NETWORK MANAGER

DPMF VDL2 MONITORING FLIGHT REPORT

August 2019 monitoring flight

Edition Number : 1.0

Edition Validity Date : 22/11/2019

EUROCONTROL

DOCUMENT CHARACTERISTICS

Document Title	Document Subtitle (optional)	Edition Number	Edition Validity Date
DPMF VDL2 MONITORING FLIGHT REPORT	August 2019 monitoring flight	1.0	22/11/2019

Abstract

This document reports on the 8th VDL monitoring flight performed on 06.08.2019.

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STATUS AND ACCESSIBILITY

Status		Accessible via	
Working Draft	☐	Intranet	☐
Draft	☐	Extranet	☒
Proposed Issue	☐	Internet (www.eurocontrol.int)	☐
Released Issue	☒		

TLP STATUS

Intended for		Detail
Red	☐	Highly sensitive, non-disclosable information
Amber	☐	Sensitive information with limited disclosure
Green	☐	Normal business information
White	☒	Public information

Edition History

The following table records the complete history of the successive editions of the present document.

Edition History

Edition No.	Edition Validity Date	Author	Reason
0.1	03/10/2019	Ch. Visée	**Initial Draft**
0.2	13/11/2019	Ch. Visée	**Internal review**
0.9	22/11/2019	Ch. Visée	**Proposed issue**
1.0	22/11/2019	Ch. Visée	**Release**

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1 Summary

Twice a year, the DPMF conducts VDL2 monitoring flights in order to monitor the performance of the European Data Link Services (DLS) as seen from an aircraft perspective.

This report highlights the multi-frequency deployment and the rise of the observed traffic volume. The key points are listed below.

1. 70% of the observed traffic volume is now taking place on the alternate frequencies.
2. Since last year, an increase of 26% in the traffic volume is observed on the alternate frequencies while it is considered constant (-0.64%) on the CSC.
3. An increase of 14% of the global traffic volume and 16% of the median traffic rate is observed between August 2018 and August 2019.
4. The traffic volume on the CSC is split 77% ARINC and 23% SITA.
5. 85% of the aircrafts on SITA's network are observed on its alternate frequencies while for ARINC the figure is 62%.
6. AOA represent 60% of the observed global traffic volume.
7. The Average Annual Growth Rate (AAGR) of the observed ATN traffic volume has increased to 27% (2018-2019) compared to the -1% observed during the period 2017-2018.
8. The AAGR of the AOA traffic volume has decreased to 10% (2018-2019) compared to the 34% observed during the period 2017-2018.
9. Voice communications are still heard on VDL2 frequencies.
10. ENAV is observed to have started deploying multi-frequency.

2 Introduction

The purpose of this document is to report some data link performance metrics, as defined in the DPMF report catalogue [5], from the last monitoring flight campaign that took place on August 6th, 2019 above core Europe. It also presents the evolution and trends of the measured parameters from the previous flights (since August 2015) as well as dedicated analyses.

As the monitoring flights are intended to analyse VHF Data Link at the airborne side, some effort has been made, when needed, to distinguish between airborne traffic (ENR) and ground traffic (Terminal) which is expected to be different in nature. However, except where stated otherwise, the traffic values presented in this report take into account all monitored frequencies as they are part of the monitoring flight results.

Since 2017, frequency assignments have been set according to AIR and GND categories (see ICAO Doc11 [7]). The designation of the frequencies in this report is then based on these two categories[1]. The terminology "alternate" frequency used in this document refers to any frequency other than the CSC. For SITA, 136.875 MHz is assigned for GND and 136.775 MHz for AIR. For ARINC[2], 136.825 is assigned for AIR and 136.725 for GND.

This monitoring flight highlights the presence of ENAV VGSs on alternate frequencies (SITA ENR and GND) and raises the question about how to partition the traffic among the ACSPs[3] in the following analysis. The ground station address allocation[4] only permits the usage of a set of prefixes and today ENAV is using ARINC and SITA ones (0001_b and 0010_b). In the previous reports the traffic was split between ARINC and SITA based on the ICAO 24-bit address prefixes only. From now on care shall be taken in order to correctly interpret the split between the two prefixes. The correct splitting between the 3 ACSPs would need to be made based on a list of VGS addresses. At the time of reporting, this list is incomplete (ENAV missing) and it is proposed to keep the "prefix" splitting in the current report as it was performed for the previous reports.

