Transformations in Wireless Connectivity at Airports

March 11, 2024

1:00 – 2:30 p.m.

NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

ACRP AIRPORT COOPERATIVE RESEARCH PROGRAM

Today's Learning Objectives

- **Understand the evolving landscape of wireless technologies and their applications in airports**

- **Use best practices and strategies for addressing the increasing demands for high-speed connectivity services**

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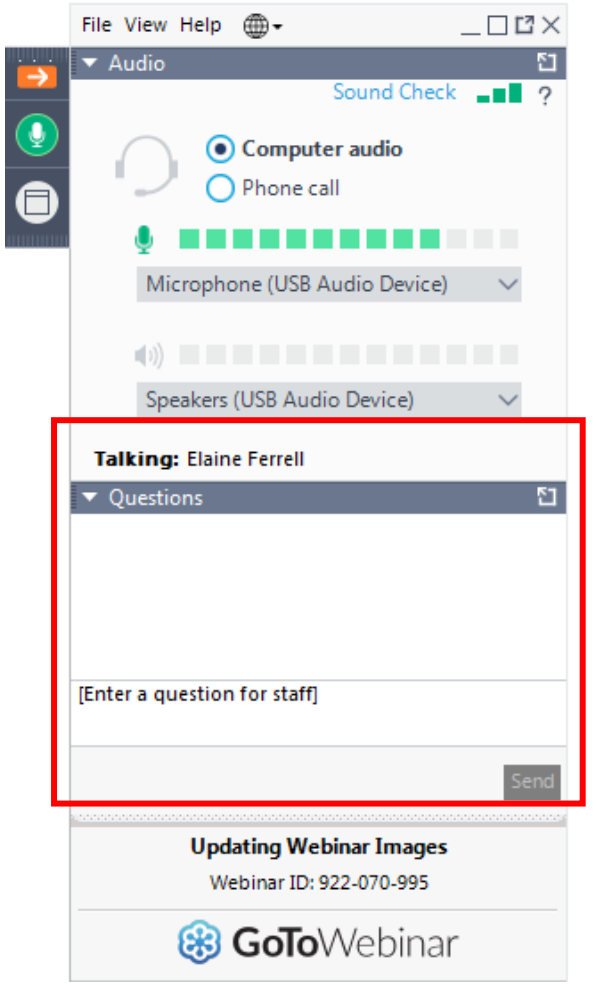
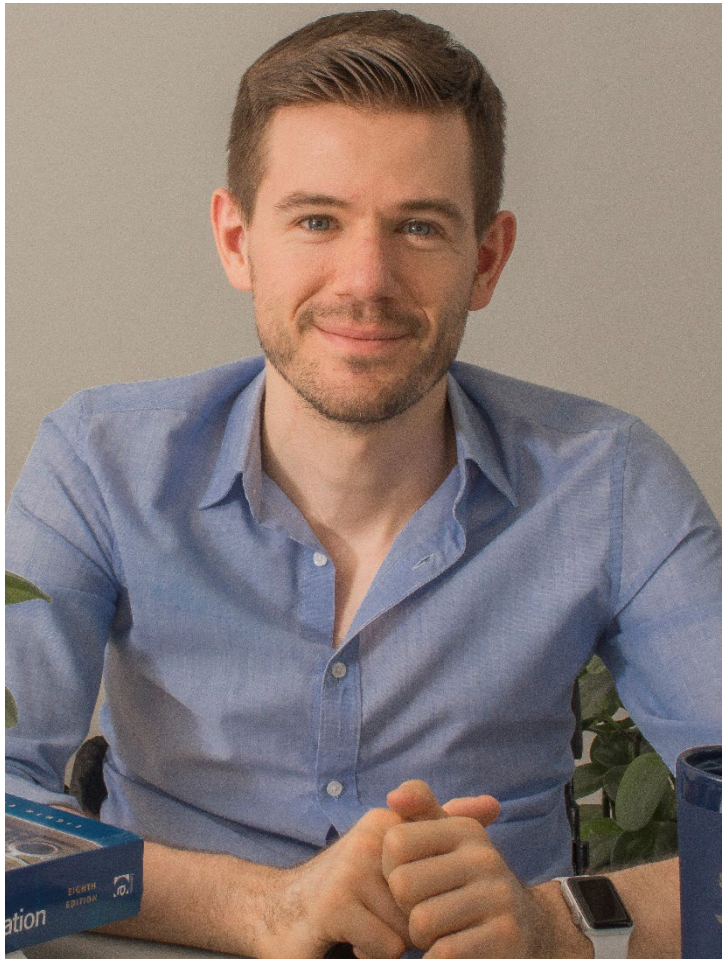


Sergio Taleisnik
Skymantics, LLC

- Lead Quality Engineer for Data and AI of DataGenesis
- Participated in many research initiatives including ACRP 03-57
- Systems Engineer with a Masters in Aeronautics from Embry-Riddle Aeronautical University



Today's Speakers

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ACRP Report 242

Transformation in Wireless Connectivity: Guide to Prepare Airports

Antonio Correas Uson, Skymantics, LLC

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  - Mission critical architectures
  - Mapping, routing and geospatial intelligence
  - Artificial Intelligence and synthetic data

Antonio Correas Uson
Principal Investigator

- Co-founder and Chief Product Officer, Skymantics
- Telecommunications Engineer with MBA in Aviation by Embry-Riddle
- 15 year's experience in wireless technologies and aviation

ACRP Report 242 Oversight Panel

Timothy Mitchell, Collinear Group, Panel Chairman

Olivia Clark, Charlotte Douglas Intl Airport

Xue Li, FAA AAS

Aura Moore, Los Angeles World Airports

Robert D. Osborne, Burns & McDonnell

Stephen Saunders, Cincinnati-Northern Kentucky Intl Airport

Ricardo Sanchez, FAA Liaison

Aneil Patel, ACI – North America Liaison

Christine L. Gerencher, TRB Liaison

Contents

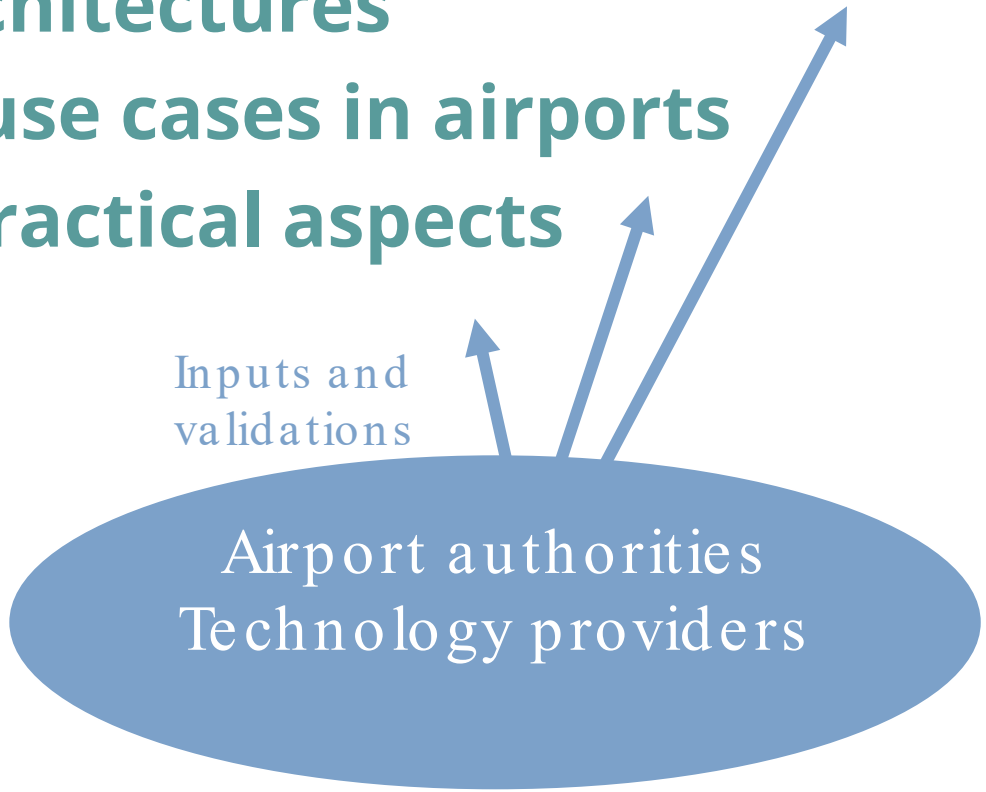
Problem statement
Methodology
Research results
Putting results into practice

Problem statement

- **Emerging wireless technologies potentially support airport use cases**
- **Wireless provides flexible growth but introduces complexity**
- **Goal: create a reference manual for airport decision-makers**
  - ✈ A menu of wireless architecture options for specific use cases
  - ✈ Methods and metrics to optimize investment

