Internet of Things at Northeastern University	Wireless Networks Operating in the THz Band	Dr. Josep Jornet (NEU)	• Described opportunities at THz bands for joint communication and sensing using extremely large bandwidth • Described technical challenges and advances to use plasmonics based Massive MIMO systems, wavefront engineering and modulation schemes to mitigate.
O-RAN ALLIANCE	6G proposed capabilities	Scott Poretsky Paul Smith Arda Akman (O-RAN Alliance)	• Described O-RAN Alliance charter, membership and structure including updates to specification development, release of open source software and plugfests to test vendor interoperability and promote deployment of Open Radio Access networks using the Option 7.2x Functional Split • Described approach to standardization harmonization with ETSI • Shared technical challenges on security of O-RAN networks with larger attack surface, threat vectors and shared work of O-RAN Security Focus Group (SFG)

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SME Speakers

Organization	Topic	Speaker	Summary
	German 6G Research Initiatives / 6G Platform	Falko Dressler (TU-Berlin)	• Shared vision of German 6G Program and development of research hubs with 160 research groups at 21 universities and 15 research institutes. • Research Focus on New NTN topologies, information theoretical concepts, open architectures, quantum, security, resiliency and privacy driven approach.
	6G system for ubiquitous computing	Clara Li Geng Wu (Intel)	• Shared vision for wide area cloud with ubiquitous computing across devices, network nodes and data centers. • Shift from radio paradigm to services and systems focus.
	Silicon Technologies for 6G sub-THz	Ned Cahoon (Global Foundries)	• Explained component and silicon advances for high frequency 6G RF circuits (PA,LNA) and phased array systems • Shared comparative analysis of SiGe,GaN,InP across technology,packing,spacing and thermal benchmarks for 6G.
	ITU-R:Future Technology Trends Report	Marc Grant (ATT)	• Shared a report produced by ITU WP 5D providing a broad view of future technical aspects of terrestrial IMT systems considering the time frame up to 2030 and beyond • Key drivers include requirements for:Energy Efficiency/Data Rate/Latency/Jitter/Sensing resolution and Accuracy/Coverage and Spectrum utilization
	O-RAN Alliance Next G Research Group (nGRG)	Dr. Chih-Lin I (O-RAN Alliance)	• Described new forum to facilitate O-RAN ALLIANCE related 6G research efforts and to publish research findings • Vision to unify the 6G technology path/timeline to avoid incompatibility b/w O-RAN ALLIANCE and other SDOs • Leverage public private partnership model with academia and industry.

SME Speakers

Organization	Topic	Speaker	Summary
	B5G Network Customization for DoD Enterprise: R&D Enablers	Dr Sumit Roy (OUSD DoD R&E)	• Shared DoD perspective on 5G-FutureG program to foster US leadership by investing in Beyond 5G, via partnerships with industry (both commercial and defense industrial base); influence international spectrum access and communications standards via technology leadership. • Focus on identifying dual-use standards feature alignments with industry. • Innovative solutions for shared spectrum access that will lay the foundation for more efficient access to the electromagnetic spectrum.
	Arizona Broadband Policy Past, Present, and Future	Mark Goldstein Jeff Sobotka Sandip B. (Arizona Commerce Authority)	• Social and physical distancing is becoming the new normal requiring unprecedented demand for digital access, including affordable Internet access and other digital inclusion and digital equity resources. • The pandemic has illuminated the long-standing deficiencies in affordable broadband Internet access in Arizona, particularly in tribal, rural and other underserved communities and low-income neighborhoods in Arizona. • As a result, the homework gap is a major issue for many of our students. • Broadband is essential to connect schools, universities, community colleges, homes, libraries, health care facilities, businesses and communities to support education, health care, community services and economic development.
	An Innovation Journey Into A 6G Future	Mischa Dohler (Ericsson)	• Described fundamentals of a 6G network platform across vectors of limitless connectivity, trustworthiness, native AI, and ubiquitous compute. • Suggested KPI(s) for data rate, spectral efficiency, latency and energy efficiency. • Framed challenges on developing a Cyber-physical continuum, self synthesizing networks and zero energy devices to meet human societal needs with 6G.

SME Speakers

Organization	Topic	Speaker	Summary
	ARA Wireless: A Living Lab	Dr Hongwei Zhang (Iowa State University)	• ARA is part of the NSF PAWR program specifically focused on last mile, rural broadband, and agricultural applications • ARA is developing mmWave,mMIMO, Microwave, Free space optical technologies for x-haul on identifying low cost service delivery options.
	Challenges to Rural Carriers	Carrie Bennett (Rural Wireless Association)	• Rural carriers are still struggling to operate 4G networks • Spectrum access remains a challenge working with incumbent licensees who are not using spectrum in the rural operators area of coverage • 6G needs to look carefully at low Total cost of ownership for networks.
	Future Networks: The INGR Vision and the Path to 6G	Ashutosh Dutta (IEEE)	• Provides a sustainable transdisciplinary framework across end-to-end ecosystems in urban and non-urban areas, and caters to different stages of priorities, resources, and technologies. • Foster Cooperation between SDOs and Open-Source Communities. E.g. IEEE-SA Open-Source Program • Foster Cooperation among SDOs/Fora, e.g. ITU-T SG13, TM Forum, BBF,3GPP, IETF, NGMN, O-RAN etc • The 5G & Beyond Testbed Project will bring together industry participants across the broad range of 5G/6G technologies to enable win-win collaboration opportunities and contribute to the roadmap for future technological direction

SME Speakers

Organization	Topic	Speaker	Summary
INTELSAT	7GHz-24GHz Usage and Future from Satellite Industry Perspective	Hazem Moakkit: VP of Spectrum Strategy Salim Yaghmour:	•Satellite use-models are expanding. GEO, MEO, LEO all being applied more to existing and new use cases. •7-24GHz band is central to Satellite industry especially given •Interference to/from Earth stations is an increasing issue with expanding capabilities of Tx (directional) and Rx (sensitivity) on satellites. •7-24 GHz band has significant incumbency with multiple shared users, international regulation, and critical applications (e.g. Earth Exploration Services) •Satellite industry becoming more integrated with mobile communications industry •WRC-23: Three significant agenda topics related to 7-24GHz range
Marcus Spectrum Solutions	>100GHz Spectrum Policy Overview and impact on potential use in 6G	Dr. Michael Marcus, Marcus Spectrum Solutions LLC	● Regulatory issues: FCC/US vs. ITU: ○ 5.340 “All emissions prohibited in certain bands” but ○ WRC 2000 Res 731: “Look for opportunities to share" ● Sharing of passive bands: high-payoff, but difficult challenge: ○ ITU rules state sharing must meet specific protection for both passive satellites & radio astronomy ○ Opening to controlled sharing canl enable new technology for spectrum-based alternatives to fiber optics where fiber is not viable ○ Also enables Terahertz spectroscopy for nondestructive testing and enhance manufacturing productivity