Finally, we remind the reader that the traffic volume expressed in this report are measured on the RF channels as seen by the monitoring aircraft taking into account all the possible retransmissions[5] observed as these are part of the real and observed traffic during the monitoring flight duration (+- 4hrs).

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[1] The denomination "mixed" frequency to denote a "mixed GND-AIR" frequency is not used as it is not compliant with the current ICAO Doc11 frequency plan.

[2] At the time of writing, ARINC is using its GND frequency (136.725 MHz) for both AIR and GND. The deployment of the AIR frequency is planned for 2019.

[3] This question was not raised before as ENAV VGSs were "hidden" within ARINC and SITA addresses on the CSC.

[4] The assignment of ground station ICAO 24-bit address is made by IATA of behalf of ICAO. A table can be found in ARINC 631-7 Appendix-F.

[5] It is observed that the traffic volume observed from the monitoring flight is very close to the channels throughput and that very few retransmissions are observed (3% of the observed traffic volume).

2.1 Outline of the report

Chapter 2 covers the measurement setup and the method of analysis.

Chapter 3 presents the results of the last monitoring flight together with the previous ones.

Remark: The metrics defined in [5] are highlighted in bold with the performance metric identification number between brackets.

The **airborne channel occupancy (A-1)** is used as a simple estimator of the traffic load on the different channels. It is computed by dividing the number of samples whose level is above a certain threshold over the total number of samples observed during a time period. This report provides a mean airborne channel occupancy, and also an airborne channel occupancy statistic based on one second integrated values. The latter is intended to have comparable values to what the VDRs are supposed to provide.

The **airborne burst collision rate (A-2)** is an estimation of the number of collisions observed at FL370. It is computed by dividing the number of bursts identified in a collision over the total number of bursts observed during a time period. It is used as an indicator to the correct behaviour of the radio channels. To achieve maximum throughput, the number of collisions needs to be minimal.

The **channel load (KPI_PHY_01)** is used to measure the evolution of traffic. It is defined as the sum of the AVLC frame size (in kB). It is also expressed in this report as a traffic rate in kbits/s computed as an average per second over periods of 60 seconds. The median and the 95th percentile values over the whole flight are presented. These values are also computed in function of the type of traffic (AOA, ATN or AVLC protocol related) referring to **KPI_PHY_02**.

This report also provides the distribution of traffic between the CSC and the alternate frequencies, and is used to monitor the traffic offload of the CSC in the scope of the multi-frequency deployment.

Interference reporting is presented for each type of observed interference in term of their total duration.

Chapter 4 covers discussion on the metric results.

Finally, **chapter 5** gives the conclusions and addresses recommendations.

3 Measurement setup and method of analysis

Measurements were performed using NLR[6]'s Cessna Citation II flying across Europe around FL370. The setup can be found in annex 1.

Figure 3-1 : Typical flight route.

The analysis is performed using dedicated software tools.

IF-PAN (spectrum) data are converted into "spectrum tiles" to display the recorded spectrum in order to perform interference analysis. It is also used to list all the voice transmissions generated by the aircraft and overloading the receiver – the latter events being excluded from the following analysis.

The recorded IQ data (500 kHz) is first channelized to the desired 25 kHz channels and saved into separate IQ files.

Each channel is then processed to detect and demodulate bursts. Demodulated AVLC frames are saved into text files in a hexadecimal format with additional RF information (time-stamp, level, duration).

Airborne channel occupancy and other RF statistics (levels distribution) are also processed channel by channel and the results saved in text files.

AVLC frame analysis is performed for each generated channel log file providing various statistics for the ACSPs, AVLC frame types, time-stamps or plane location. Only correctly demodulated and valid AVLC frames (correct CRC) are used for the analysis.

