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LDACS - Technical Details

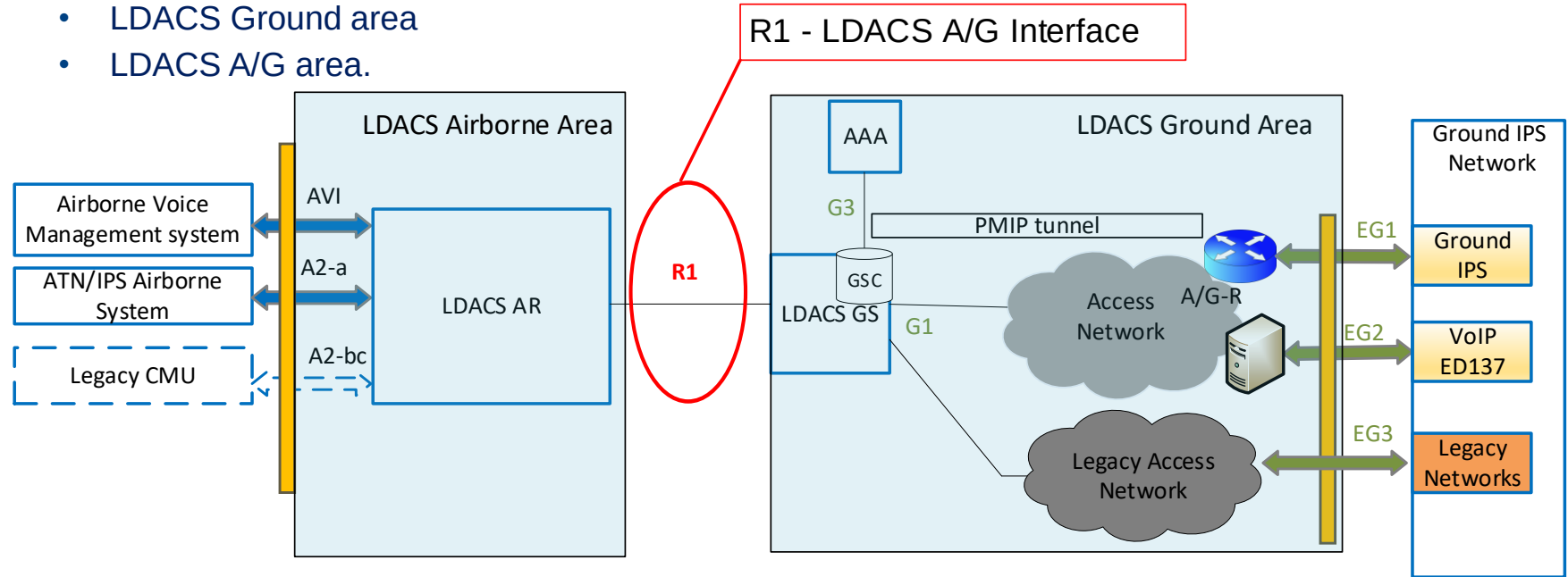
Bernhard Haindl Frequentis

ECTL/SESAR Webinar 2

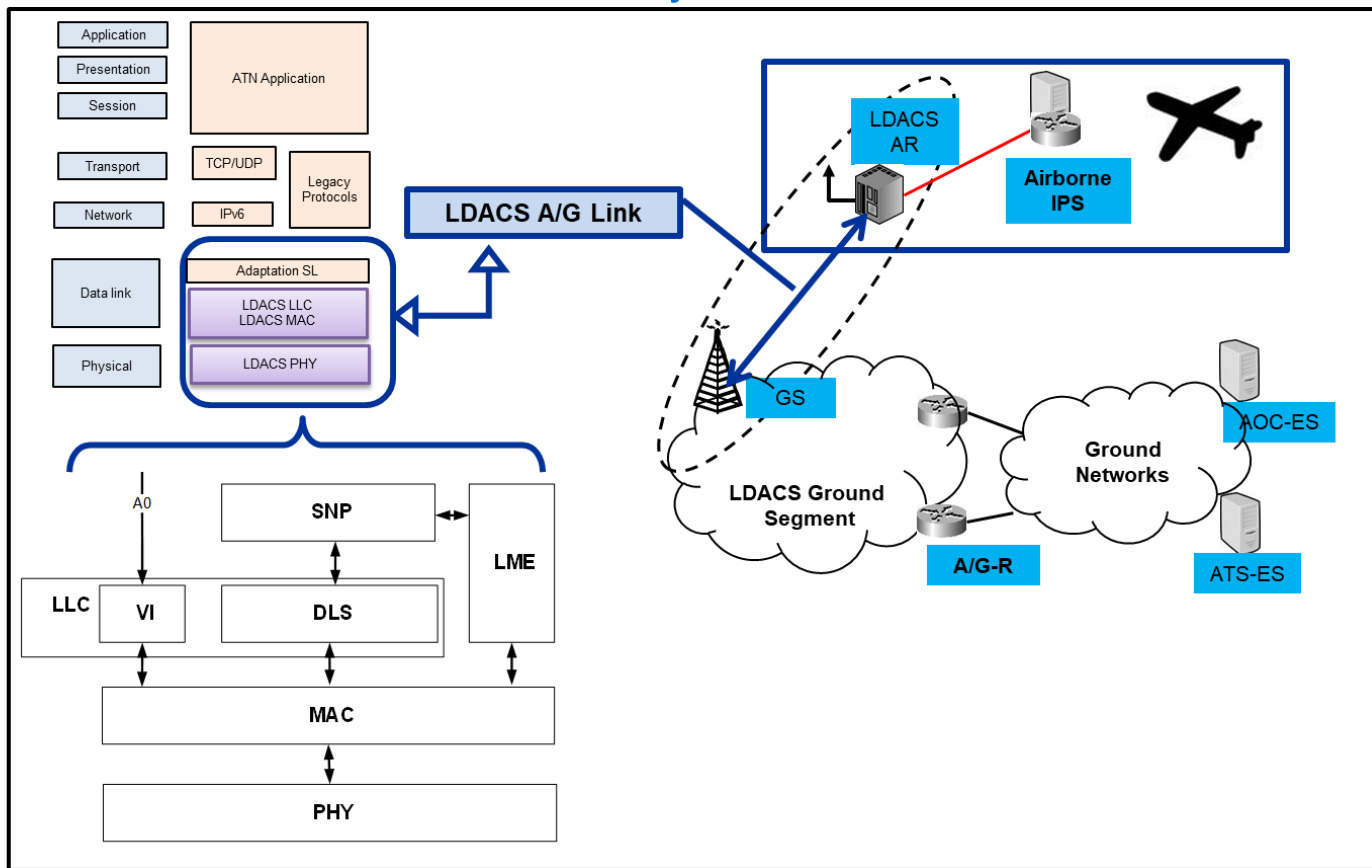
06/2021

What is LDACS - LDACS Architecture

- LDACS is an aeronautical air/ground communication system consisting of three areas:
- LDACS Airborne area
 - LDACS Ground area
 - LDACS A/G area.

