

Technical details and capabilities of LDACS

Questions and Answers from the second LDACS webinar. Most recent question on top.

Nr	Question	Answer
#1	Hello To the participants in this webinar, Do you give a certificate of participation in the webinar?	<u>Ruben Flohr</u> No, we do not give a certificate for participation.
#2	Hello. Thanks for these excellent presentations. For those knowing the practical issues in current ATN/VDL services through DSG and DPSG meetings, linked amongst others to bad avionics behaviours, how do you see the migration with LDACS could help improve the situation ?	<u>Klauspeter Hauf</u> VDL concept is based on technologies introduced in the 70's, i.e. approx. 50 years ago and inherited a number of conceptual shortcomings that could not be fixed. The CSMA channel access scheme used in VDL is the weakest point causing a non-deterministic behaviour and limits the usable throughput to less than 40-50% of the theoretical Maximum of 31500 bps. On the opposite LDACS based on proven state of the art cellular communication technics will transport up to 100% of the maximum possible Datarate (550-2600 kbps) without a degradation in performance.
#3	Comparing to the nowadays VHF comm, where ATCO transmits to all the A/C in the sector over the same frequency and says the call sign of the particular A/C to be contacted, how does it work with LDACS, how the ATCO suppose to contact the particular A/C? What means of addressing are used?	<u>Bernhard Haindl</u> The LDACS digital voice concept supports the existing analogue VHF A/G voice conops and is capable to provide additional voice features and services. E.g., it is capable to support a PTT based group call service for flight-centric operations. The LDACS digital voice solution benefits from features of LDACS, like security means, coordinated channel access. That means that each aircraft is authenticated, and

		<p>the systems knows, which A/C is transmitting. This information could be displayed on the controller's CWP. A point-to-point voice call between ATCO and A/C is currently not requested for ATC in continental airspaces since it is not suitable for the current operational concept.</p> <p><u>Michael Schnell</u> Please note, although currently not requested, it would be technically feasible with LDACS to establish a point-to-point voice call between ATCO and A/C (or even point-to-multipoint).</p>
#4	<p>The low latencies discussed during the panel can only be achieved after mutual entity authentication and key agreement. However, three passes and asymmetric crypto will take rather long. Are there any plans, that high priority messages can be sent without prior full authentication?</p>	<p><u>Thomas Gräupl</u> Authentication has only to be performed once at the network entry of the aircraft. After that no further authentication procedures are necessary and all messages can be sent immediately. In addition to that the means of authentication will be negotiable between aircraft and ground-station. If the ground-station operator wants to, he can make authentication optional.</p>
#5	<p>Is it envisaged to use LDACS for UTM/U-space ?</p>	<p><u>Klauspeter Hauf</u> LDACS is optimized for (commercial) Aircrafts operations and it is also expected to serve single piloted Aircrafts if the pilot becomes unable. Serving UTM/U might be feasible from a technical perspective but the system would lack the spectrum (i.e. capacity) to include a large number of unmanned Aircrafts in addition.</p>
#6	<p>For voice communications, studies under FAA's NEXCOM showed that users of voice communications will be affected negatively with latencies as low as 200-250 ms. Will LDACS be able to achieve that?</p>	<p><u>Thomas Gräupl</u> LDACS voice latencies are expected to be below 100ms between aircraft and ground-station.</p>

#7	How robust is LDACS regarding noise, interference, jamming?	<p><u>Michael Schnell</u> LDACS is designed with robustness in mind. To achieve the necessary SNR in noisy environments, LDACS applies Forward Error Correction (FEC) coding. This is even adjustable to the channel condition, i.e., very noisy channel strong coding, less noisy channel less strong coding and with that more available data throughput. In addition, the LDACS receiver applies interference mitigation against pulsed interference, since there are navigation systems active in L-band (e.g. DME) which apply pulsed transmissions.</p>
#8	What about interference risks by using radio sites for LDACS?	<p><u>Klauspeter Hauf</u> The risk is considered minimal for VHF radio sites considering the frequency spacing of at least 800MHz. However additional tests are required and planned.</p>
#9	Unacknowledged messages for voice will work. But in case of exchange of data I assume acknowledged messages are needed?	<p><u>Bernhard Haindl</u> Right!</p>
#10	All logged aircrafts need to be time synchronized before transmitting, either in the RA slot or data ones. Does the system implement a synchronization control loop per aircraft? If it is the case, depending on the accuracy there can be significant overhead?	<p><u>Michael Schnell</u> Yes, there is a synchronization control loop. An aircraft trying to join a certain LDACS ground station, first listens to the ground station transmissions. With that, a very coarse synchronization is achieved. Then the Aircraft transmits in the RA slot to initialize net entry to the ground station. This RA slot has the necessary guard times not to interfere with other transmissions. Using the RA transmission the ground station determines the time advance required to fully synchronize the airborne station and sends this value to the aircraft. Then, the time-advance value is monitored and adjusted continuously.</p>
#11	Can you indicate how to download the Q&A? there are a lot of useful information there!!	<p><u>Ruben Flohr</u> The Q&A will be completed after the webinar. We are committed to be complete and therefore take about one week</p>