Channelized IQ data (25 kHz) is also used to visually count the burst collisions over a set of 120 one-second data using a dedicated GUI tool. The latter is also capable of performing burst demodulation of a selected burst when required.

When needed IQ data is also used to demodulate other type of signals (i.e. voice, ACARS (POA))

[6] Nationaal Lucht-en Ruimtevaarlaboratorium (NLR).

4 Results

4.1 Airborne channel occupancy

Occupancy measurements are computed over channelized IQ data using 64 kSamples/s.

As occupancy values depends on the level threshold used, level density function graphs are provided for each frequency in the annex 2. In the following sections a -90 dBm threshold at the antenna is considered ("*idle to busy*" threshold defined in ICAO annex 10 [6]).

4.1.1 Average occupancy

The following tables summarizes the mean occupancy measured above FL285 since 2015. Tables are split into spring and summer flights due the seasonal variation of traffic.

Table 1 : Average occupancy for summer flights.

Frequency / assignation		*08.2015*	*08.2016*	*07.2017*	*08.2018*	*08.2019*
136.975 MHz	CSC	20.35%	26.23%	31.02%	23.12%	22.43%
136.875 MHz	SITA TER	1.84%	6.33%	8.69%	7.75%	9.54%
136.825 MHz	ARINC ENR	0.02%	1.69%	0.00%	0.22%	0.72%
136.775 MHz	SITA ENR	0.01%	0.63%	4.33%	4.53%	13.87%
136.725 MHz	ARINC TER	0.40%	0.82%	3.01%	19.52%	17.89%

Table 2 : Average occupancy for spring flights

Frequency / assignation		*04.2017*	*05.2018*	*04.2019*
136.975 MHz	CSC	18.82%	18.03%	23.59%
136.875 MHz	SITA TER	5.20%	6.80%	8.87%
136.825 MHz	ARINC ENR	0.31%	0.18%	0.02%
136.775 MHz	SITA ENR	1.29%	2.84%	8.97%
136.725 MHz	ARINC TER	1.49%	11.50%	17.43%

Note 1: The greyed values are occupancy measurements performed on channels where no VDL2 transmissions were recorded.

Note 2: The reader shall note that the occupancy measurement on the SITA Terminal frequency does not reflect the real behaviour of the channel due to the location of the monitoring receiver (aircraft at FL370). In order to have a correct representation of the channel occupancy, the measurement would need to be done at the airport location (and is not in the scope of this document). However, average channel occupancy values are still presented in this report as they give information on the use of the frequency.
This phenomenon is not addressed on ARINC's terminal frequency because today this frequency is used for both en-route and terminal use. As soon as ARINC implements its dedicated en-route frequency, the same comments will also apply to ARINC's terminal frequency.

Note 3: The rise of the mean occupancy on the SITA's ENR frequency (a factor 3 of increase since last year) is probably due to a) the SITA's CVME improvement leading to more aircraft tuned on alternate frequencies and b) the ENAV multi-frequency deployment leading to more aircraft on alternate frequencies.

Note 4: The small decrease of the mean occupancy on ARINC's mixed frequency could be explained by the following elements: a) as it is observed in Figure 4-1 and 4-2 the repartition of channel occupancy over the flight duration is more constant than during the last year's flight and that it might affect the computation of the average occupancy value b) a small decrease of the traffic volume is also observed for this monitoring flight compared to last year that might lead to a decrease of occupancy. It is also to be noted that the mean occupancy value of August 20019 is coherent with the value measured during April.

4.1.2 One minute occupancy over time

Using an integration time of 60 seconds, the following graphs gives occupancy in function of time (flight path) for each frequency. The graph for the same period last year is also provided for comparison purposes.