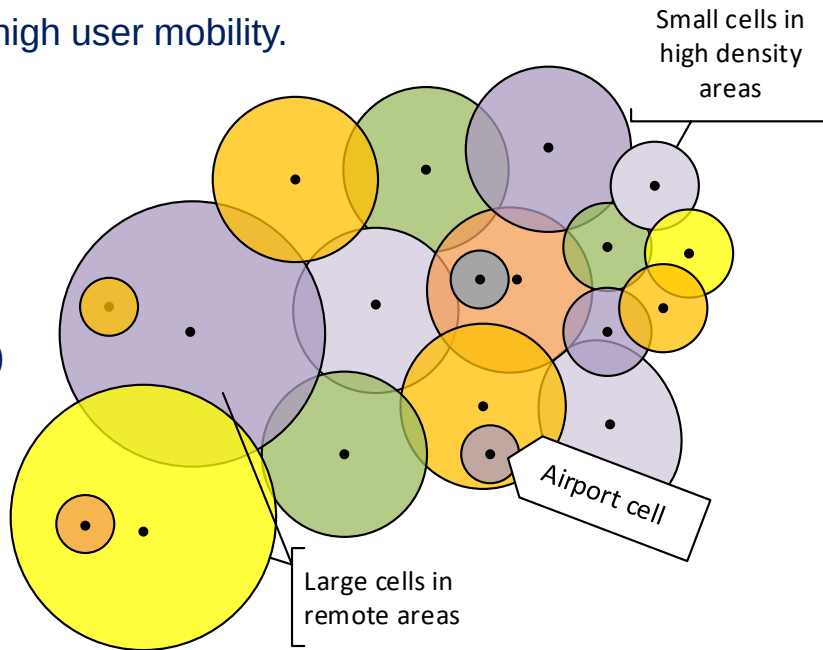


What is LDACS - A/G Interface Layers



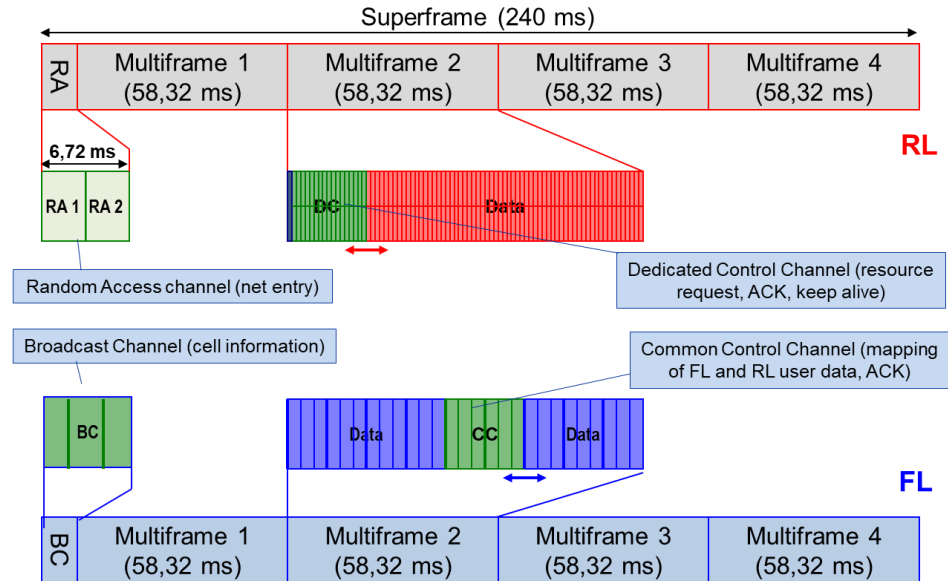
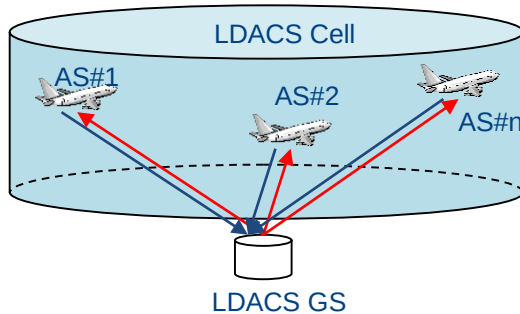
What is LDACS - A/G Interface Design and Characteristics

- Designed for the specific requirements of an aeronautical communication system in the L-band.
 - Considering transport of safety-critical data (Latency, QoS, security, and robustness).
 - Consideration of the existing systems in the aeronautical L-band.
 - Efficient coverage of the airspace and support very high user mobility.
 - Addresses limitations of the existing systems
- Based on OFDM modulation technology (50 Subcarriers, ~500 KHz Bandwidth)
- Efficient coding and adaptive modulation, covers QPSK to 64-QAM (Net data rate 550kbps -2.6Mbps)
- Cellular communication concept with up to 512 users per cell.
- LDACS cells designed for up to 200 NM range. (e.g.120, 60 or 40 NM)