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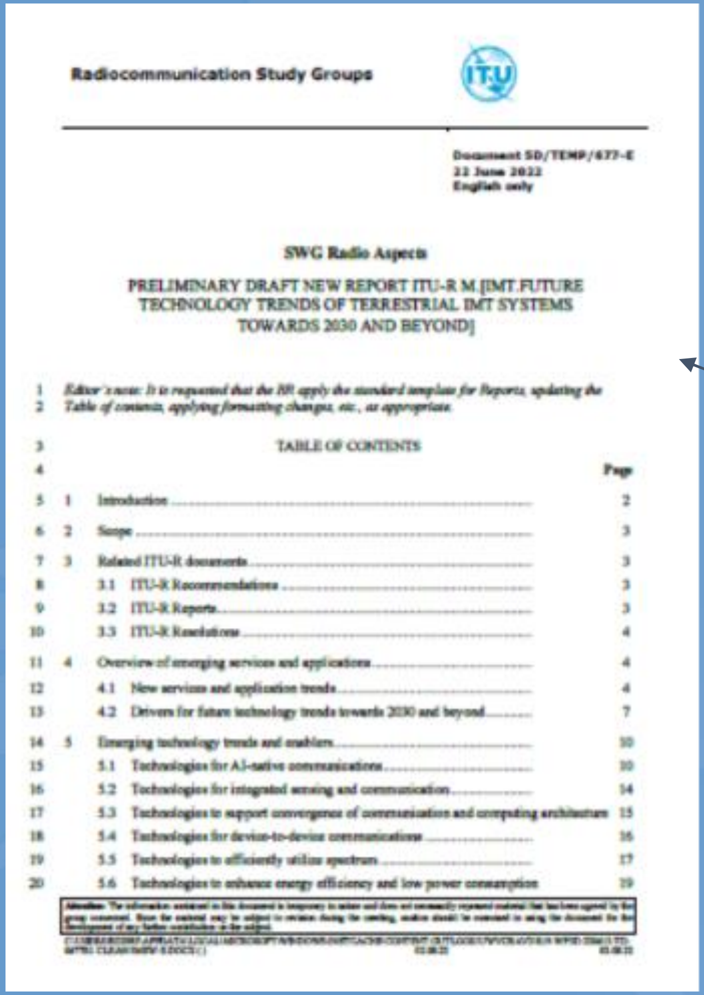
5G, 5G Advanced, & 6G Standards, Consortia Roadmap

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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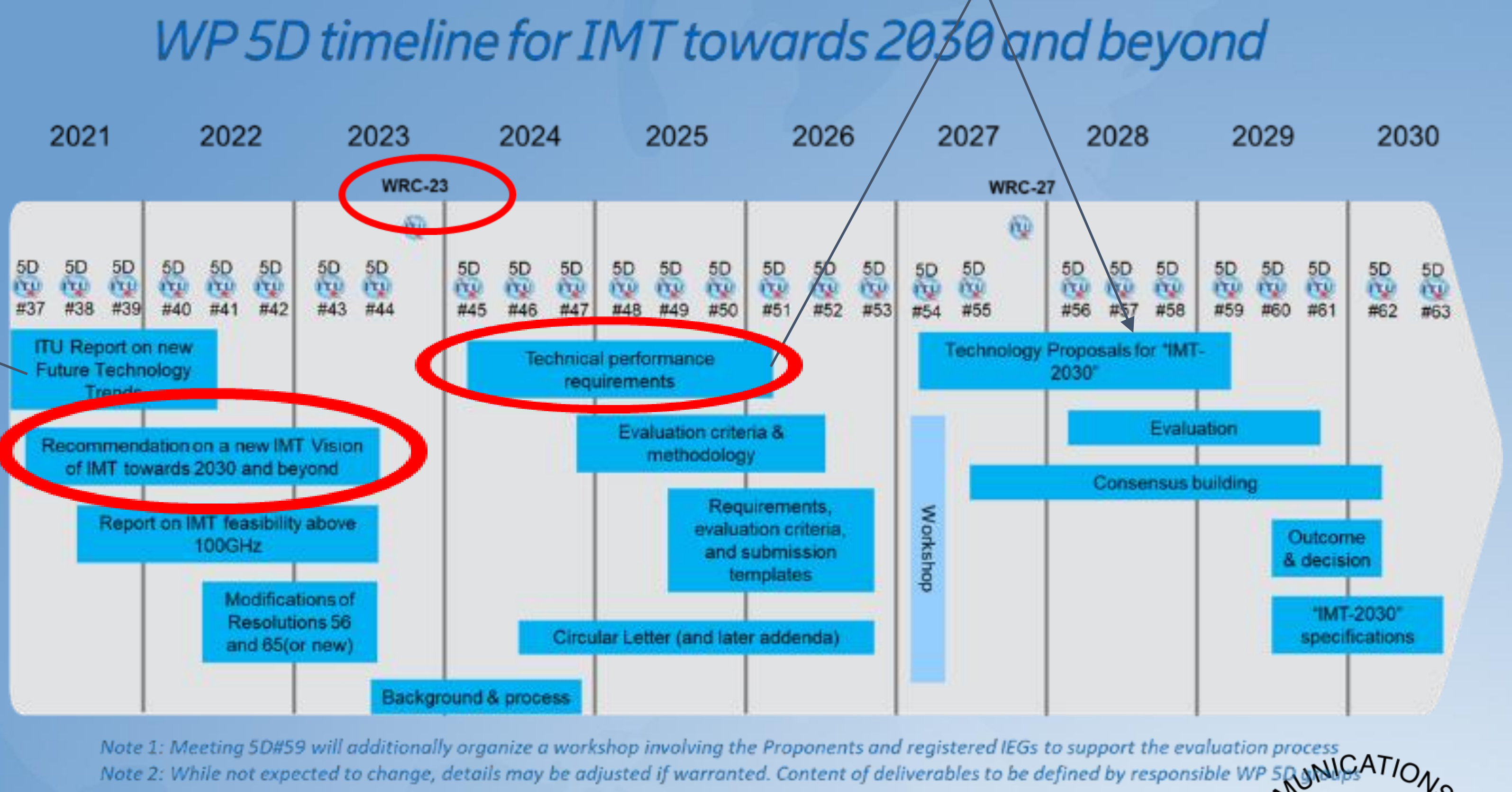
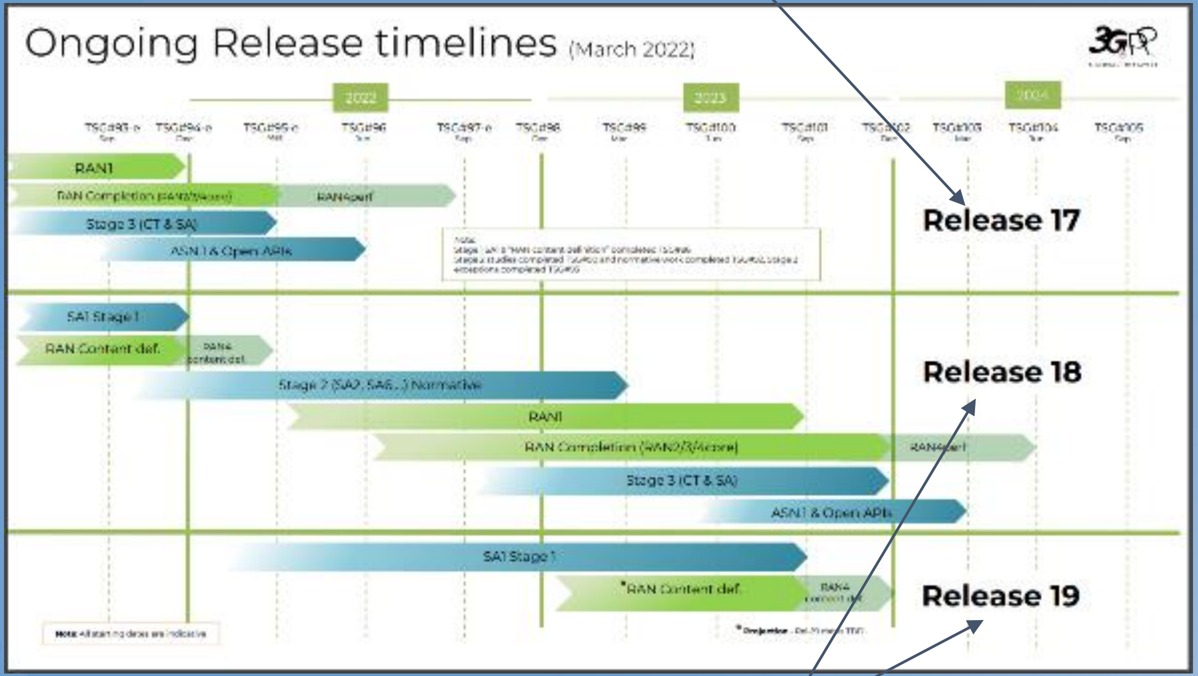