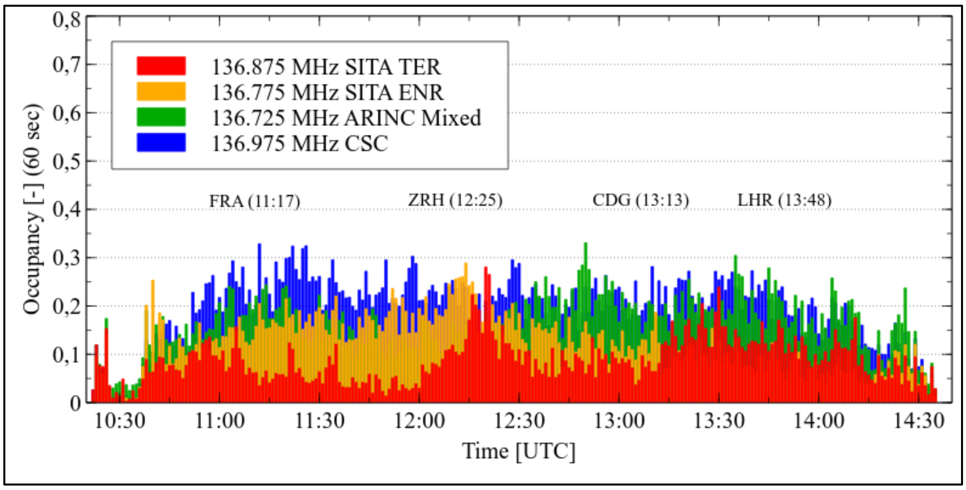


Figure 4-1 : Occupancy in function of time on 06/08/2019.

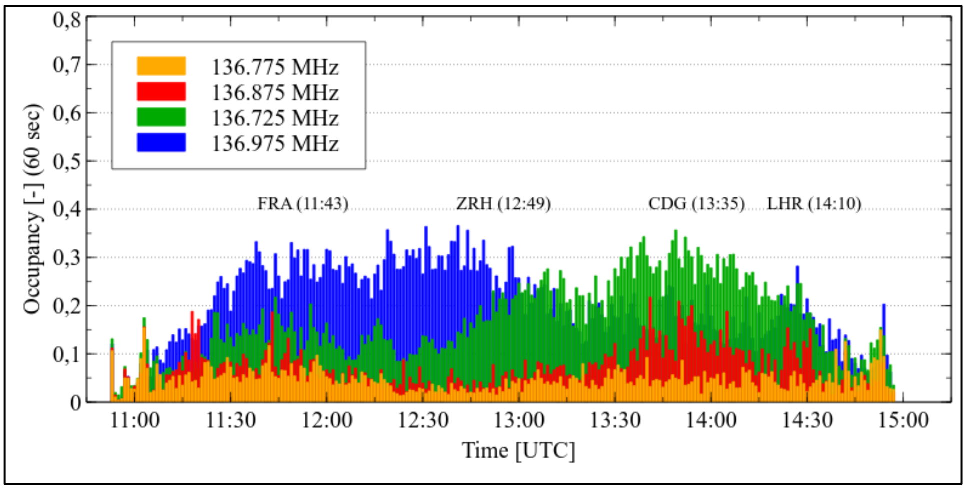


Figure 4-2 : Occupancy in function of time on 02/08/2018.

Note : A decrease in the CSC's occupancy for the first half of the monitoring flight (2019 to 2018) is observed together with an increase of occupancy on both ACSP's alternate frequencies highlighting a "balancing" of traffic between the CSC and the alternate frequencies.

4.2 Airborne collision rate

Using a dataset of 120 one-second[7] samples of data, the collision rate is estimated by computing the ratio between the number of collided bursts over the total number of observed bursts. The values are summarized in the following table.

Table 3 : Collision rate for summer flights

Frequency / assignation		*08.2015*	*08.2016*	*07.2017*	*08.2018*	*08.2019*
136.975 MHz	CSC	47.85%	42.57%	50.28%	37.10%	34.76%
136.875 MHz	SITA TER	6.43%	16.31%	16.26%	15.82%	13.27%
136.825 MHz	ARINC ENR	-	-	-	-	0.00%
136.775 MHz	SITA ENR	-	-	7.52%	5.91%	24.76%
136.725 MHz	ARINC TER	-	0.00%	9.92%	29.51%	23.23%