		before publishing the Q&A, to ensure all answers are provided. The will be published with the recordings on https://www.sesarju.eu/past-events
#12	QoS means not guaranteed bandwidth but only 3 Quality steps. That means if all users classify their data "high" the QoS concept will not work?	<p><u>Klauspeter Hauf</u> In a radio system all users share the available bandwidth. Prioritisation helps to overcome temporary shortages but cannot fix a constant overload. In such a case additional bandwidth should be made available (deploy smaller Cell size, add additional cells). It is worth to note that the assignment of Message Classes to different types of communication is predefined in the Avionics and cannot be changed by the user. ICAO provide guidance on the classification of different message types and Aircraft manufactures and operators are expected to respect this regulation.</p>
#13	Here in this slide you are talking only about VoIP, not the native circuit mode digital voice, right?	<u>Klauspeter Hauf right!</u>
#14	Not sure if the handover between cells in LDACS will be performed automatically the same way as typical cellular technologies, so it is possible that manual operational frequency change between ATC sectors is no longer needed.	<p><u>Klauspeter Hauf</u> The LDACS Cell handover is automated and there is not even a provision to manually change the frequency. But keep in mind that legacy VHF voice will still be around at the same time for many years and will continue to require a manual selection of the VHF voice channel.</p>
#15	If we integrate VoIP/ED137 into LDACS does it means migration from VHF to LDACS/L-Band?	<p><u>Klauspeter Hauf</u> The ICAO long term vision does currently not foresee such a step. DSB analog Voice on VHF will stay to be the backbone for continental Air-Ground Voice Com for many more years.</p>
#16	Any altitude constraints for LDACS A-PNT? Can we expect reduced coverage in mountainous areas as with DME, or may LDACS A2A help to alleviate this?	<u>Klauspeter Hauf</u>

		LDACS is Line of Sight, i.e. mountains can block the signal. A suitable Ground Station position with a good radio horizon remains a requirement.
#17	From the IP layer point of view: will LDACS network be a single IP subnet throughout all Europe, every cell is a subnet, or several cells, country, region?	<u>Thomas Gräupl</u> The addressing architecture of the LDACS subnet is hidden from the aircraft subnet which uses its globally unique ICAO IPv6 prefix. Any tunnelling necessary for that in the subnet is done by the LDACS ground installation transparently. <u>Bernhard Haindl</u> From IP layer point of view every aircraft is a separate IPv6 subnetwork. The LDACS ground network is hidden for the aircraft.
#18	Linked to my previous question. in option 1 if LDACS and VDLm2 radio_mode cannot be active at the same time, has the impact of switching from LDACS to VDLm2 or viceversa (e.g. due to coverage) been assessed?	<u>Klauspeter Hauf</u> The switch between the two technologies is expected to be seamless, but this claim needs to be validated as soon as there are dual Mode Radio prototypes available..
#19	Will the combined LDACS+VDL radio architecture look like single link to the CMU and ground infrastructure with the link selection managed internally in the radios? (I.e. LDACS becoming sort of extension of VDL.) Or will the CMU and ground still see LDACS and VDL as separate links?	<u>Bernhard Haindl</u> : The final concept is not defined, yet. But the idea is to have LDACS as an extension of VDLM2. From the ground side, LDACS and VDLM2 are two separated and independent links.
#20	What is the overall investment that will be needed, both at ground equipment and facilities and airborne? Are the ANSPs and Airspace users ready and willing to take this big step?	<u>Ricardo de Sousa</u> As mentioned before this is an equally important point, in parallel with technical development. The investment and transition aspects will be a primary focus as we go towards technical readiness
#21	Will LDACS be used for ACARS? If yes, isn't there a risk that bandwidth is monopolized by ACARS (whose data needs are increasing a lot)?	<u>Klauspeter Hauf</u> LDACS will be used by AOC and ATS communication. However, LDACS supports prioritisation and safety critical messages get priority over less critical ones. This is tested