3GPP - 5G to 6G Path



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

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3GPP Release 18

Sampling of Topics

eMBB: Dynamic spectrum sharing, network energy savings, duplex operation evolution, NR sidelink evolution, UL coverage enhancements, smart repeater, CA enhancements, NTN evolution

eMBB and URLLC: Positioning evolution, enhancements for XR, mobility enhancements

Massive MTC: RedCap evolution, low power WUS, small data

Public safety: UAS/UAV/UAM, NR sidelink evolution, multicast/broadcast

Cross domain: AI/ML RAN enhancements, resiliency of gNB-CU-CP

Mobile IAB

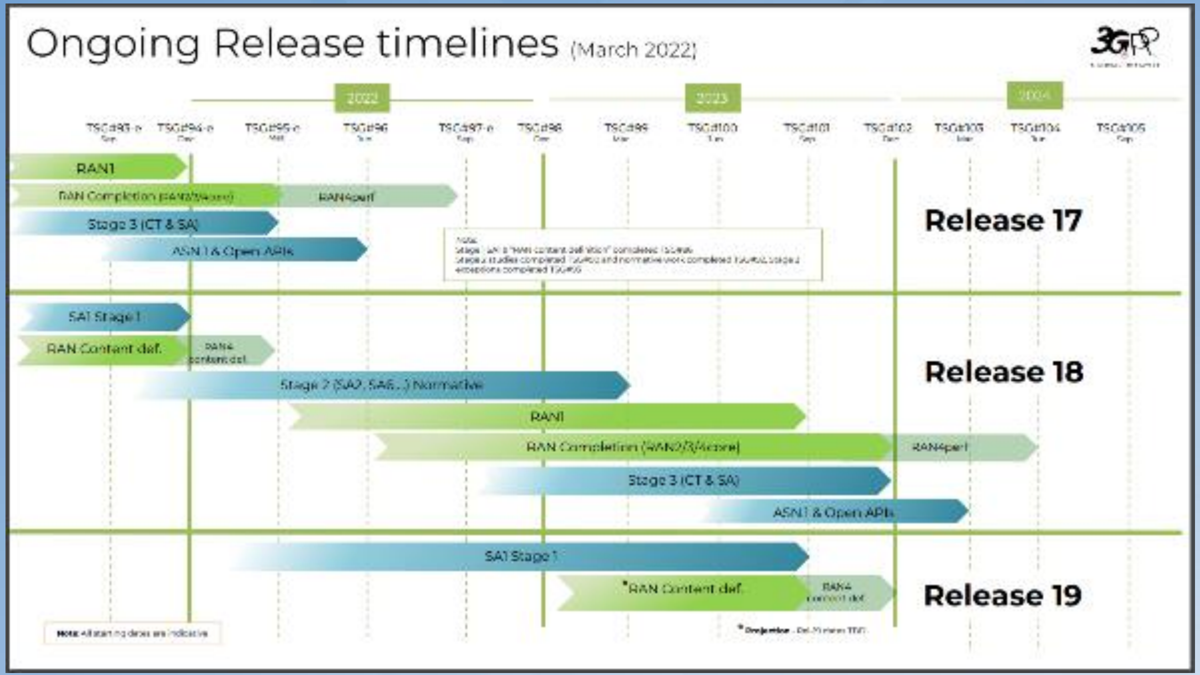
MIMO Evolution for Downlink and Uplink

Network Slicing Phase 3

Edge Computing Phase 2

Non-Terrestrial Networks

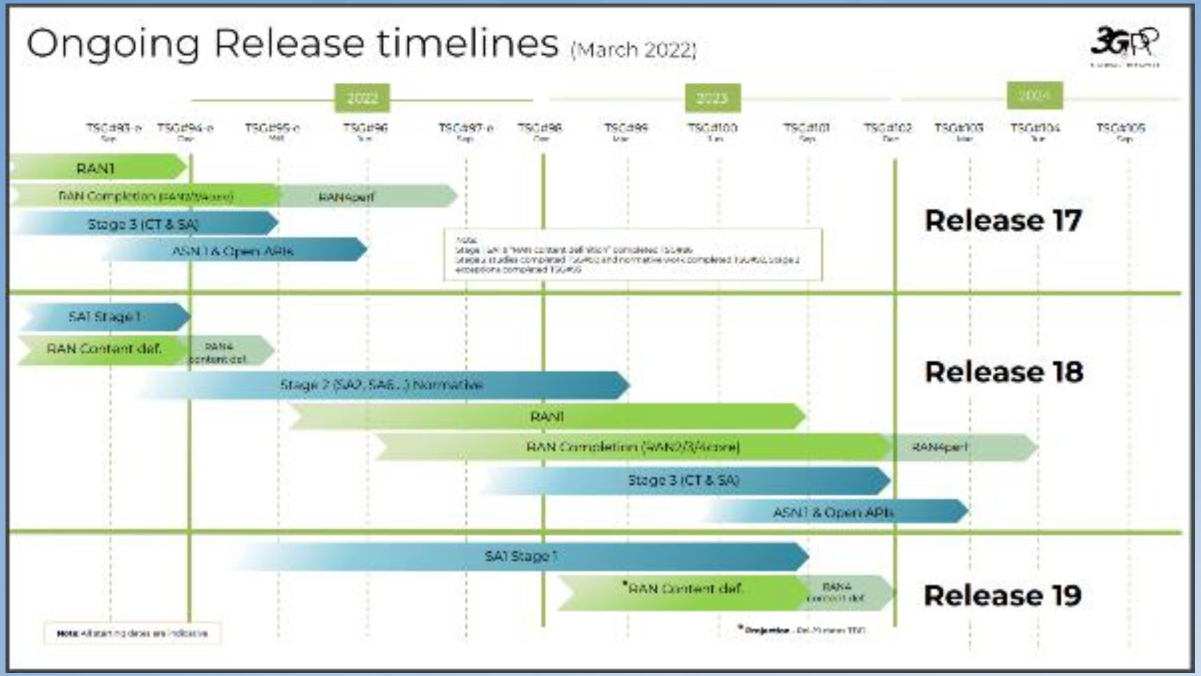
System Support for AI/ML-based Services



3GPP Release 19

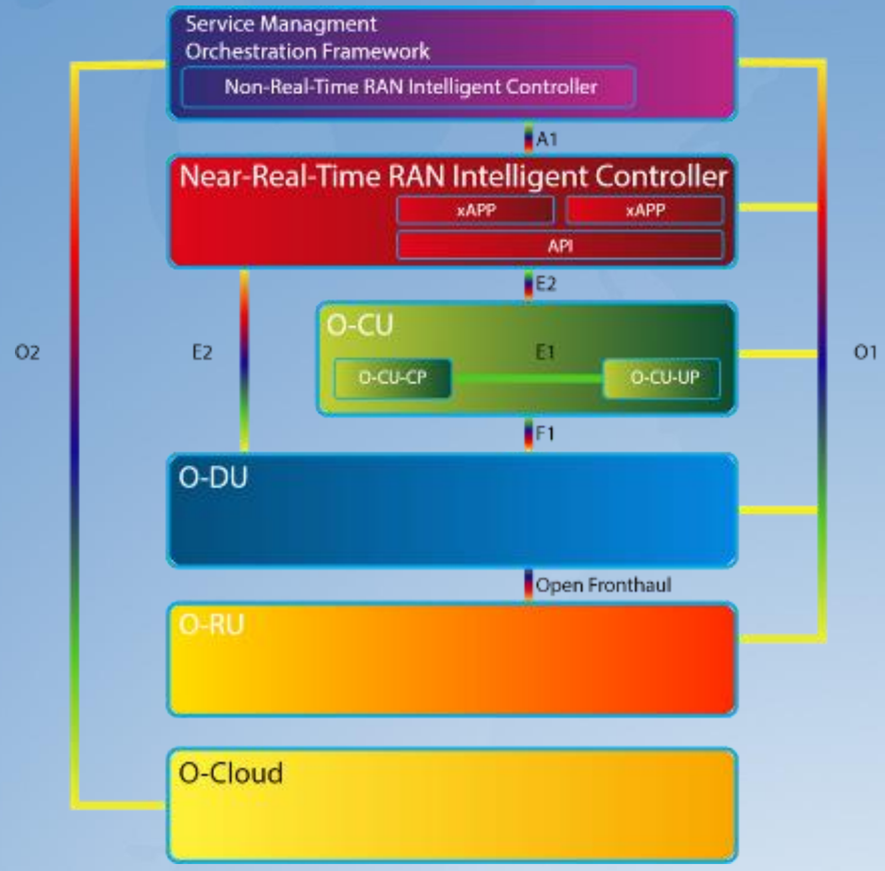
Sampling of Study Topics

- Integrated Sensing and Communications
- Network Sharing Aspects
- Localized Mobile Metaverse Services
- Satellite access - Phase 3
- Network of Service Robots with Ambient Intelligence
- FRMCS (Future Railway Mobile Communication System) Evolution – Phase 3
- Study of AI/ML Model Transfer – Phase 2
- Roaming Value Added Services
- Upper Layer Traffic Steering, Switching and Split over dual 3GPP Access
- Energy Efficiency as Service Criterion