Table 4 : Collision rate for the spring flights

Frequency / assignation		*04.2017*	*05.2018*	*04.2019*
136.975 MHz	CSC	36.71%	37.48%	34.17%
136.875 MHz	SITA TER	17.29%	15.43%	18.32%
136.825 MHz	ARINC ENR	-	-	-
136.775 MHz	SITA ENR	2.99%	5.49%	13.06%
136.725 MHz	ARINC TER	6.12%	20.73%	25.27%

Note 1: As mentioned earlier, the measurements on the SITA Terminal frequency do not reflect the real behaviour of the channel. The number of collisions as seen from the aircraft at FL370 is strongly overestimated when compared to the expected reality. We expect very few collisions on a terminal frequency at a specific airport as most aircrafts (on ground) and VGSs see each other whereas the airborne monitoring aircraft sees transmissions from all airport stations acting as hidden transmitters. However, the values are still presented as they are good examples of the hidden transmitter problem phenomenon.

Note 2: A significant increase of the collision rate is observed on SITA ENR frequency since last year. This is to be related to the increase of traffic observed (including April's monitoring flight).

[7] Since 2019 the one-second dataset have been extended to 180 (flight duration above FL285).

4.3 Channel use

This section presents statistics on how the traffic is distributed over the different channels depending on the type of frame sent. The analysis is performed only using correctly received AVLC frames during the full flight duration. All the following analysis is based on the frame size (bytes), not their number.

The traffic rate is expressed in kbits/s[8], and is computed using one-minute datasets of traffic along the flight duration. The one-minute integration time is chosen to reduce various "averaging" effects (time, location) that is observed if we use the aggregated data from the full flight when analysing the peak of the traffic[9]. The Median and the 95th percentile values are used to estimate the "mean" and "peak" traffic on the different channels.

4.3.1 Share of channels by ACSPs

The following graphs summarizes the share of each channel by the service providers over time.

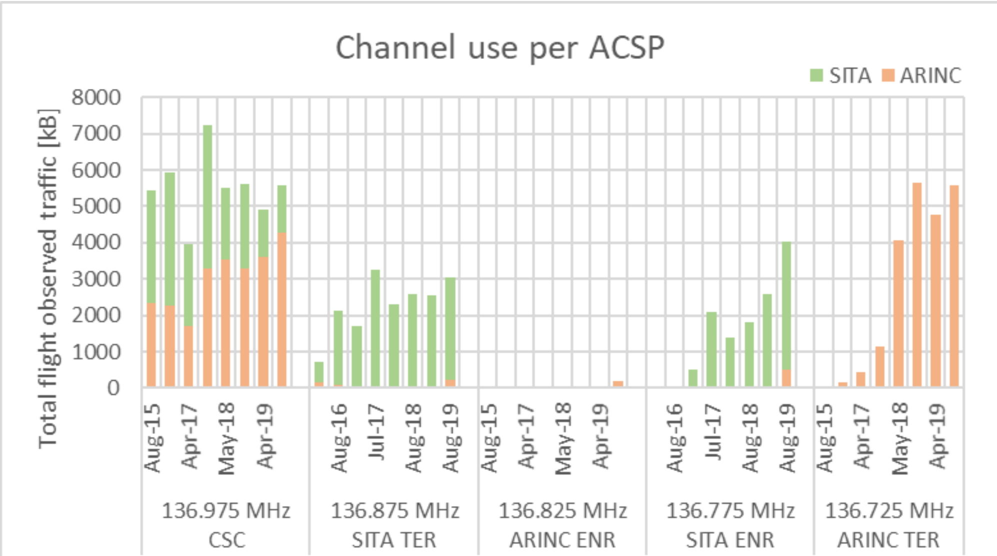


Figure 4-3 : Traffic distribution between ACSP per frequency

Note 1: The use of 136.875 MHz by both ACSP in 2015 and 2016 is due to the mixed used of the frequency prior to 2017.

Note 2: The presence of "ARINC" stations on SITA's alternate frequencies since August 2019 is due to ENAV's multi-frequency deployment in Italy advertising both CSPs on the same alternate frequencies.