Methodology

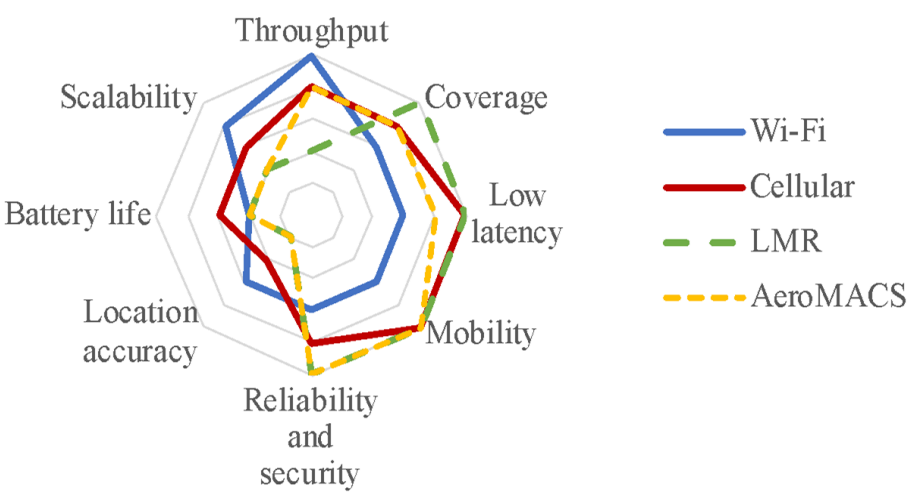
1. **Create a taxonomy of wireless technology standards and architectures**
2. **Identify wireless use cases in airports**
3. **Define KPIs and practical aspects**
   - ✈ Technical
   - ✈ Operational
   - ✈ Financial



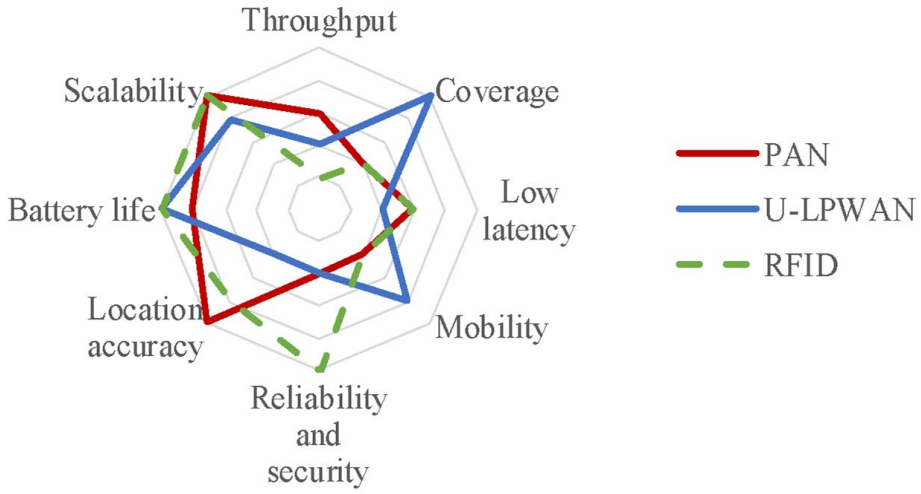
Research results

Taxonomy of wireless technology standards

Mobile user communications



IoT applications



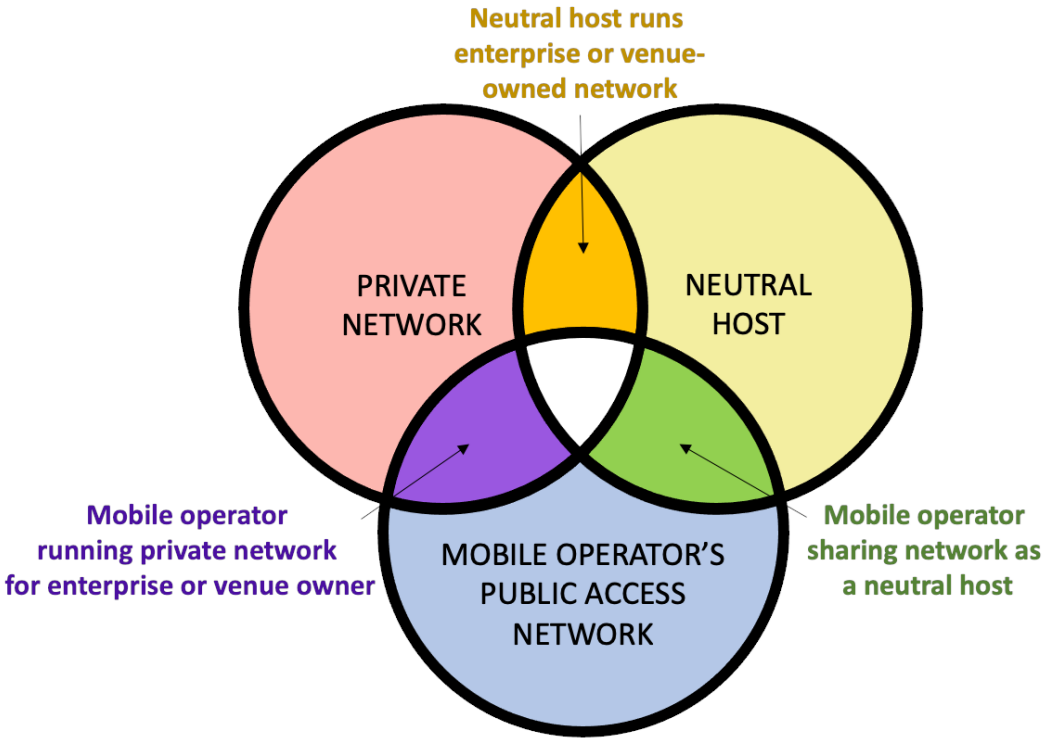
Research results

Taxonomy of wireless use cases

- Passenger experience and commercial service
- Airport/airline operations
- Safety, security and surveillance
- Autonomous vehicles and robotics
- Incident response and recovery
- Travel health

Research results

Wireless architecture options



Putting results into practice

Step-by-step checklist

- Select your use cases
- Determine your wireless transition scenario
  - Current stage
  - Where you want to be (goals, and business model)
- Quantify your investment and ROI
- Create your wireless transition plan
- Deploy the system
- Manage and maintain

Putting results into practice

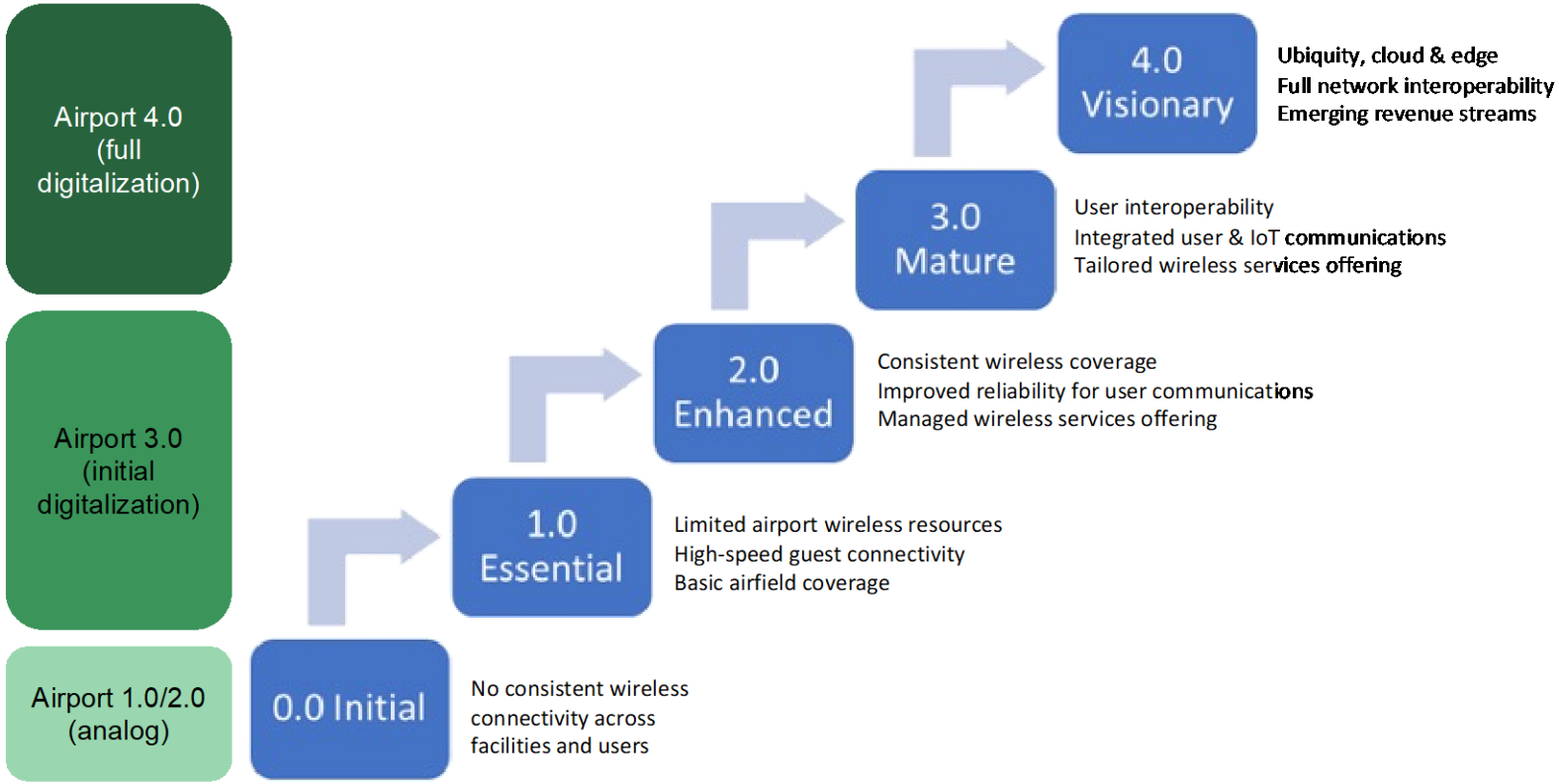
The architecture choice: what type of airport do I want to be?