- UAV Phase 3
- Ambient power-enabled Internet of Things

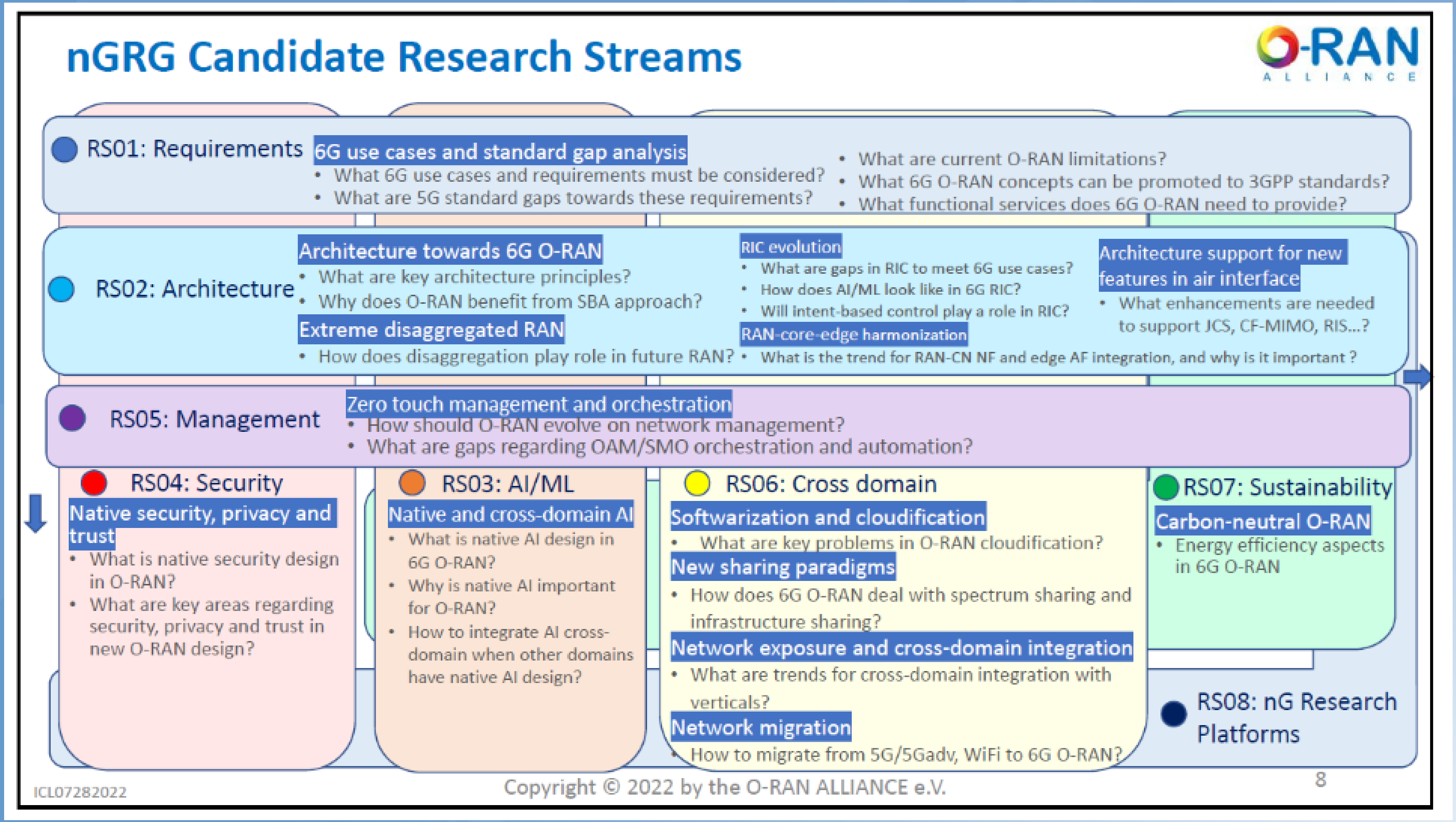


O-RAN ALLIANCE 2022 Updates

- 52 O-RAN ALLIANCE Specifications published since March 2022
- 6th Release of open software for the RAN - “F” - delivered by the O-RAN software community
- 1st certificates awarded in the O-RAN Certification & Badging program by Asian OTICS
  - O-RAN certificates state that an equipment or function is conformant to O-RAN specifications
  - O-RAN badges confirm interoperability or end-to-end functionality of an O-RAN solution.
- WG11: Security Working Group: Security experts from the O-RAN ecosystem have been applying systematic threat analysis on different components of the O-RAN Architecture. CSRIC WG 2 and NSA Enhance security framework have also released vulnerability analysis reports.
- O-RAN testing and integration via global plugfests have demonstrated proof of concepts across energy efficiency, resilience and automated orchestration.
- O-RAN fronthaul control, user and synchronization plane specification, which was submitted earlier this year for adoption by the ETSI Technical Committee Mobile Standards Group through the ETSI PAS (Publicly Available Specifications) process
- O-RAN ALLIANCE has formed its next Generations Research Group (nGRG) to address technology gaps and architectural enhancements for Next generation.