Note 3: A small amount of traffic is observed on ARINC ENR frequency

[8] The traffic rate is expressed as : $Rate\ [kbits/s] = 8 * \frac{Traffic\ [kB/minute]}{60}$

[9] The observed traffic being a function of time and location, the monitoring aircraft flying across Europe above different locations will observe different traffic profiles. Moreover, some flights experienced interferences and/or corrupted data of various sources, hence reducing the total number of correctly received AVLC frame during the flight.

4.3.2 Share of the CSC by the ACSPs

The following graph focuses on the distribution of traffic between ACSPs on the CSC.

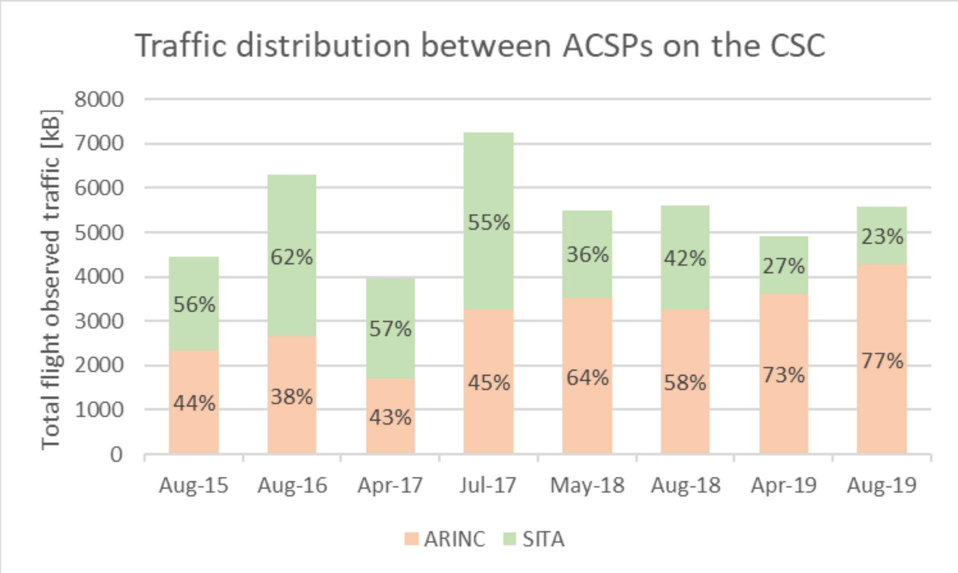


Figure 4-4 : Traffic distribution between ACSPs on the CSC

4.3.3 CSC offload

The following graph summarises the percentage of traffic between the CSC and the alternate frequencies (per ACSPs), highlighting the increase of traffic on the alternate frequencies.

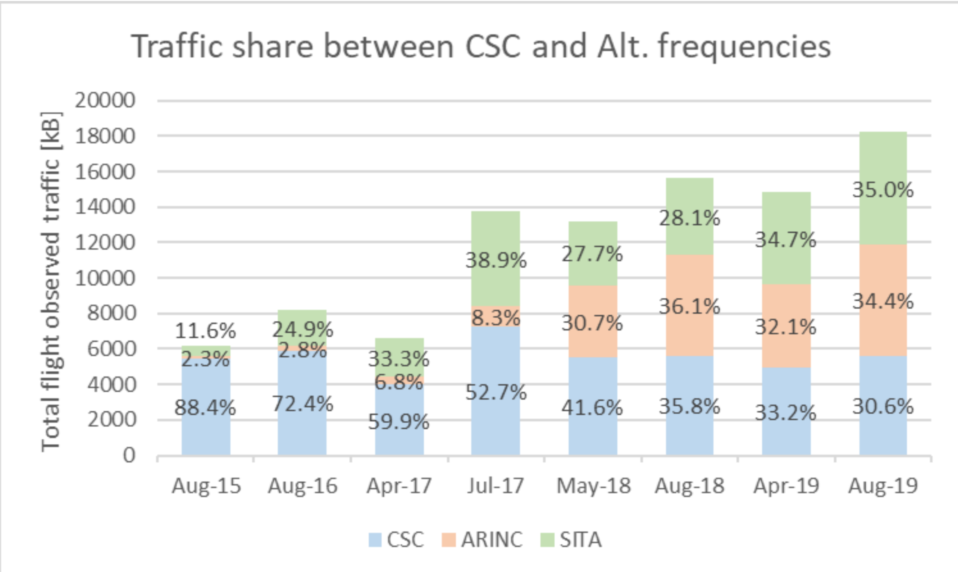


Figure 4-5 : Partition of the total traffic between the CSC and the alternate frequencies

The following graph displays the evolution of the total traffic volume heard during the monitoring flights for each ACSP, on the CSC and on their alternate frequencies, highlighting the percentage of traffic volume offloaded from the CSC for each ACSP.