		and demonstrated in the Test flights performed; i.e. LDACS guarantees that high priority safety critical messages (like ATC) gets priority over less (time) critical messages (like Engine data), delivering the critical messages within the limits set by RCP.
#22	with an integrated radio, can you confirm that in that case switching from VDLm2 to LDACS can be made transparent for the ATN protocol... ?	<u>Klauspeter Hauf</u> This is the aim, but needs to be validated as soon as there is a dual Mode radio prototype is available.
#23	In option 1, LDACS and VDLm2 could not be used in parallel/simultaneously, could they?	<u>Klauspeter Hauf</u> Why should someone like to use in parallel? Similar to public cellular networks the communication switches to the most capable connection available in an area. I.e. will stay on VDLm2 if there is no LDACS ground station in reach but will switch to LDACS as soon as a LDACS connection could be established.
#24	Is LDACS A2A expected to provide some alternative pos/nav capability in remote/oceanic areas?	<u>Okuary Osechas</u> This has been explored at the conceptual level. There is a paper that you can download here: https://www.ion.org/publications/abstract.cfm?articleID=15593
#25	Will a link to the presentations be provided so we can refer to them after the session?	<u>Ruben Flohr</u> The webinar recording, the presentations and the Q&A will be published on the SESARJU.EU website.
#26	@KlausPeter - as a continuation to my previous question about latencies. RCP130 and RCP60 still means a 95th percentile latency of 130 and 60 seconds respectively, does it not?	<u>Klauspeter Hauf</u> The vast majority of this figure is the Human reaction... The technical latency of the message is a fraction of it, but I have to pick the correct values from the standards. PS: RCP130: The (two way) time assigned for the Communication Infrastructure is $RCTP_{CSP}$: ET=18 sec, TT=10 sec

		<p>This figure includes the communication Service Provider network connection, routing etc. RCP60: is not yet defined but discussed in some groups.</p> <p>The Latency of the LDACS trunk is part of the RCTP_{CSP} figure.</p> <p><u>Michael Schnell</u> Results from our flight trials showed that with a mean load of 100 kbit/s created through a combination of small high priority ATC packets (175B) and large low priority AOC packets (1400B) the following latencies are achieved:</p> <table border="1" data-bbox="1227 584 1711 756"> <thead> <tr> <th rowspan="2">Priority</th> <th colspan="2">Avg. Latency (ms)</th> <th colspan="2">95% percentile Latency (ms)</th> </tr> <tr> <th>FL</th> <th>RL</th> <th>FL</th> <th>RL</th> </tr> </thead> <tbody> <tr> <td>All</td> <td>74</td> <td>166</td> <td>173</td> <td>429</td> </tr> <tr> <td>High</td> <td>57</td> <td>96</td> <td>81</td> <td>229</td> </tr> <tr> <td>Low</td> <td>114</td> <td>330</td> <td>200</td> <td>537</td> </tr> </tbody> </table> <p>FL: Forward Link (ground to aircraft) RL: Reverse Link (aircraft to ground)</p>	Priority	Avg. Latency (ms)		95% percentile Latency (ms)		FL	RL	FL	RL	All	74	166	173	429	High	57	96	81	229	Low	114	330	200	537
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#27	Can LDACS be used as a secondary positioning source for ADS-B and TAWS/EGPWS in case of a GNSS outage?	<p><u>Ricardo de Sousa</u> LDACS will act as an additional positioning source which is available to an equipped aircraft. How the avionics takes advantage of this to support certain applications such as ADS-B is largely down to avionics architecture choices.</p>																								
#28	Architecture Question: How does LDACS support FANSx-operations for Aircraft coming inbound from the US? Is there an encapsulation of ARINC 619 protocols?	<p><u>Klauspeter Hauf</u> LDACS is an IPS based system. AEEC is working on an ACARS/FANS IPS based protocol that might be used. However an IPS capable Aircraft is expected to support ATN/IPS.</p>																								
#29	Shall we wait for ICAO specification to start deployment, or you expect to start deployment at the finalization of the SESAR activities?	<p><u>Ricardo de Sousa</u></p>																								