O-RAN ALLIANCE nGRG Candidate Research Streams



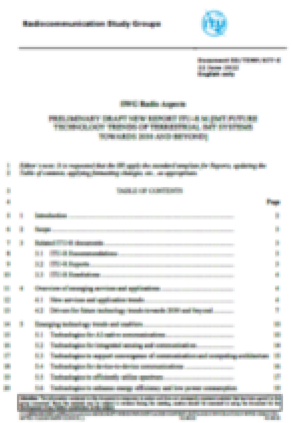
WG Observations

1. Development and Deployment of 6G Technology

6G Planning & Global Research is in Progress

ITU-R WP5D

- IMT towards 2030 and beyond



ATIS Next G Alliance

- Collaboration across U.S. government, academia, and industry to promote U.S. leadership on the path to 6G. (Just announced on Oct. 13)

Founding Members

AT&T	Bell	Charter	ciena
ERICSSON	FACEBOOK	intel	InterDigital
JMA	Microsoft	NOKIA	Qualcomm
SAMSUNG	T Mobile	TELNYX	TELUS
uscellular	verizon	vmware	

...and growing

Other Regions

- China, Japan, S. Korea, EU, Finland, and Brazil launched 6G research programs with industry and academia w/ national strategic funding.

Next G Alliance Audacious Goals

- Top priorities for North America's contribution and leadership
- Selected by Next G Alliance membership
- Address multiple stakeholder interests

Next G Alliance Desired Outcomes

NORTH AMERICAN LEADERSHIP

- Powerful work collaboration across industry, government and academia
- Robust marketplace using innovative applications and technologies that connects society in a new digital world
- Increased ownership of technology advancements that enable the 6G vision

DISTINCTIVE ADVANCEMENTS

(a few examples)

Multi-dimensional, multi-party and multi-sensory experiences

AI-Native, trusted and ethical AI

Higher Frequency (THz/Sub-THz) and multi-use spectrum

Design for Sustainability, reduced energy, zero-energy devices

Transform quality of life and work across healthcare, public safety, and education

6G Planning & US Research Investments are Underway

New NSF Spectrum Innovation Center

International 6G R&D and Innovation Consortium (RDIC)

ComSenTer:
140/220/300 GHz MIMO Testbed to Demonstrate the next generation "6G" Hydra basestation

US DoD Future G to modernize services capabilities and adoption of 5G/6G

JUMP 2.0
Exploratory research on an 8- to 12-year time horizon that is anticipated to lead to defense and commercial opportunities in the 2030–2035 timeframe

New NSF directorate:
Technology Innovations and Partnerships and PAWR Platforms

CHIPS & Science Act

- On August 22, the President signed into law CHIPS and Science Act.
- Includes ~$52.7B to increase domestic semiconductor capacity and another $1.5B for a grant program promoting and deploying wireless technologies that use open and interoperable radio access networks
- establishes a technology, innovation, and partnerships directorate at the National Science Foundation (NSF) to focus on fields like semiconductors and advanced computing, **advanced communications technology**, advanced energy technologies, quantum information technologies, and biotechnology
- NTIA tasked with developing the open RAN grant program

Needs of the telecom industry should be addressed as the funding is allocated

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Semiconductor Research

Innovation pipeline

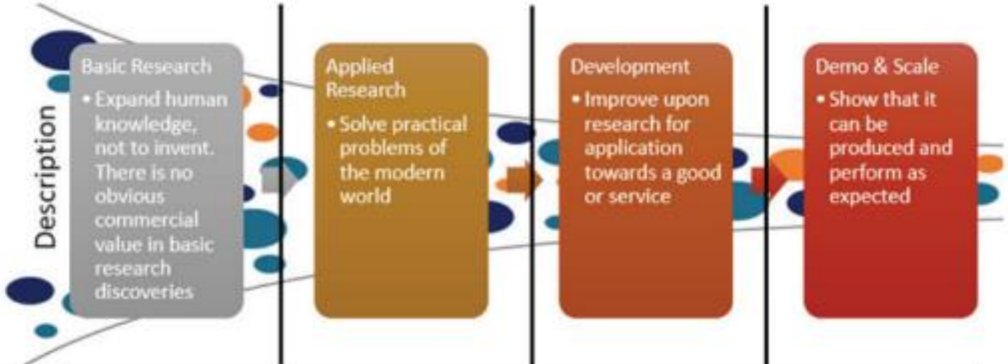
- Create new technology, mature that technology, and manufacture it to strengthen the US economy, strengthen national security, and improve society

Key new programs in the pipeline

- National Semiconductor Technology Centers (NSTC)
- National Advanced Packaging Manufacturing Program (NAPMP)

Telecom industry interest

- Engage with these programs to ensure that innovations in technology and manufacturing benefiting the telecom industry are pursued



Lead performer	Nat labs, NIST, Academia	Academia, Industry	Industry, Academia	Industry
Annual: $3B+ Cost-share	$1,250M low	$250M 1:1		$1- 2B TBD
Gov. Program (commercial)	NSF, NIST, DOE	Microelectronics Manufacturing USA Institute		NSTC, NAPMP
Projects	Basic research User facility projects	Programs/ projects Research centers	10X bigger/ 10X fewer, start-up	10X bigger demo, pilot
IP Model	Open IP	NERF IP	Exclusive IP	Exclusive IP, Revenue %

Figure 7. The U.S. innovation pipeline divided into four segments and their corresponding characteristics.

Source: SRC response to RFI by DoC and NIST:
Incentives, Infrastructure, and Research and Development
Needs to Support a Strong Domestic Semiconductor Industry.

2. Open RAN

Areas for Advisements: O-RAN

Multi-vendor Interoperability

Open RAN architecture introduces a more diverse ecosystem of vendors due to disaggregation and virtualization of traditional network functions.

- Focus on Multi-Vendor testing and produce performance benchmarks
- Monitor federal initiatives such as DoD/NTIA 5G Challenge,which is incentivizing vendor diversity and testing standards compliance of open interfaces.
- TIP, Test facilities in academia and test equipment vendors are testing interoperability

Security

O-RAN Open Fronthaul interfaces form a real-time communication system.Key security objectives produced by CSRIC WG 2 and NSA Enhanced Security Framework highlight:

- Confidentiality and integrity of mobile subscriber data
- Availability to transport 5G control,user and synchronization messages
- Authentication for Open Fronthaul network elements

Advisement and Recommendation: Open RAN Strategy

Why does O-RAN matter to policymakers?

- US government and its allies views concentration of vendors and dominance of a small set of suppliers as a national, economic, and network security threat
- See Open RAN as a vehicle to diversify the supplier chain to include trusted vendors, offer alternatives to existing supply chain and increase American participation in the supply chain.
- Policymakers also recognize the benefits of increased competition, innovation, and potentially lower prices.

Policy Advisements

- Continued Monitoring of government support for open and interoperable networks as part of NTIA Wireless Innovation Fund.(i.e. CHIPS Act)
- Drive adoption of Open RAN based solutions to both achieve scale and performance parity
- Open RAN development through R&D investments, government procurement and financial support for deployment and integration of open and interoperable wireless technologies
- Encourage continued focus on systems integration, security, and cloudification.
- Avoid mandating particular technologies through heavy-handed or prescriptive solutions.