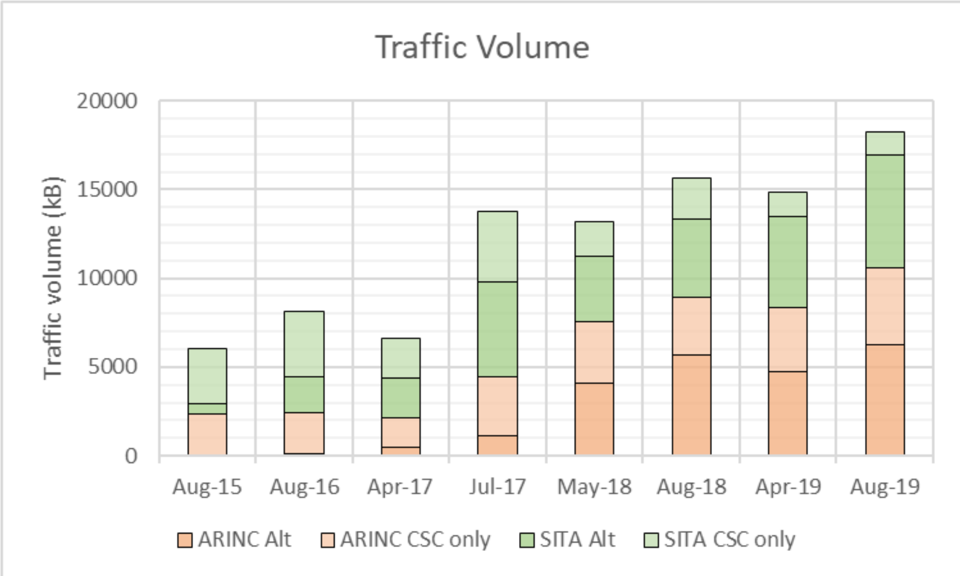


Figure 4-6 : Evolution of the traffic volume per ACSP between the CSC and Alternate frequencies

Note 1: 83% of the traffic volume heard on SITA's network is seen on alternate frequencies while 60% of the traffic volume heard on ARINC's network is seen on the alternate frequency.

Note 2: 70% of the global traffic volume is observed on alternate frequencies. This is an increase of 25.83% since last year.

4.3.4 ENR traffic volume

The following graph shows the global traffic volume observed delivered on ENR frequencies other than the CSC (136.775 MHz for SITA and 136.725 MHz ("mixed") for ARINC).