		In terms of deployment, both technical developments and business case/service provision aspects are important of course. These streams will move forward in parallel and both contribute to the timeline for deployment. As you will know, the buy-in from airspace users as well as ground providers is a key point to develop.
#30	What geographical density of ground stations do you expect/recommend (besides of terrain covering effects) ?	<u>Klauspeter Hauf</u> LDACS Com range can be as large as 200NM with a reduced datarate (adaptive rate coding) Regular range of a cell is 80 or 120 NM for an enRoute scenario; i.e. similar to DSB VHF radio stations.
#31	To avoid misunderstanding: LDACS native ditital voice (circuit mode) is not VoIP, is it?	<u>Klauspeter Hauf</u> These are two different modes. The circuit Mode is the more demanding one, while VoIP can be used for regular Point to Point comm.
#32	What technical latencies can we expect under LDACS as compared to VDL2, e.g. for CPDLC?	<u>Klauspeter Hauf</u> LDACS will serve RCP130, that is the best class defined up to know. It is expected however that LDACS will also comply with more demanding RCP when defined (e.g. RCP60)
#33	OK, BW shared. Does it work sharing lower BW "portions" between all the A/C in the cell, or by competition? Does LDACs provide congestion avoidance mechanisms?	<u>Klauspeter Hauf</u> LDACS supports QoS and prisonisation; i,e, will guarantee that the important messages get delivered in time. However if the capacity is continuously overstretched additional frequencies/cells should be assigned in this area.
#34	Is the freq band/spectrum available and secured throughout the world for LDACS?	<u>Klauspeter Hauf</u> The aeronautical L-Band is assigned by ITU on a global base and is open for all CNS services when approved by ICAO.
#35	Referring to 550-2600Kbps bandwidth - is it per aircraft or is it shared between a certain amount of aircrafts ?	<u>Klauspeter Hauf</u>

		The Bandwidth is shared by all Aircraft in a cell, however it is possible to assign additional frequencies or smaller cells if the demand exceeds the capacity of a single cell (e.g. at an airport)
#36	Why such a large range for bandwidth?	<u>Klauspeter Hauf</u> LDACS is using an adaptive coding scheme similar to public cellular systems. LDACS Groundstation and avionic will “negotiate” the best rate possible in the current situation and will dynamically adapt the rate if situation changes. i.e. mobile users (Aircraft) close to the Groundstation can expect a higher rate compared to Aircraft far from the Basestation.
#37	Hi Klauspeter, can you please explain what you say that digital voice is not fully standarized. What is pending? It seems specified already by doc SESAR2020_PJ14_D3_3_030_LDACS_AG_Specification_00_02_02-1_0...	<u>Klauspeter Hauf</u> LDACS digital Voice is not standardized at ICAO layer yet. Europe (SESAR) studies and validate LDACS digital Voice and will feed the ICAO, Eurocae/RTCA standardization process.
#38	I've heard rumours that there may be an issue with frequency allocation for LDACS? Are you reasonably confident that you will be able (and allowed) to use the frequencies you need?	<u>Klauspeter Hauf</u> The aeronautical L-Band is identified by ICAO as the most reasonable Band for a new terrestrial Communication system. The Compatibility Investigations with the existing Aeronautical users in the L-Band (DME, SSR) are ongoing and it is to early to provide a final statement. Considering a reasonable frequency planning process it looks promising. It is also worth noting, that SJU study on L-Band navigation (DME) shows promising results on a way Forward to rationalise todays DME frequency usage.
#39	Why do you consider that LDACS can provide reduction of separation minima which is usually related to surveillance and not to communication?	<u>Ricardo de Sousa</u> Not initially, as the primary services will be data, with a secondary capability for navigation - however the support for digital voice is a clear known evolution path for LDACS

		Note - for the question below!
#40	I saw digital voice in the slide: is it one of the first requirements of LDACS?	<u>Klauspeter Hauf</u> Digital Voice is a possibility considered, but not yet fully standardized for LDACS at ICAO level
#41	More bandwidth? Good. But how much more? And how do you assess the demand for data capacity?	<u>Klauspeter Hauf</u> 550-2600Kbps per Cell and Frequency assigned The demand for AOC and ATC is doubling about every 4-5 years according to the CSP reports, confirmed by an assessment performed by SDM in 2019