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3. mmWave and THz

mmWave and Sub-THz Opportunities and Challenges:

Opportunities

- Terabit wireless backhaul
- Inter-satellite and Space Networks
- Terabit Wireless Personal Area Network(WPAN) /WLAN
- Joint Communication and Sensing

Huge Transmission Bandwidth <-> Very High Pathloss

Technology and Deployment Gap

- Need for Ultradirectional Antenna Systems,Ultrabroadband Analog Front ends, Ultra High speed Digital back ends
- Need for New, better sharing capabilities to provide additional spectrum access in 300 GHz-1 THz

Recommendation:

Super Directional dynamic beamforming

RIS (Reflective Intelligent Surface) : Reflect Arrays and Metasurfaces

Study impact of THz Comms on incumbent passive services

4. Spectrum Needs

6G Spectrum Needs Analysis

Spectrum Needs Study: Vertical outlook from devices, sub-systems to architecture for sub-THz and THz + low/mid-band needs outside of current NPRM proceedings

6G Spectrum Needs SWG Strategic Priorities

- Anticipate/Optimize Mobile Wireless needs given growing use & other demands
- Set stage for development & innovation in new/existing bands
- Closing the Digital Divide

Problems We Are Trying To Solve

- Which are the most appropriate additional bands for consideration?
- Which use-cases will demand additional spectrum?
- What are the technical ramifications and required innovations to address these new bands?
- What are the most acute co-existence and interference issues that can arise?
- How can we make the best use of spectrum for all users—especially under-served locations & demographics?

Nature of Our Recommendations

- Practical technical considerations for bands new to 6G
- Use-Case considerations for bands new to 6G
- Geographic Area-based licensing considerations for bands new to 6G
- Considerations given the expanding use of Unlicensed and Lightly-Licensed Bands
- Considerations to motivate the operators and their vendors to increase efficiency of existing spectrum use
- Considerations to address unused spectrum allocations
- "Public" vs. "Private" networks: How do these impact spectrum needs

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2022 Focus Areas For 6G Spectrum Needs Sub-Working Group
Topic #1: New Use-cases' impact on 6G Spectrum Needs. What will drive demand for spectrum new to terrestrial mobile communications, or new approaches to addressing spectrum.
Topic #2: Closing Digital Divide: Recognizing the complex nature of this issue, what part can Spectrum Technology play to progress closing the digital divide.
Topic #3: Novel Spectrum #1: Technical considerations for adding spectrum for 6G between **7GHz and 24GHz**.
Topic #4: Novel Spectrum #2: Technical considerations for adding spectrum for 6G between **100GHz and 1000GHz**?

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FCC TAC 6G WG: Spectrum Needs Topic #1: ***Use-Case Drivers for Spectrum***

Use-Case Summaries Spectrum Considerations	JCAS: Joint Communications & Sensing	"Metaverse" (3D Multi-sense, Mapping/ Positioning)	Massive Digital Twins with HWITL	Industrial IoT & Cooperative Robotics	Ubiquitous Coverage (NTN, Digital Divide)
…managing existing spectrum	Impact on 24-71GHz—esp. sensing applications impacting ISM (BW, TRP, ERP)	Incremental demand on all existing mobile spectrum bands (bandwidth, positioning, etc.)	No Significant Incremental Driver	Consider dedicating spectrum unique to these applications (e.g. Germany, France, Japan)	Consider new approach to: • Spectrum allocation, (e.g. "Ubernization" ,tokens), • Power flux density requirements • 3D Models (NTN)
…novel Spectrum 7-24GHz for macro deployments	Suitable for smart transportation requiring longer range and bandwidth (e.g. ADAS)	Coexistence with popular UWB channels 8-15 (7-10GHz)	Incremental needs for wider contiguous bandwidth at least 500MHz and up to 1GHz		New MIMO technology for economic macro-deployments
…novel Spectrum >100GHz	Leverage BW & physics • 110-220 GHz (e.g. channel & imaging) • 220-330GHz & above Novel ideas including spectroscopy	Incremental needs for 100's-1000 Gbps driving demand for wide contiguous BW > 10GHz			Incremental for fixed-link (esp fronthaul/ backhaul, disaster recovery, tetc) (NPRM 18-17 for PTP can have impact on backhaul issues)

FCC TAC 6G WG: Spectrum Needs Topic #2: *Technology for Digital Divide*

Primary Driver—Close the Gap: Adequate Internet for a Modern Education and Provision of Ubiquitous Coverage

Framework

- Elevate this to a key objective of 6G (Education as a special and critical case of "ubiquitous coverage")
  - Target Device costs $25-$50
  - Target Access costs $5/month/user
- Consider a balance between:
  1. A specialized 6G network & devices aimed at educational services—some specialization likely required to minimize cost.
  2. A subset of limited but less-specialized multi-purpose programmable/flexible networks addressing needs in both education and related demands in both rural and under-served urban areas (must be sustained and reliable)

Technical Considerations*

- Update definition of "Broadband Access" esp. for education. e.g.
  - Today 100Mbps both UL and >=20Mbps DL
  - Build model to update & stay current as associated demands increase
- Address "fallow" spectrum in rural areas for ubiquitous coverage & affordable access for education
- Leverage multi-use network flexibility that evolves from 5G to 6G

* It is acknowledged that closing the digital divide in the USA requires a recipe including a complex mix of solutions, most of which are not technology-related. These advisements are therefore contained within the scope of the TAC being a *Technological* Advisory organization.

FCC TAC 6G WG: Spectrum Needs Topic #3: *Novel Spectrum 7GHz-24GHz*

New Paradigm: Consider 6G to be "Sharing Native"

Considerations from Advanced Spectrum Sharing WG

- Without direct DoD/NASA/NTIA engagement, avoid "NATO" and Passive EES bands
- Potential bands for 6G to be investigated further:
  - 10.7 – 13.25 GHz for sharing with non-federal satellite
  - 17.8 – 18.6 GHz and 18.8 – 20.2 for sharing with federal satellite

Specifics for 6G

- 7-24GHz as novel spectrum for mobile terrestrial communications is an industry-favorite for initial 6G rollouts
- Look for 500MHz-1000MHz Contiguous Spectrum
- Given incumbency, co-primary sharing may be a "must". Incent technology to make this feasible (e.g. advanced sharing technologies)

FCC TAC 6G WG: Spectrum Needs Topic #4: *Novel Spectrum 100GHz-1THz*

Leverage large bandwidth and associated physics

Fundamental Assumptions

- >100GHz under investigation for novel Joint Communications & Sensing (JCAS) (high-speed communications combined with positioning, imaging, and/or spectroscopy enabled by ~1mm wavelengths and associated physics)
- >100GHz must be considered Sharing Native (vs. exclusive license). Easier due to directivity, atmospheric loss, and lower power levels
- Initial use cases may be covered by existing regulation. LAN/PAN
  - PtP NPRM (FCC 18-17) (limit to ~2GHz BW is somewhat small)

Issues To Consider for 6G

- Realistic path to Tbps communications may require 50GHz BW. Contiguous Spectrum > 12GHz not available below 275GHz: Requires inter-agency work on sharing (reconcile with ITU 5.340 with ITU WRC-2000 Res. 731).
- Consider work w/NTIA to extend experimental license duration beyond 6 months to encourage research in this band
- Significant risk: Sustainability (in the form of Energy Efficiency). FCC/Interagency consideration for EE in regulating this spectrum?