Ownership of wireless and data assets

	Control	Responsibility of service quality	Participation in revenue and cost
Private Network	HIGH (controls network configuration and data)	HIGH (full responsibility of service quality)	HIGH (Full revenue and cost burden)
Neutral Host	MEDIUM (within agreement with 3rd party)	MEDIUM (SLA with 3rd party)	MEDIUM (Revenue/cost sharing)
Operator's Public Access Network	LOW (3rd party owns the network)	LOW (3rd part has SLA directly with consumer)	LOW (Subscription Cost)

Putting results into practice

Wireless maturity framework



Putting results into practice

Pick your business model(s)

- Real Estate Rental
- Managed Services
- Shared Services
- Network as a Service (NaaS)
- Service Brokerage
- Freemium
- Fractionalization
- Standardization
- Automation

Putting results into practice

Practical recommendations

- Balance organizational and vendor management to promote competition and adoption
- Address financial plan strategically
- Secure spectrum
- Predict and measure performance
- Address new cybersecurity vectors
- Plan for continuous maintenance and upgrades

Putting results into practice

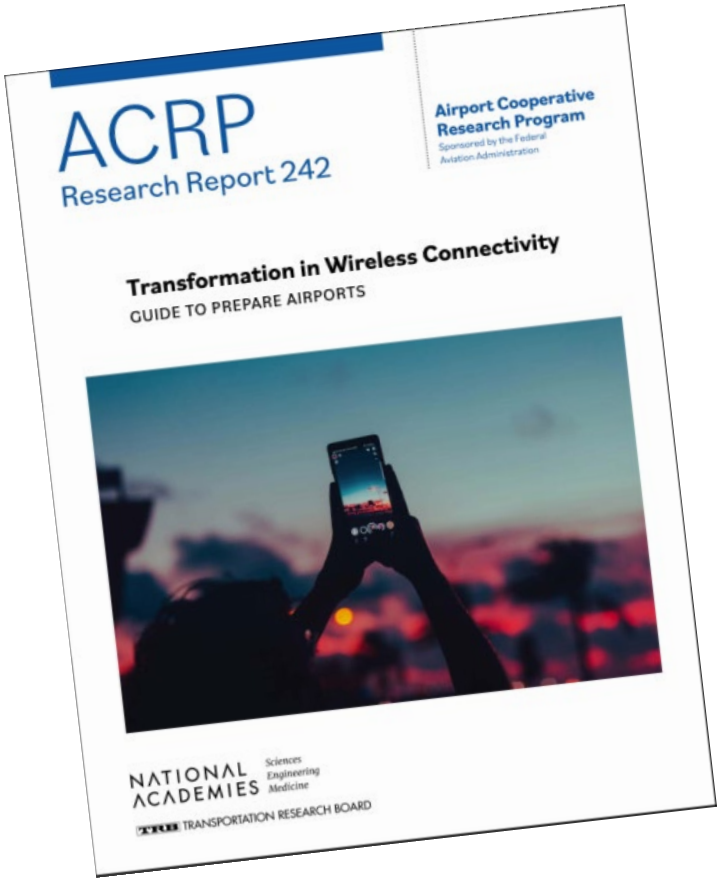
Towards automated & intelligent airports

Putting results into practice

Towards automated & intelligent airports

- Fueled by IoT adoption: large data capture and governance
- Synthetic data and Digital Twin
- Two stages:
  - Predictability and automation in decision workflows
  - Trained AI to create new workflows and adapt
- Transformative use cases
  - UAVs, AAM vertiport automation
  - Passenger/baggage flow volume management
  - Energy savings
  - Threat risk assessment and response
  - Retail site optimization

FOR ADDITIONAL INFORMATION



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Airport Connectivity and Emerging Wireless Technologies

Gerard James Hayes, Ph.D.
President & Founder
Wireless Research Center of North Carolina

11 March 2024

Wireless Research Center of North Carolina

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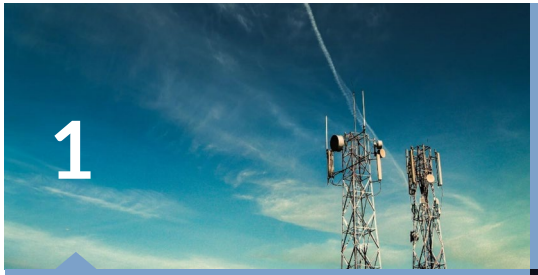
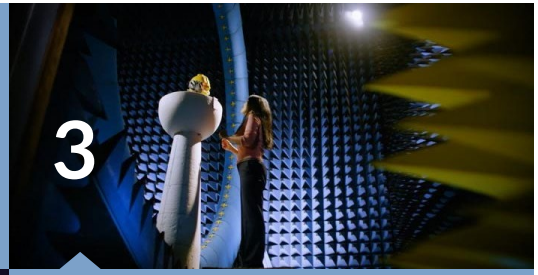
Founded in 2010 to advance wireless communication technologies and foster innovative solutions as a nonprofit, 501(c)(3) research and development center.



Architecture
Wireless Systems & Networks



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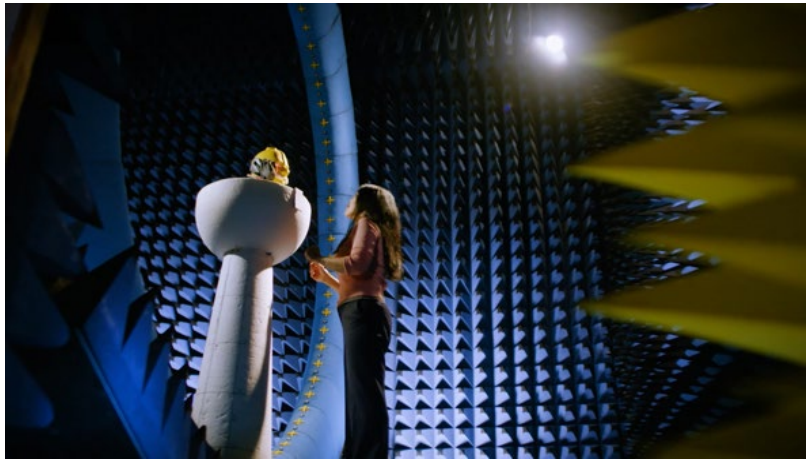

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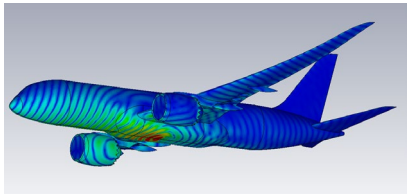

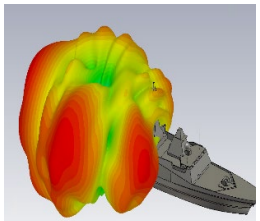

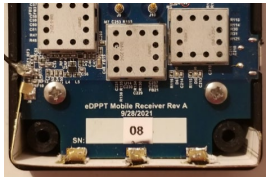

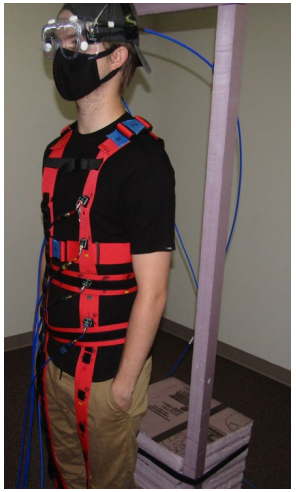

Airport Connectivity and Emerging Wireless Technologies

Use Case

Technology

Implementation & Architecture

Evolution and harmonization

Airport Connectivity and Emerging Wireless Technologies

Table 9. Wireless end users.

