ADVANCED VHF CONCEPT

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VHF COMM INDUSTRY BACKGROUND

- FAA Next Gen and SESAR ATM concepts increase reliance on data communications
- Existing VDL Mode 2 communication link approaching saturation in some areas due to
  - Increasing number of aircraft
  - Increasing amount of data per aircraft
- Challenges increasing capacity by adding more VDL Mode 2 frequencies
  - Global spectrum allocation and usage challenges
  - Ground station co-site & hidden transmitter issue
- Limited spectrum availability requires improved communication link spectral efficiency
- “Open” nature of existing VHF communication link
  - Cybersecurity vulnerability, open to “bad actors”

WHAT CAN BE DONE?

- Receive additional VHF spectrum for additional capacity
  - No “new” VHF spectrum currently available, but
  - VOR reduction to Minimum Operational Network (MON) may make some navigation spectrum available
    - However, most frequencies already planned for reallocation to GBAS ground stations
- Implement another technology with new spectrum allocation (e.g., LDACS)
  - Significant airborne and ground infrastructure investment required
  - Unresolved interference issues with legacy L-band equipment (e.g., DME)
- Offload VHF data network
  - Move non-safety messages to other media
- Update VHF using modern waveforms and technology
  - Add modern high symbol constellation waveform to VHF to significantly increase data rate

OFFLOAD VHF NETWORK

RECLASSIFY VHF MESSAGE TRAFFIC

- ICAO effort to reduce ATM Safety Message traffic
  - Review current ATM Safety Message list
  - Reclassify messages not directly impacting immediate flight status to Non-Safety
    - **Reduces quantity and size of ATM Safety Message Traffic**

- Move reclassified messages and Aircraft Information/Engine Data to other media (e.g., Cellular, WiFi, Ku/Ka SATCOM)

- Concept of Operations for sending Safety Messages over IP-based link media also under development

Reclassification reduces demand on VHF data link performance

MEANS TO MOVE MESSAGES

Usage Category	Communication Means	Range	Maximum Bit Rate	Availability	Latency	Supporting Infrastructure Timeframe
Airport Surface	Gatelink WiFi	~50 m	~100 Mbps	Low	Low	Now
	AeroMACS	~5 km	~2.5 Mbps	Medium	Low	Now (limited areas)
Short Range (Line of Sight)	Legacy VHF	~200 nmi	31.5 kbps	High	Low	Now
	Advanced VHF	~200 nmi	~100 kbps	High	Low	~2027
	LDACS	~200 nmi	~2.5 Mbps	High	Low	~2035
	Cellular 5G	~200 nmi	~1 Gbps	Medium	Low	~2022
Long Range (Beyond Line of Sight)	Legacy HF	Global	1.8 kbps	Medium	High	Now
	HF Next	Global	~100 kbps	Medium	Medium	~2024 (partial) ~2026 (full)
	Inmarsat SATCOM	Non-polar	~432 kbps	Medium	High	Now
	Iridium Next SATCOM	Global	352-700 kbps	Medium	Medium	Now
	Ku-Band SATCOM	Global (LEO) Non-polar (GEO)	~500 Mbps ~50 Mbps	Low	Low (LEO) High (GEO)	~2022 (LEO) Now (GEO)
	Ka-Band SATCOM	Global (LEO) Non-polar (GEO)	~500 Mbps	Low	Low (LEO) High (GEO)	~2024 (LEO) Now (GEO)

UPDATE VHF - MODERN WAVEFORM

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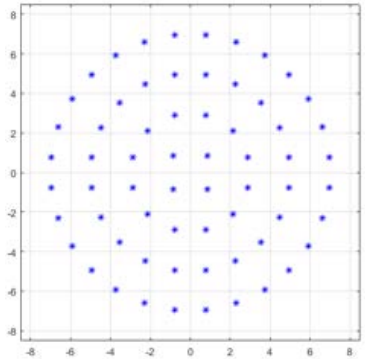
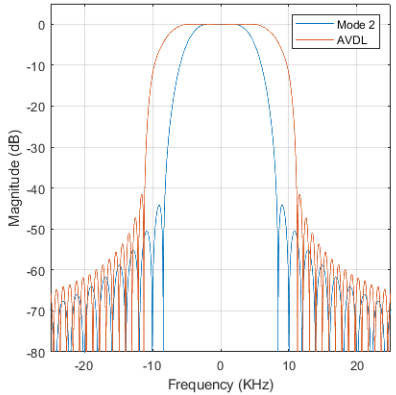
ADVANCED VHF DATA LINK (A-VDL)

- Higher symbol constellation waveform (64APSK, 15.75 ksps, 0.4 RRC, 7/8 rate coding)
  - Triples modulation bit rate on existing 25 kHz channel
    - 94.5 kbps vs. 31.5 kbps
  - Results in ~2.5X data throughput improvement
    - Increased FEC to maintain similar coverage area to Mode 2
  - Changes limited primarily to Physical Layer
    - CSMA channel access to ensure co-existence with Mode 2
    - Supports addition of DTLS MIC packet for Security (like ATN/IPS)
    - Connectionless protocol to maximize throughput
  - Supports future airspace ATM needs (see next slide)