6G Spectrum Needs Issues To Consider for 2023 Session

Areas with reasonable alignment

- **Impact of NTN** on Spectrum (3D licensing, co-existence, most likely bands)
- **Spectrum Allocations**: explore flexible approaches
- Explore each of the above especially (but not limited to) the 7-24GHz areas
- Examine whether AAS, higher density, MIMO, and RIS require revisit of approach to **EMF exposure specifications and measurements**
    - Relates **not to EMF exposure limits** but rather how **EMF exposure is specified and measured**

Areas discussed but with less conclusion

- Continued work on **Digital Divide**. Challenge is to stay technical in what is largely a political and business-case problem
- And two which remain areas of difficulty based on whether they are appropriate for FCC regulation vs. driven by business case perspectives: Increased attention to **regulating**
    - **Spectral efficiency**
    - **Energy efficiency** (in the network)

5. 6G Services and Application Vertical(s)

6G Use case perspectives from around the globe, across the industry

6G Use Case	Description	6G Network KPI Perspective (Preliminary)
Holographic/Immersive communications	Dynamic interaction among people, things, and environments through lifelike 3D rendering -Personalized education, training	-Throughput per stream: multi-Gbps -Number of streams: 100's -Latency and jitter: <20 ms
Multi-sensory communications	Experiencing touch (including the feelings of temperature, pressure, texture) as well as smell and taste in a more distant future -Remote work, Virtual meetings	-Throughput per stream: multi-Gbps -Number of streams: 100's to 1000's -Latency and jitter: <20 ms -Synchronization across streams: <10ms
Mapping, positioning, sensing, twinning	Sense, detect, locate, identify, and image targets during remote operation, thus improving situational awareness, and enabling better allocation of for physical resources including preventive maintenance -Manufacturing -Smart cities	-Throughput per stream (Bidirectional): Multi-Gbps -Number of streams: 1000's -Latency and jitter: < 10 ms
Robots and Cobots	Humans working collaboratively with robots to achieve outcomes that are challenging to be done by robots alone -Industry 5.0 applications	-Throughput: Multi-Gbps -Latency: <10 ms -Number of streams: 100's -Reliability: 7 9's -Positioning accuracy: < 1 cm -Sensing accuracy: >99%

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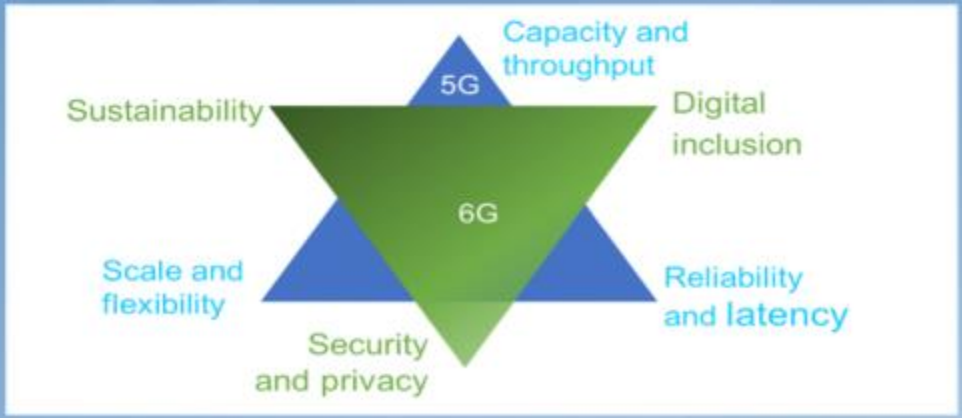
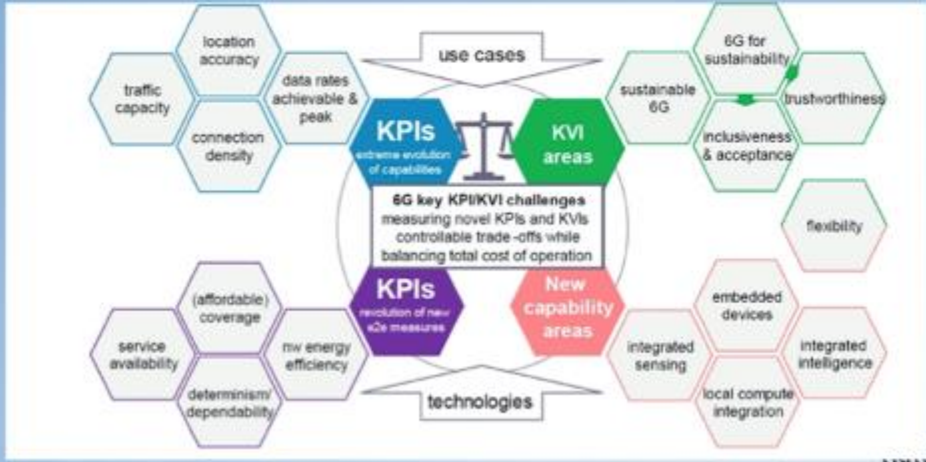
Expectations of 6G and setting the directions on the foundation of 5G

- 6G Key Performance Indicators (KPIs) are built upon 5G KPIs and further extended
- 6G Key Value Indicators (KVIs) are introduced to cater to the United Nations Sustainability Development Goals (UN SDGs) and are NOT always easy to measure directly





Source: https://hexa-x.eu/

Example new KPIs :

- Area traffic capacity
- Control plane latency
- Connection reliability
- Positioning accuracy
- Sensing accuracy
- …

Example new KVIs:

- Energy efficiency
- EMF radiation
- Carbon footprint
- Trustworthiness
- Inclusiveness
- …

Next G Alliance Applications & Use Cases

Four Foundational areas:

1. **Living**: How to improve the quality of everyday living
2. **Experience**: How to improve the quality of experience in areas such as entertainment, learning and healthcare
3. **Critical**: How to improve the quality of critical roles in sectors such as healthcare, manufacturing, agriculture, transportation, public safety
4. **Societal Goals**: How to attain and improve on high-level societal goals

Four categories of use cases:

1. Network-Enabled Robotics and Autonomous Systems,
2. Multi-sensory Extended Reality,
3. Distributed Sensing and Communications, and
4. Personalized User Experiences.

6. Bridging the Digital Divide

6G & the Digital Divide

Social and physical distancing is becoming the new normal requiring unprecedented demand for digital access, including affordable Internet access and other digital inclusion and digital equity resources.

Students, parents, teachers, seniors, library patrons and the general public do not have affordable and equitable access to the Internet.

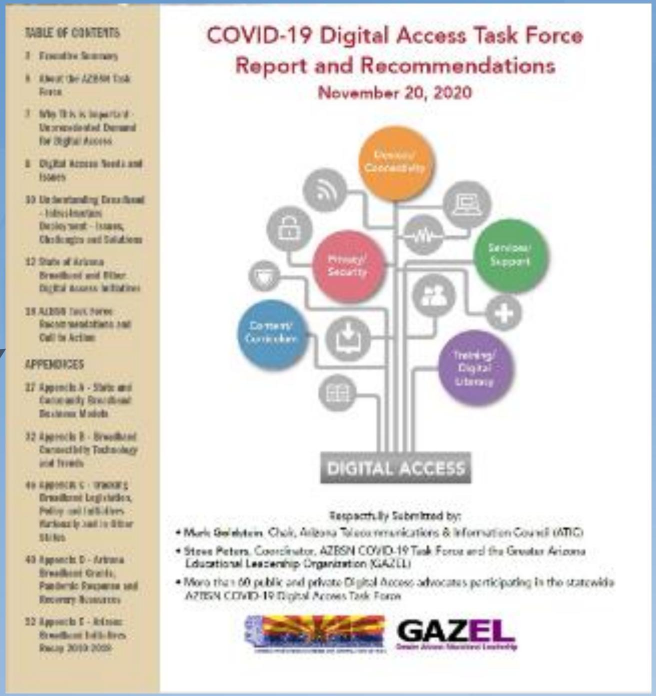
- As a result, the homework gap is a major issue for many of our students.
- Broadband is essential to connect schools, universities, community colleges, homes, libraries, health care facilities, businesses and communities to support education, health care, community services and economic development.

In many places, rural and remote areas lack proper connectivity which has led to an increasing digital divide.

- These areas may have low population density, low incomes, difficult terrain, and non-existent infrastructure, lacking a power grid, for example

6G could be the first mobile radio generation that truly aims to close the digital divide.