Wireless end user	Can access wireless service via
Airport operator staff	Public mobile carrier network
	Private network offered by a mobile carrier to the airport operator
	Private airport enterprise network
	Private airport critical network
Tenant staff	Public mobile carrier network
	Private network offered by a mobile carrier to the tenant or the airport operator
	Private airport/tenant enterprise network
Passengers and other visitors or staff using personal devices	Public mobile carrier network
	Private airport/tenant consumer network (limited to guest services)

Commercial Use Cases

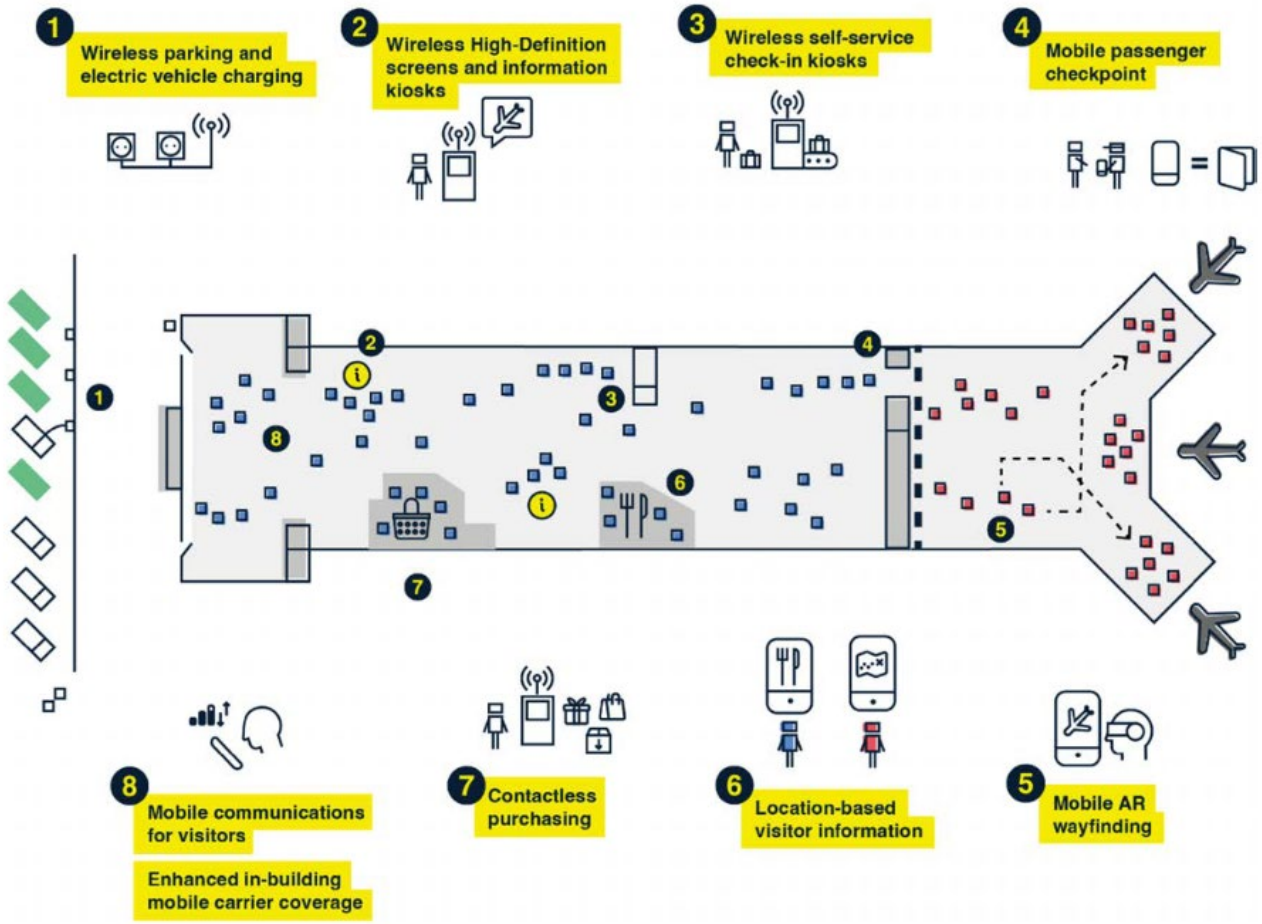

Figure 2. Passenger experience and commercial service use cases.

Operations Use Cases

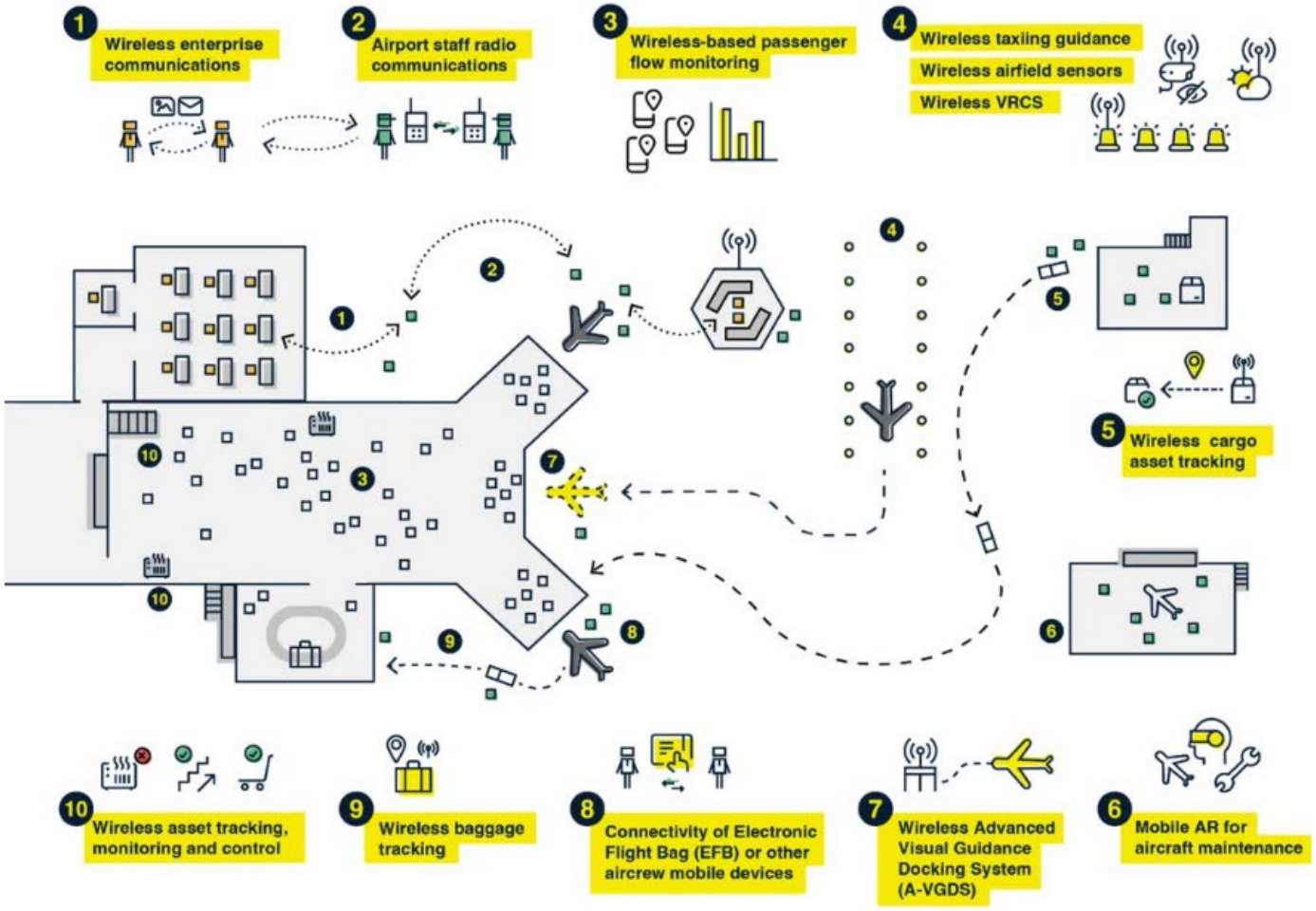

Figure 3. Airport/airline operations use cases.