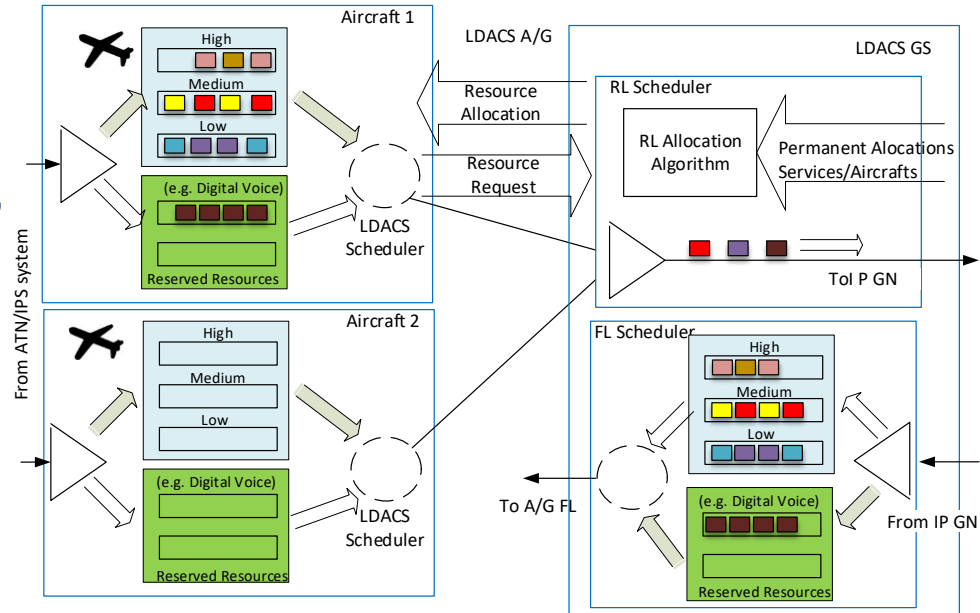
What is LDACS - A/G Interface Framing Structure

- Dedicated channel (DC) for each aircraft enables Low-latency transmission, deterministic channel access as well as fast and reliable link error detection on the ground. (avoiding faulty link conditions on ground.)
- Centralized communication via ground station enables coordinated channel access
- Guaranteed limited duty cycle on the reverse link



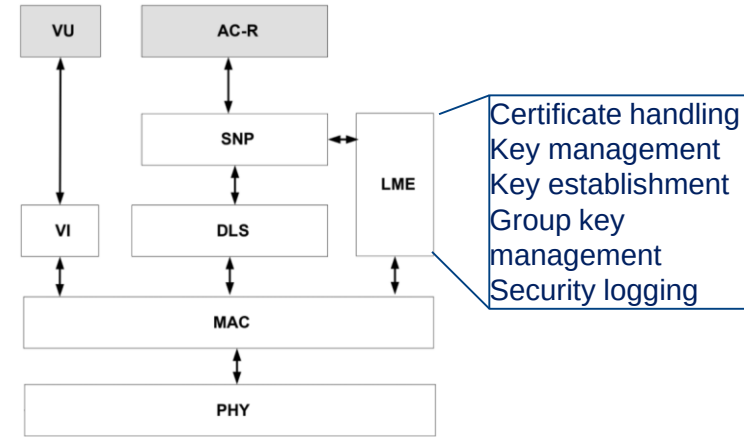
LDACS – IP connectivity, mobility and QoS

- Ack. P2P and Unack. P2P/P2MP communication between ground-station and aircraft.
- LDACS supporting ATN IPS mobility required for IPS communication. During LDACS airborne radio authentication, the LDACS ground infrastructure obtains and distributes the IPV6 prefix (MNP) assigned to the aircraft. (I.e. announces the MNP to the core IP network)
- LDACS provides a local mobility solution in an overlay network (e.g. PMIPv6) using existing IP infrastructure untouched.
- LDACS provides a 3-stage QoS approach, enabling joint use of ATC and AOC traffic.
 - LDACS AS provides a DSCP/DLS CoS based prioritizing/queuing.
 - LDACS GS allocates resources to the aircrafts based on the requested CoS.
 - Additional reservation for special services/applications. (e.g. digital voice)