- However, to do so, **special requirements and challenges must be considered from the beginning of the design process.**



Digital Equity and 6G

Digital equity means all individuals and communities have access to a reliable broadband connection, thereby playing an important role in achieving several U.N. Sustainable Development Goals.

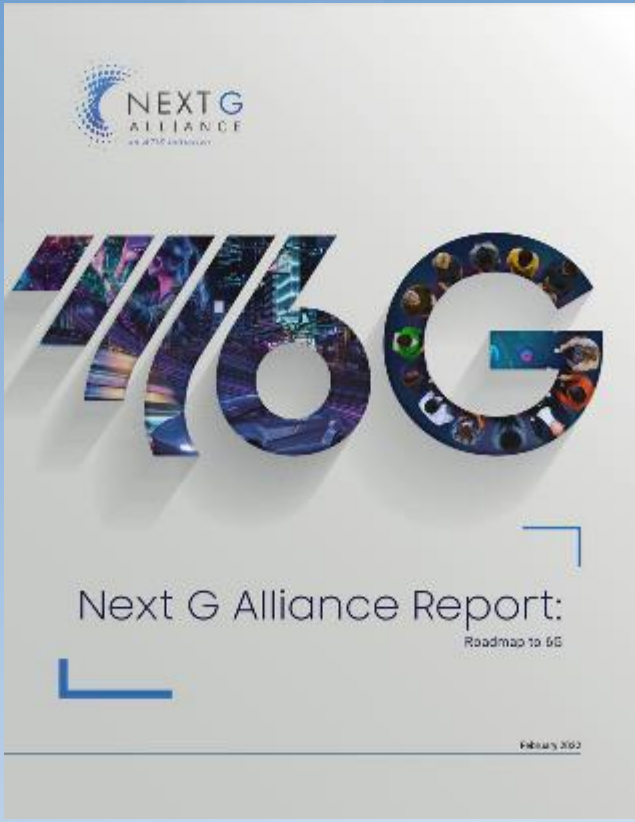
- ➢ Internet access supports greater access to education, employment, and economic growth.
- ➢ The result is a society that is inclusive and allows participation from all components of society, increasing innovation and spurring sustainable industrialization.

Digital equity should be understood as a requirement to achieve three conditions for each user:

- ➢ **Affordability**: Affordability is an enabler of Digital Equity and Accessibility, subject to policy and market forces.
    - ○ 6G user equipment and the 6G network architecture must be cost effective and with improved operational efficiency, thereby reducing overall cost of access to individuals.
- ➢ **Accessibility**: 6G technologies, providing multiple modal forms of access/communications, must be accessible to all members of the population.
- ➢ **Geographic availability**: 6G network services must be available to the entire population of potential users.

6G-enabled services will be important to improving the quality of life in North America and its local communities.

- ➢ They apply to areas such as public services, health care, education, safety and security, and the environment.



Recommendations & Advisements

BLUF - Recommendations/Advisements

- **6G Development Timeline**
  - 5G Deployments are still nascent and potential impact still needs to be realized.
  - 5G Advanced Evolution to continue for future 3GPP Releases (17,18,19)
  - 6G Fundamental research is underway with Federal and Industry Investments
  - ITU defined IMT-2030 and twinning with WRC23 will set 6G radio performance requirements
  - 6G is an undefined formal term adopted by any SDO or Consortia.

- **Spectrum Needs**
  - Mid Band: 500MHz opportunity in 7-24 GHz, existing sharing mechanisms
  - Sub THz: 100-1000GHz for highly demanding use cases: Immersive comms,,cobots
    - Policy is nascent
  - Heterogeneity of access: Space,Aerial,Terrestrial Integrated Networks requires coordination

- **O-RAN and Open RAN Security**
  - Focus on demonstrating multi-vendor interoperability in disaggregated O-RAN Networks
  - Federal incentives need to align with subsystem integration and demonstrate performance parity with legacy networks
  - Securing the Open Fronthaul interface real time system from targeted attacks

- **6G Use Cases and Application Verticals**
  - Focus on application centric view with Multi-sensory and Immersive Communication use cases are quickly emerging
  - Emergence of Key Value Metrics (KVI) beyond traditional metrics for 5G
  - Focus on energy efficiency, sustainability, inclusion and deployment economics

- **mmWave and Sub-THz**
  - Opportunity: joint comms and sensing, large transmission bandwidth, indoor and personal area network deployment
  - Challenge: High mid-band value for deployment scenarios, very high path loss
  - Focus on high directionality systems

6G WG Advisements

- As today's networks implement more 5G features and enable use cases, TAC should continue to understand the technology and application gap to capture what 6G promises to offer.
- ITU-R performance requirements analysis and WRC 23 proceedings will have profound impact on development of 6G component technologies and architecture. Continue monitoring these forums and report out key contributions as part of 2023 TAC agenda.
- The 5G->5G Advanced journey within 3GPP continues to take shape with future Rel 18,19 study items adopting native AI/ML, comms and sensing and metaverse service applications.
- Consolidation and convergence of 6G roadmaps and technology areas from various consortia and alliances will be key to keep abreast of Industry consensus.
- Open RAN technology development and deployment acceleration needs to monitored continuously to understand performance and cost comparisons to existing 5G deployments.
- 6G spectrum needs across mid band and higher frequency bands will be tightly coupled with use cases required to support with respect to latency,capacity,positioning and sharing potential

Proposed 6G WG Items to address in 2023

2023 6G Working Group (proposed) Focus Areas

Since 6G is early in the development cycle, there are study Items that the TAC should carry over into 2023:

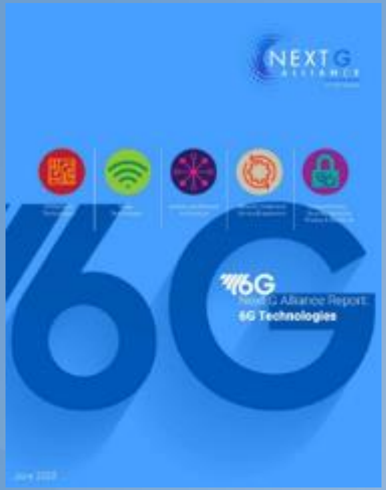
- 5G Advanced Evolution Towards 6G
- 6G Research & Standards Progress
- Spectrum related - WRC ‘23
- Compute and Communication convergence at the network Edge
- Hybrid network approach with NTN (LEO,MEO,GEO) and WiFi
- Backhaul,mid-haul,repeaters, Wi-Fi Offload
- Update on Use Cases & Applications – How is 6G technology envisioned to enhance or be utilized in **autonomous driving, edge computing, emergency alerting, and smart city technology** deployments

References

References 1/2

Next G Alliance 6G Library

(https://www.nextgalliance.org/6g-library/)



References 2/2

ITU-T (Jan 2020)
- International telecommunication industry

Next G Alliance (Feb 2022)
- Americas telecom industry and academia

5G Americas (Dec 2020)
- Americas telecom service providers and equipment vendors

Hexa-X (April 2021)
- Telecom industry and academia in Europe

IMT-2030 Promotion Group (June 2021)
- Telecom industry and academia in China

NGMN (Feb 2022)
- Leading global mobile network operators

Thank You

FCC Technological Advisory Council Agenda – December 8, 2022

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	AI/ML WG Presentation
12:00pm – 1pm	Lunch Break
1pm – 1:45pm	Advanced Spectrum Sharing WG Presentation
1:45pm – 2:30pm	6G WG Presentation
2:30pm – 2:45pm	Closing Remarks
2:45pm	Adjourned

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