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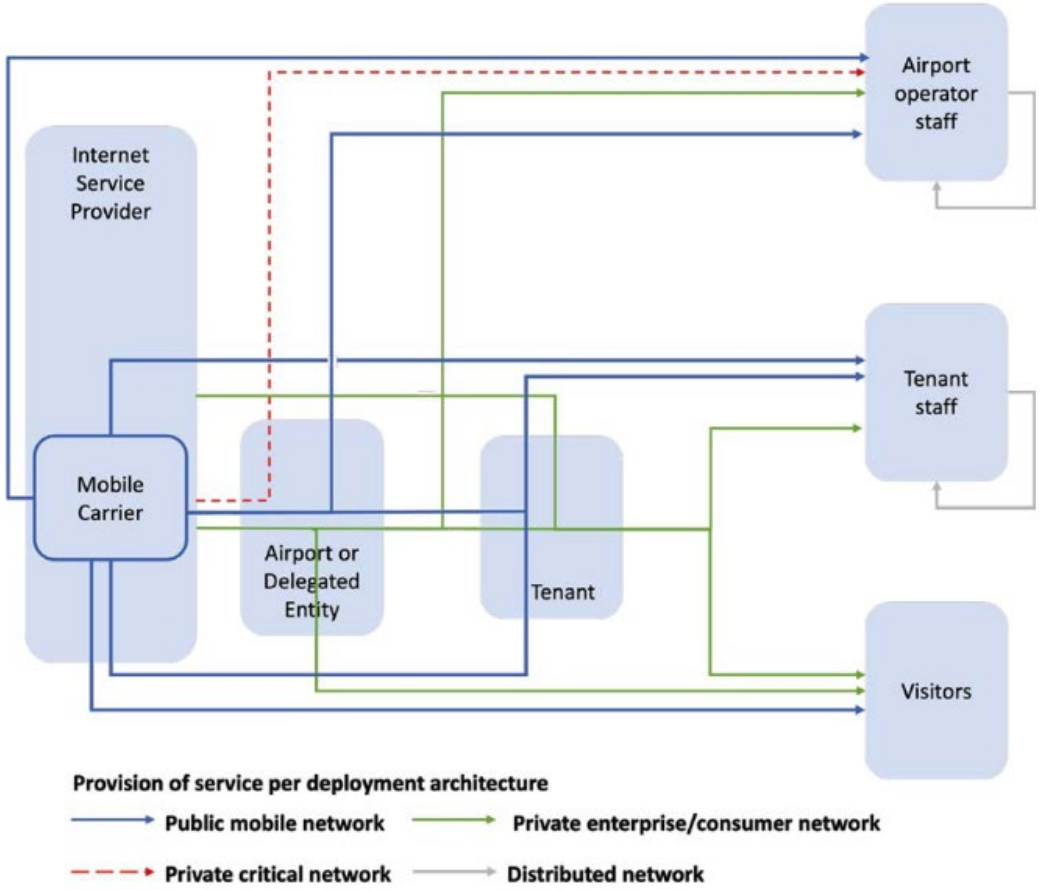

Figure 22. Relationship options for wireless connectivity among airport stakeholders.

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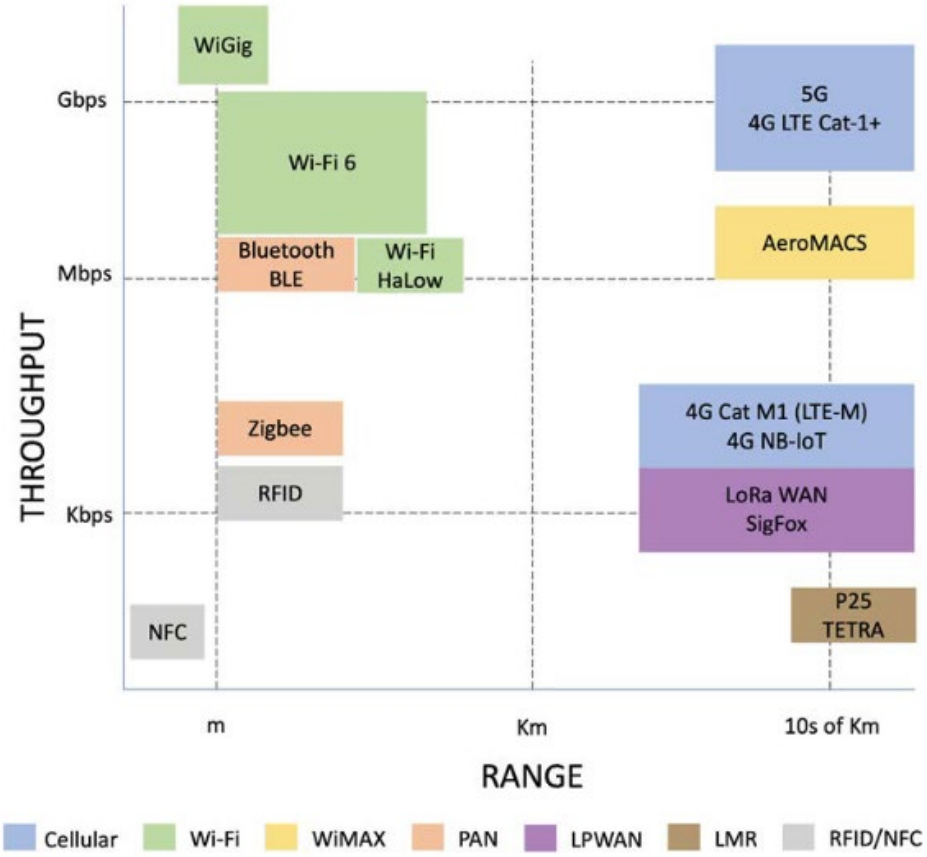

Figure 17. Comparison of range and throughput among wireless technologies.

Airport Connectivity and Emerging Wireless Technologies

Table 3. Summary of wireless technologies.

Technology type	Relevant technology standards
Cellular	4G/Long-Term Evolution (LTE), 5G
Wi-Fi	Wi-Fi 4/5, Wi-Fi 6, Wi-Fi 6E, WiGig
WiMAX	AeroMACS
Land mobile radio	P25, TETRA, analog FM
Low-power wide-area networks (LPWANs) in unlicensed spectrum	LoRa, Sigfox, HaLow
Personal area networks	Bluetooth, Zigbee, Ultra-wideband (UWB)
Radio-frequency identification (RFID)	RFID, NFC

Airport Connectivity and Emerging Wireless Technologies

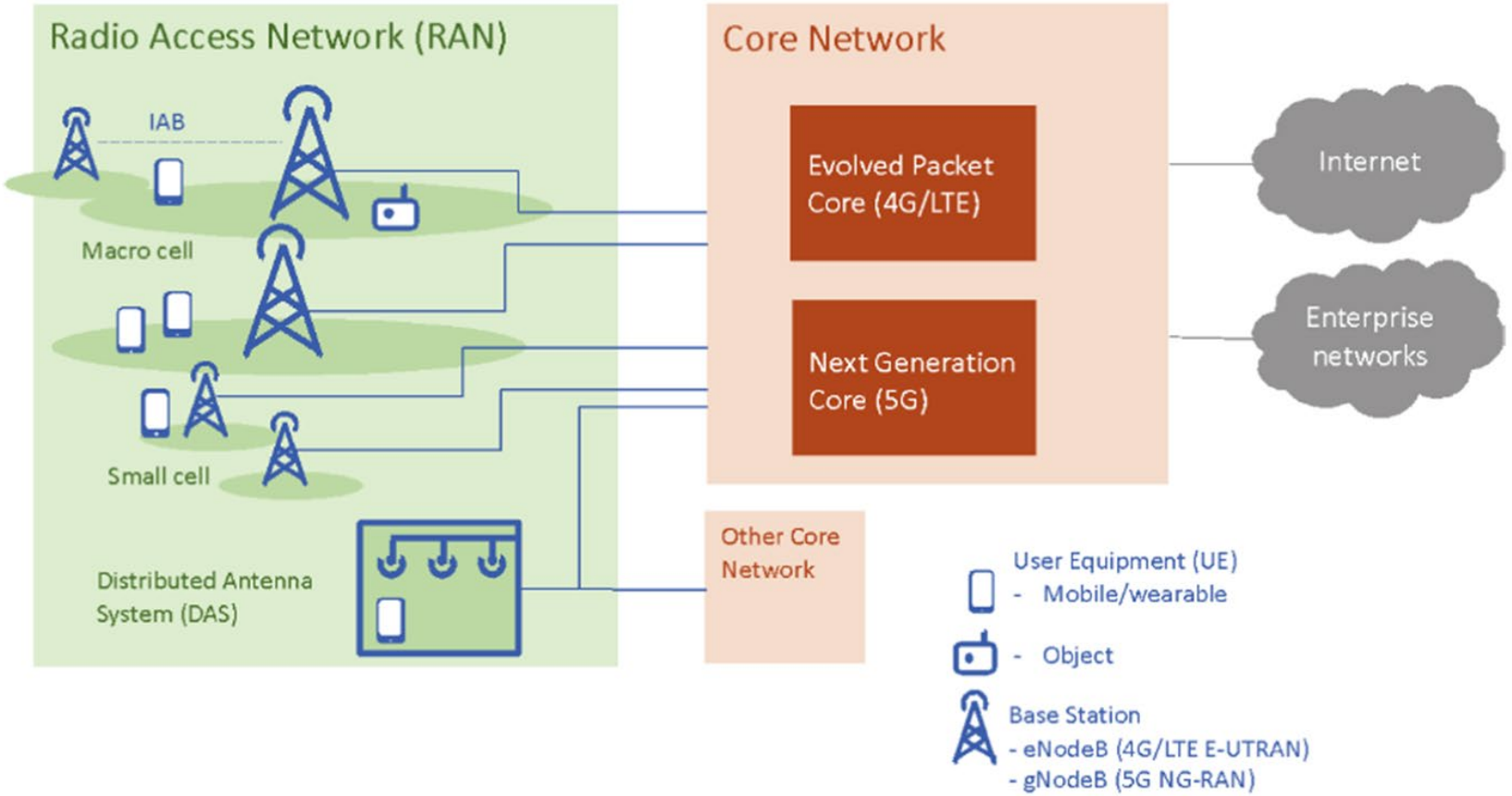

Figure 8. Cellular network (4G/LTE and 5G) architecture.