- Compatible with existing VDL Mode 2 waveform
  - New waveform meets today's spectral mask requirements
  - Retain legacy waveform for backward compatibility



- Compatible with existing ground/aircraft infrastructure
  - Incrementally deployable, only where and when it is needed
    - **In many regions, existing VHF capabilities sufficient for foreseeable future**
    - Minimizes cost challenge of upgrading

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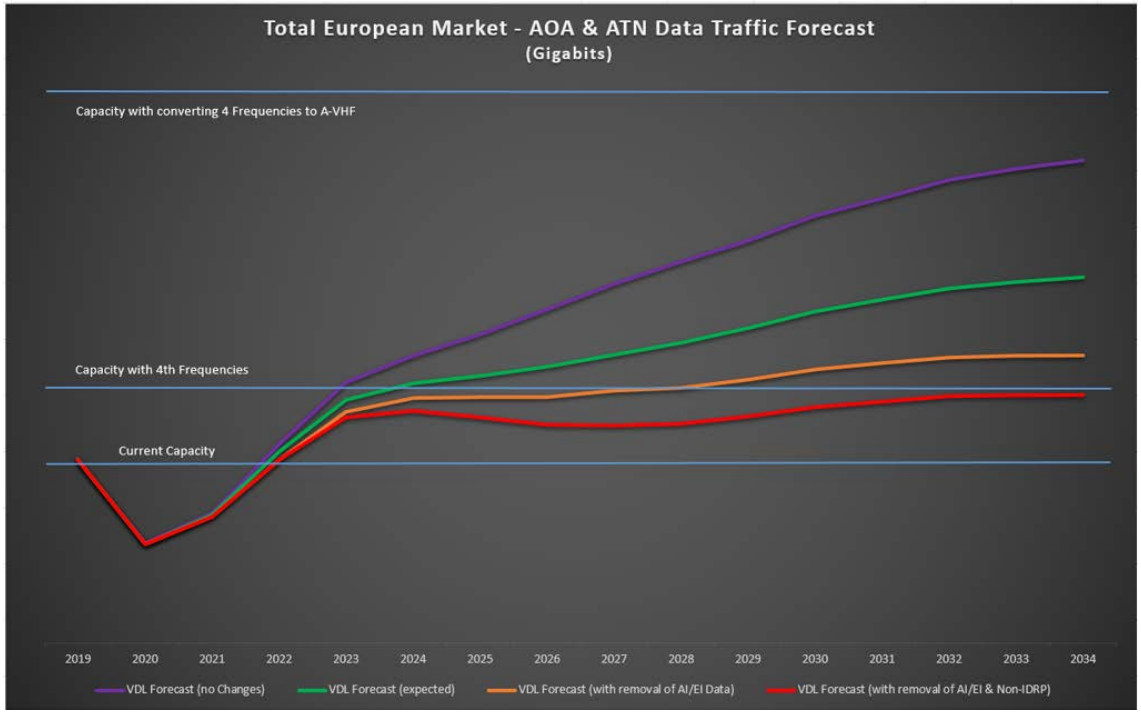
EUROPEAN VDL FORECAST VS. CAPACITY



- Projected increase in datalink demand due to modern aircraft and operations (variables out of our control, e.g., COVID-19, could impact timeline)
- Limited spectrum (capacity) will result in performance issues starting in 2024
- A-VDL would provide the needed capacity increase
- This graph is for illustrative purposes only and is not a representation of the traffic split between CSPs (for simplicity, traffic load was assumed to be split evenly between two CSPs)

A-VDL could extend lifespan of VHF datalink communications beyond 2040

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ADVANCED VHF IMPLEMENTATION APPROACH

- Hardware and software changes required to existing VHF Comm radios
  - Advanced waveform requires PA linearity improvements
  - Software-based modulation/demodulation
  - Existing avionics form factor retained
  - No impact to existing VHF antennas
- Software update to CMU for new media type
- Advanced VHF deployed to CSP ground stations
  - Selectively deployed on existing Mode 2 frequencies in congested airspace to increase capacity
    - Frequencies must be shared in order to continue supporting large quantity of Mode 2 users in transition phase
  - Advanced VHF aircraft seamlessly managed in airspace with VDL and ACARS aircraft
- Seamless interoperability with ANSPs through using existing network
  - No investment requirements for a new infrastructure and network

ADVANCED VHF OBJECTIVES/SUMMARY

- Advanced VHF guiding principles:
  - Open industry standard driven implementation
  - Safety service performance
  - Delivers data throughput ~2.5X today's VDL Mode 2
- Extends the usable lifespan of VHF Data communications
  - Modest modifications to airborne and ground infrastructure in a backward-compatible manner
- Business case driven
  - Incrementally deployable
  - Significant cost savings compared with alternate future terrestrial-based communication systems and SATCOM-based systems requiring aircraft mods
  - New global infrastructure not required
  - Leverages ANSP and Airline investments
    - Do not need to invest in a new communications system for networks and fleets

QUESTIONS?

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