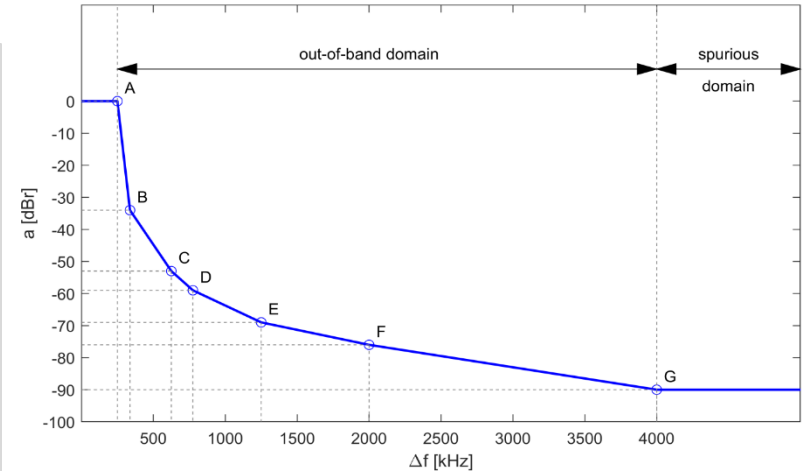
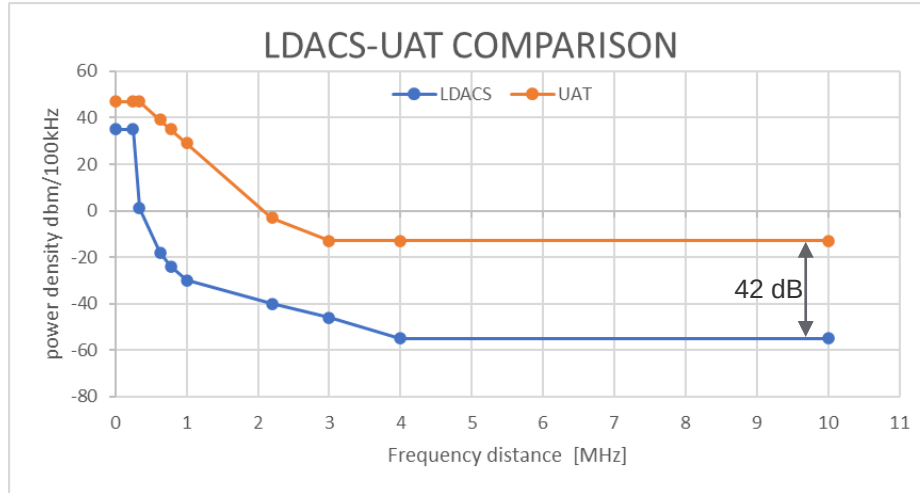
LDACS – Security

- LDACS security architecture is in line with the work of AEEC and ICAO WG-I Security SG.
- The LDACS security concept requires all entities in an LDACS network to authenticate to each other to ascertain that only trusted participants can use the system.
- LDACS provides during the login a Mutual Authentication between the aircraft and the LDACS access network
- LDACS security implemented directly in the sub-network layer and applied to all data sent over LDACS
 - Independent of higher layer security mechanism
 - Adds layer of security to the FCI
 - LDACS provides the capability to protect the integrity and privacy of messages in transit.
 - LDACS Control Plane protection: LDACS protects Authenticity and Integrity of its Control Data



LDACS - Spectrum Mask

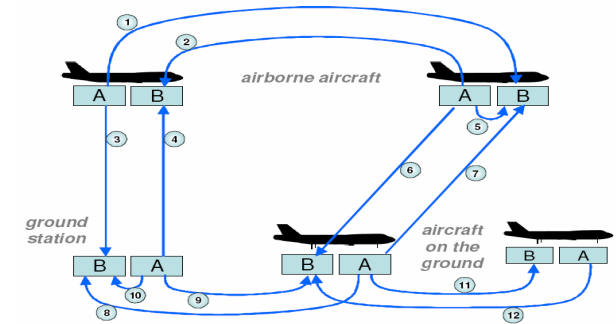
- To minimize the interference to existing L-Band systems the LDACS TX spectral mask is very stringent.
- LDACS/UAT comparison shows more than 40 dB lower power density in the spurious domain than UAT.