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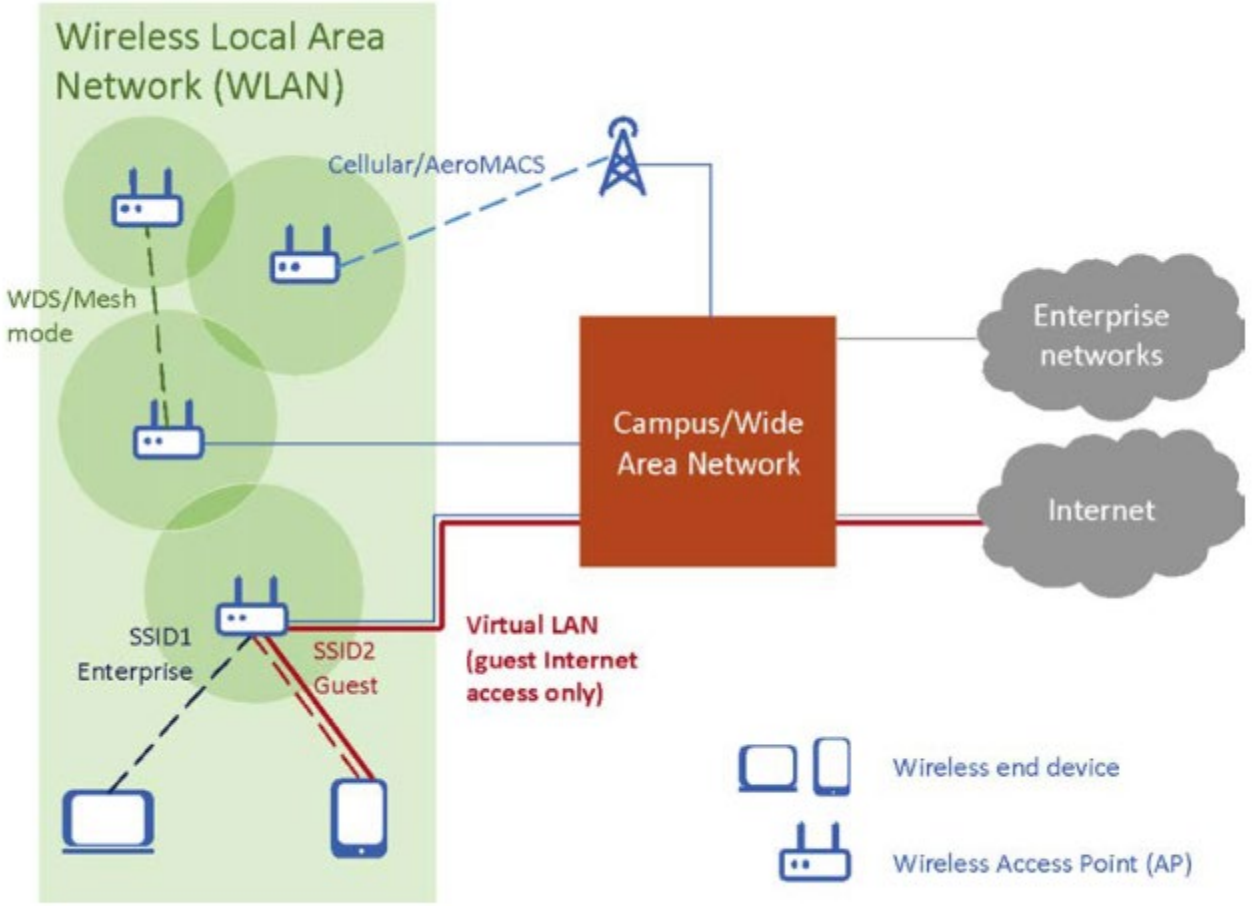

Figure 11. Wireless LAN (Wi-Fi) architecture.

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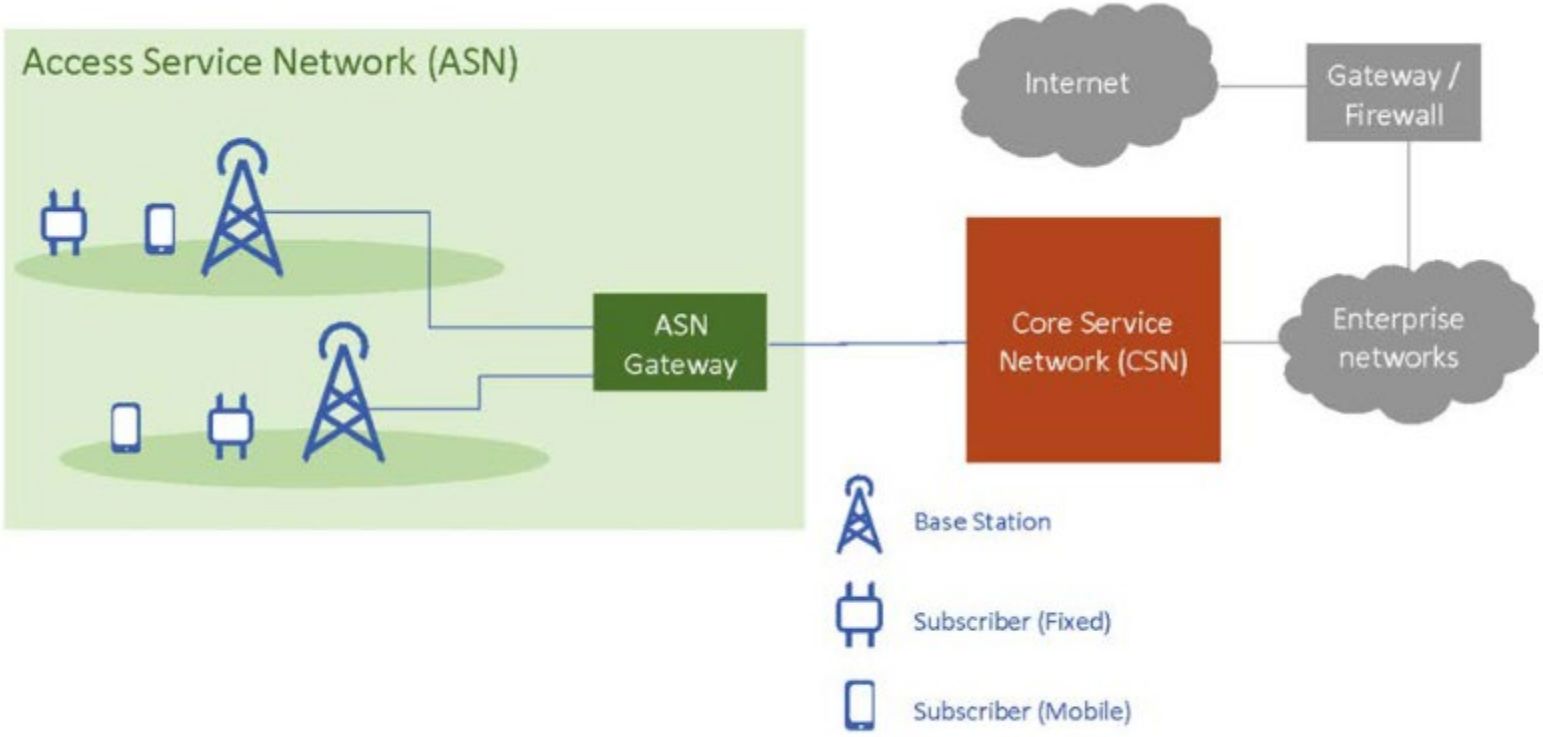

Figure 12. AeroMACS architecture.