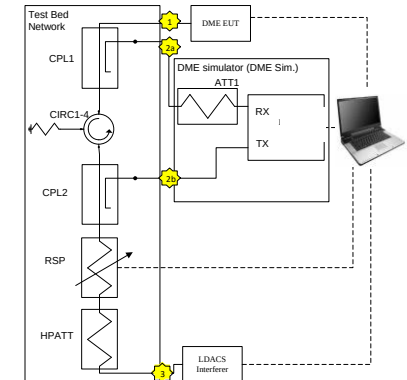
	$A(\Delta f, a)$	$B(\Delta f, a)$	$C(\Delta f, a)$	$D(\Delta f, a)$	$E(\Delta f, a)$	$F(\Delta f, a)$	$G(\Delta f, a)$	Spur
Frequency Offset Δf	250.0	337.5	625.0	775.0	1250	2000	4000	>4000
Attenuation a	0	34	53	59	69	76	90	90

LDACS - Compatibility With Navigation and Surveillance Means

- Deployment in the L-Band needs to ensure that LDACS will not impact negatively other legacy radio systems operating in the same or adjacent bands.
- First LDACS compatibility testing at DFS labs in 2014 used single interference scenarios.
- After feedback and coordination with ICAO NSP, further LDACS vs. DME/TACAN compatibility testing were conducted 2019. This time with aggregated interference scenarios. (JTIDS/MIDS and DME background noise).
 - Background interference defined by NSP for the compatibility measurements has turned out to be overly conservative
 - DME Equipment used was partly outdated and not covering a representative cross section of equipment currently in use.
-> New update of the test plan with ICAO NSP is ongoing.
- Technical discussions about compatibility with surveillance means started this year and is ongoing.

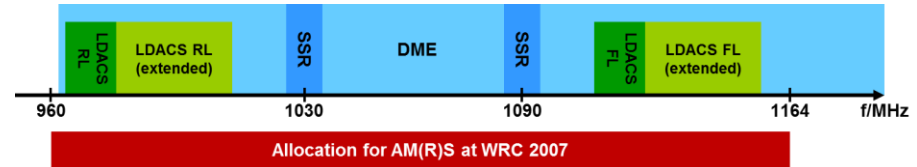


- Scenario 1 and 2: Aircraft to Aircraft
- Scenario 3: Aircraft to Ground Station
- Scenario 4: Ground Station to Aircraft
- Scenario 5: Co-located, same Aircraft
- Scenario 6 and 7: Aircraft to Aircraft on Ground
- Scenario 8: Aircraft on the Ground to Ground Station
- Scenario 9: Ground Station to Aircraft on Ground
- Scenario 10: Ground Station to Ground Station
- Scenario 11 and 12: Aircraft on the Ground to Aircraft on Ground



How will LDACS be deployed?

- Deployment in the L-Band in coordination with DME channels (Ensuring frequency separation and geographic distance)
 - Forward link: 1110-1125 (1156) MHz;
Reverse link: 964-979 (1010) MHz
- LDACS duplex spacing between the LDACS FL and RL frequency bands is 146 MHz.
 - No fixed assignment between the forward link channels and the reverse link channels allows a dynamic allocation of FL and RL channels.
 - Maximum transmitted power is 42 dBm for airborne and ground radios
- Re-use existing infrastructure on-board and on ground as far as possible to reduce costs
 - Combine technological advantages of LDACS with the existing VDL mode 2 ground infrastructure -> (LDACS Transition Concept from SITA)
 - Develop LDACS airborne radios supporting the combined usage of LDACS and VDLM2. -> Bring LDACS on-board without additional antenna.
 - Aircraft can use LDACS wherever deployed on ground, otherwise VDLM2 is used.
 - Enabling gradual introduction of LDACS starting where broadband connectivity is needed most



Summary

- Takes into account all characteristics for safety-critical communication in aviation, such as guaranteed data throughput and latency, efficient coverage of the airspace, spectrum-efficient use in the aeronautical L-band.
- LDACS is well established in ICAO's Global Air Navigation Plan (GANP) and SESAR's ATM Master Plan
- Well integrated into the Future IPv6 based communication infrastructure.
- Extends VDLM2 and complements the satellite links with a scalable, high-performance ground-based communication system.
- As a distributed system with no central single point of failure, LDACS is highly resilient and the provided maintenance approach further reduce the downtime
- Existing radio sites can be reused for LDACS, cutting the time and cost of deployment

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