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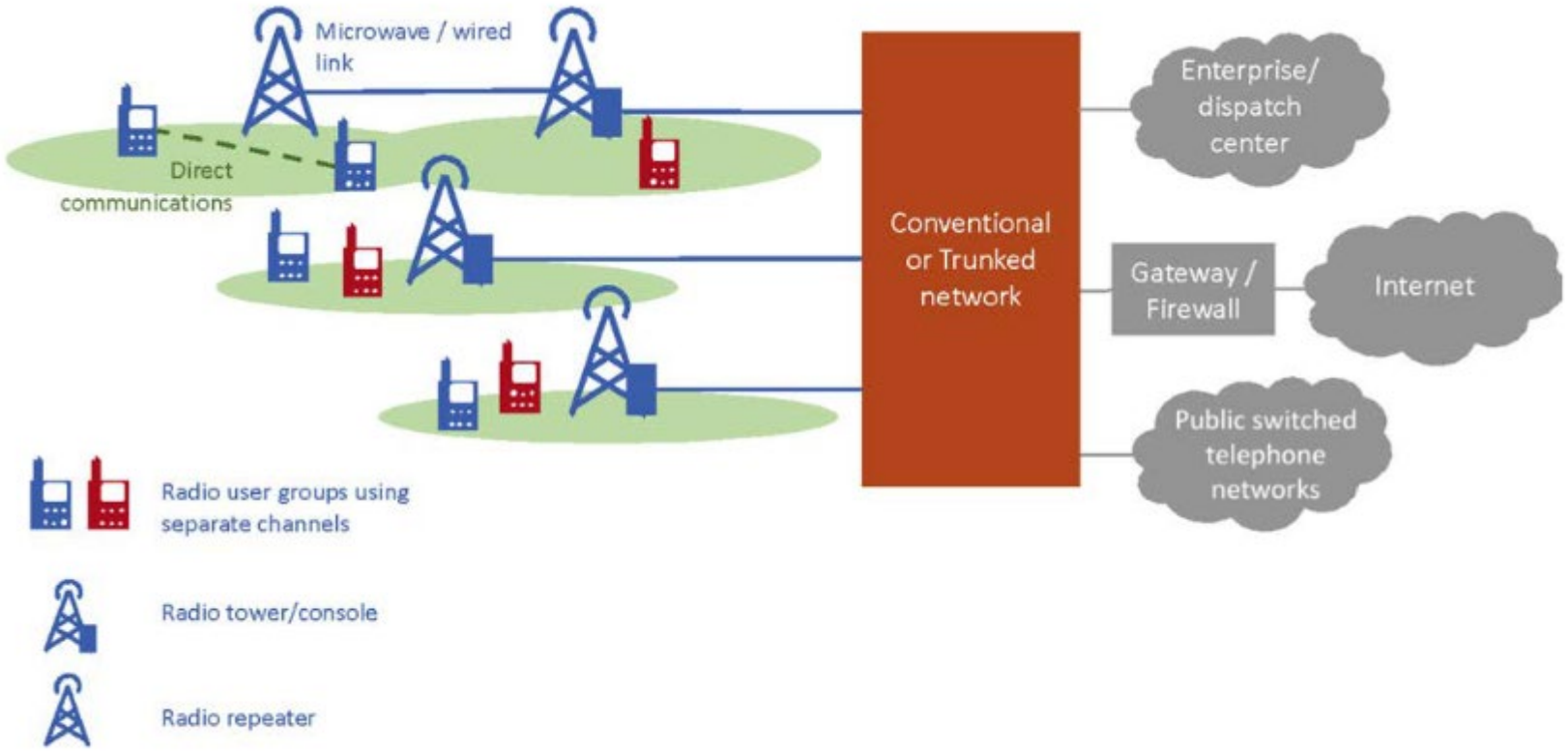

Figure 13. LMR architecture.

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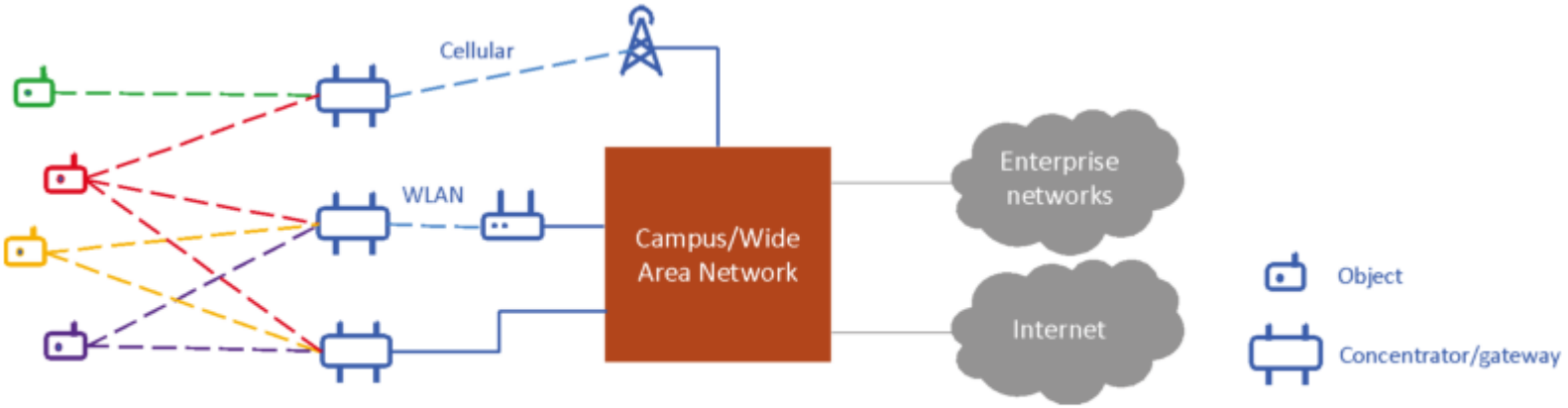

Figure 14. Unlicensed spectrum LPWAN architecture. Dashed colored lines show the connections between an object and one or several concentrators/gateways.

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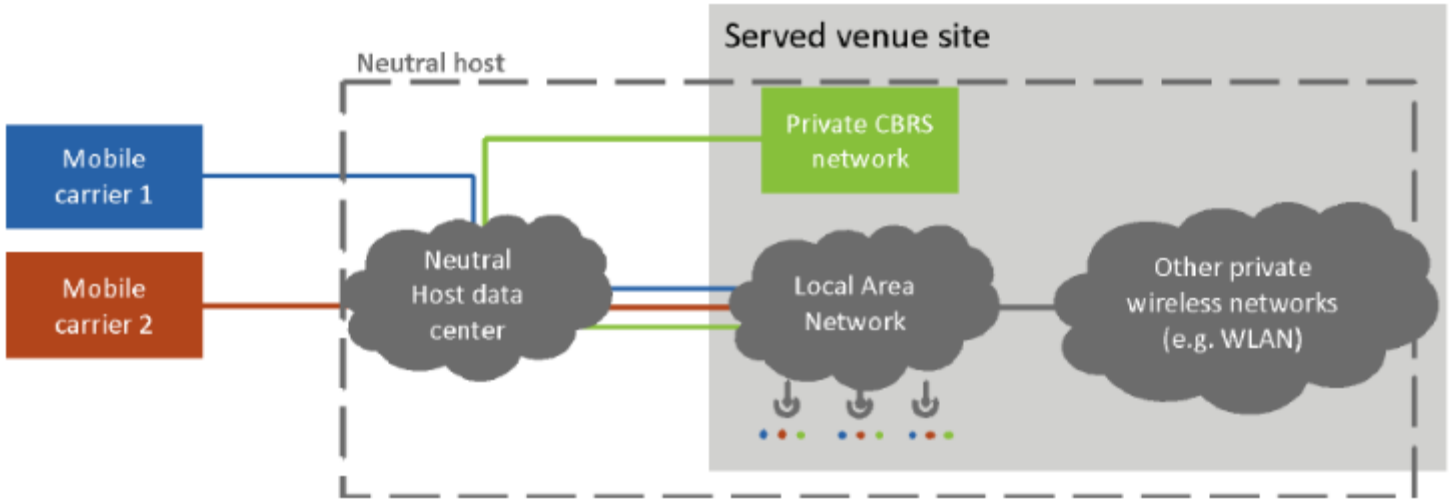

Figure 21. Neutral host operating DAS shared between mobile carriers and private cellular networks.

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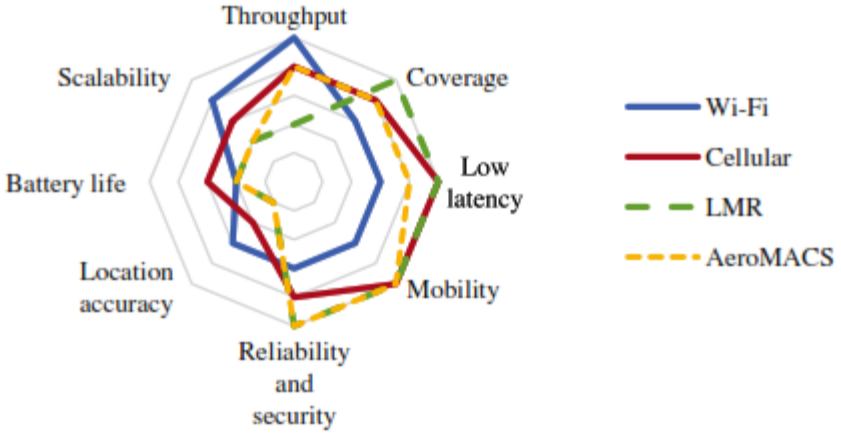


Figure 18. Comparison of technologies for mobile user communications.

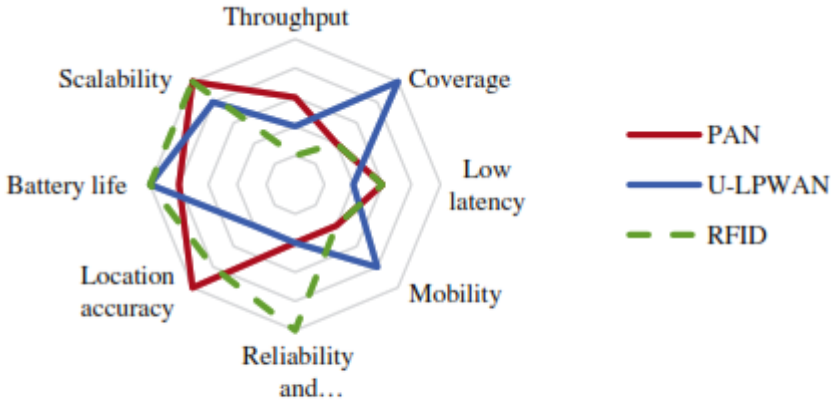


Figure 19. Comparison of technologies specific to automation and IoT reliability and security.

Airport Connectivity and Emerging Wireless Technologies

Table 12. Summary of wireless connectivity maturity framework.

Wireless maturity level	Main capabilities	Corresponds to airport digital maturity level
0.0 Initial	• Still improving wideband internet access at the facility. Airport limited to managing operations and real estate, not concerned with connectivity. • Users connect to ISPs and mobile carriers directly; set up their own wireless infrastructure at offices and key locations (e.g., MRO). • Heterogeneous coverage and capacity across facilities.	1.0/2.0 Operations mostly analog, with some process improvements in specific airport areas (e.g., kiosks).
1.0 Essential	• High-speed, secure access via the airport's private network for guests and staff across the terminal. Cellular coverage with at least low capacity in the entire area. • Basic tactical communications for staff and first responders in the airfield. • Low-volume sensor networks for smart building and health tracking. • Airport operator has some IT resources, performs limited spectrum management, and has commercial agreements with wireless providers.	3.0 Initial digitalization focused on the enhancement of passenger experience and airport operations; the target is the improvement of performance and reduction of response times for processes.
2.0 Enhanced	• Improved capacity and reduced latency for more stringent wireless applications; increased reliability at critical locations. • Agreements with mobile carriers for high-capacity cellular coverage in the entire area. Limited cellular/Wi-Fi roaming with specific mobile carriers; dedicated planning for dual network optimization depending on zone usage. • Airport offers managed wireless services and initial IoT for the reliability of operations.	
3.0 Mature	• Centralized wireless platform, auto-adjusting for variable capacity and security. Comprehensive cybersecurity planning. • Decreasing wireless cost improves financial flexibility. Offers tailored wireless service and scaled-up capacity. • Federated roaming, user interoperability between networks, and integrated authentication. Most airport and tenant applications moved to the cloud. • Expanded IoT for reliability and smart building efficiency, cloud-based management.	4.0 Full digitalization involving all stakeholders; targets cross-platform implementations to host common applications; targets efficiency and revenue generation by centralization of resources and consolidation of digital service offerings.
4.0 Visionary	• Large-scale IoT, big data management, and airport-wide AI. • Cloud and edge applications for varying data and safety requirements. Edge data centers in the airport for high-capacity, low-latency safety applications. • With full network interoperability, the user has a completely seamless experience and expects total ubiquity and performance. Network includes a high variety of users, including automated mobile things (robots, vehicles). • Novel revenue streams allow airports to commercialize wireless capacity as an asset in numerous ways, become a communications hub orchestrating data (smart city), and seek new commercial formulas and legal agreements.	

Airport Connectivity and Emerging Wireless Technologies

Wireless technologies and use cases

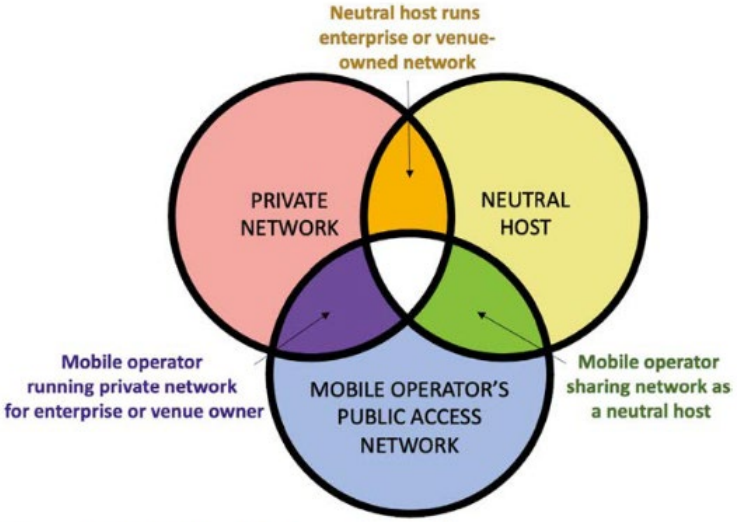
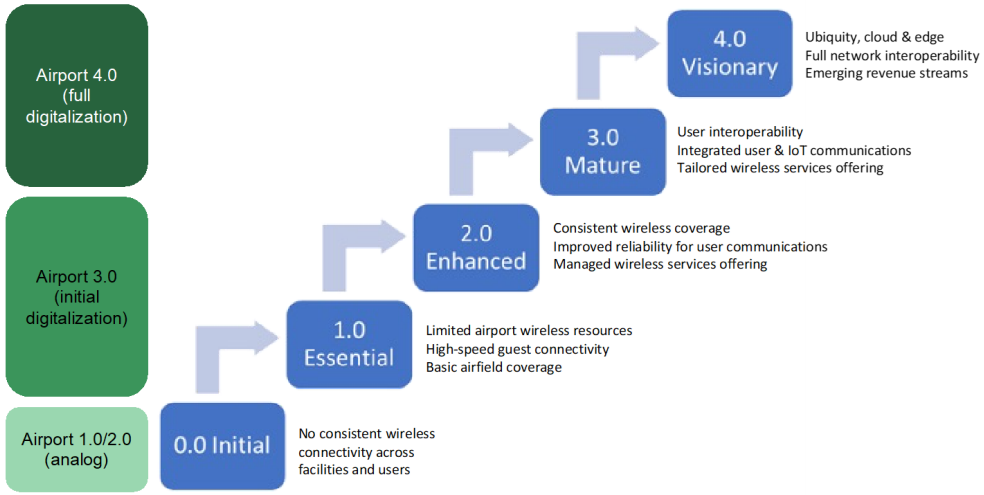


Figure 20. Wireless deployment models.



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Thank you!

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Gerard Hayes
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Wireless Research Center of North Carolina

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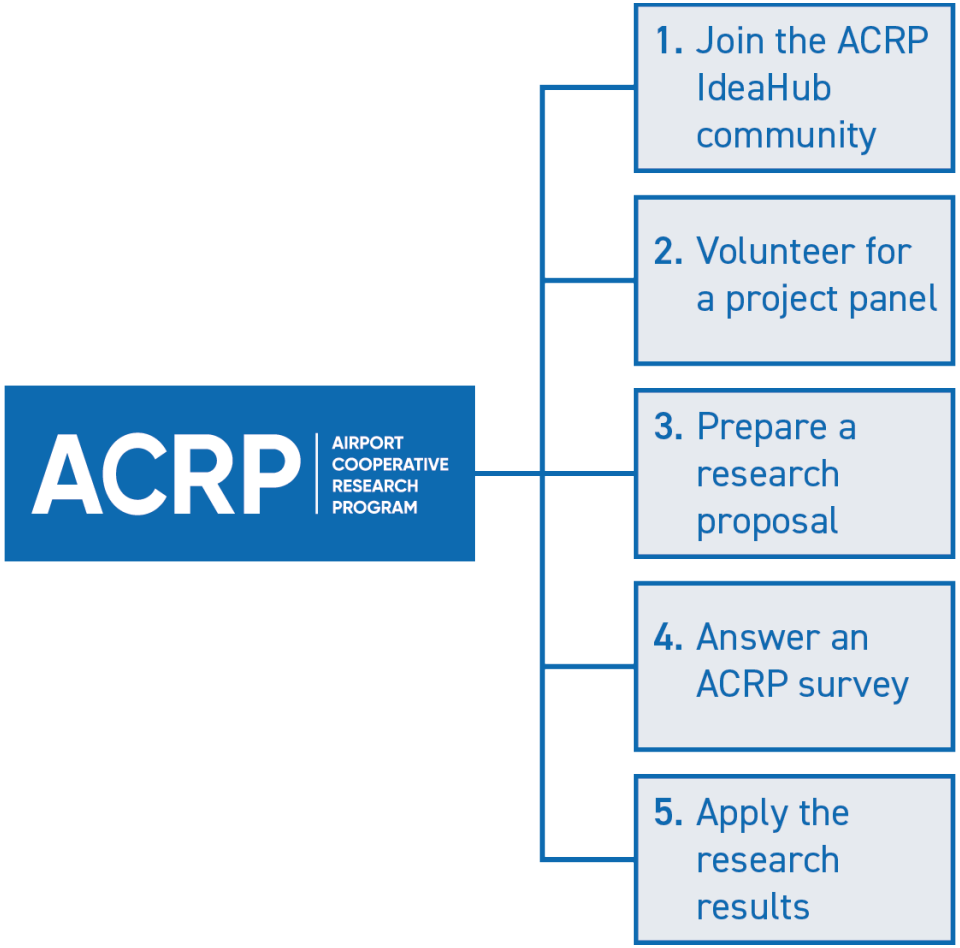

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