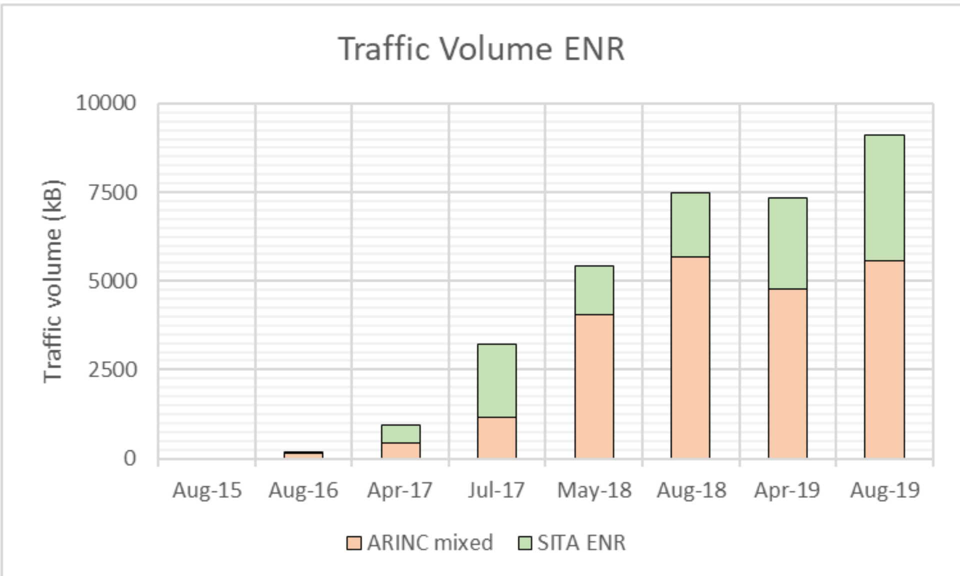


Figure 4-7 : Traffic volume on dedicated ENR frequencies

4.3.5 Aircraft multi-frequency capability

The following graph shows the number of aircraft (unique ICAO 24-bits address) observed during the monitoring flight in function of the frequencies (CSC-alternates). It highlights the number of aircraft tuned to alternate frequencies in function of the monitoring flights. The number of aircraft only heard on the CSC is computed as the difference between the total number of aircraft heard (per ACSP) and the ones heard on alternate frequencies.

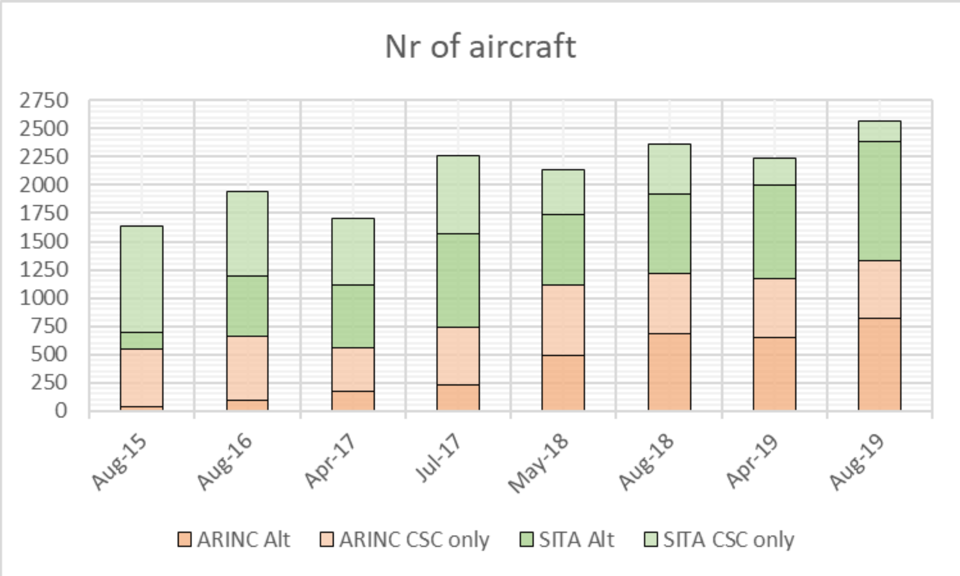


Figure 4-8 : Number of aircraft heard on alternate frequencies

Note 1: An aircraft only heard on the CSC does not mean it is not multi-frequency capable.

Note 2: 85% of the aircraft (unique ICAO 24-bits address) on SITA's network were heard on alternate frequencies (increase of 50% since last year) while 62% of the aircraft (unique ICAO 24-bits address) on ARINC's network were heard on an alternate frequency (increase of 19% since last year).

Note 3: Looking at both ACSPs, 73% of all the aircraft are heard on alternate frequencies. This is an increase of 14% since last year.

4.3.6 Distribution of AVLC frame by type

The following graphs shows the distribution of the AVLC frame types computed over all the frequencies and for the flight duration. AOA frames convey ARINC-620 packets, X.25 frames convey ATN packets, while AVLC-type frames convey AVLC protocol related packets (RR, SREJ, XID,…). Graphs are provided for all frequencies (top graph) and for frequencies only conveying ENR[10] traffic only (bottom graph)[11].

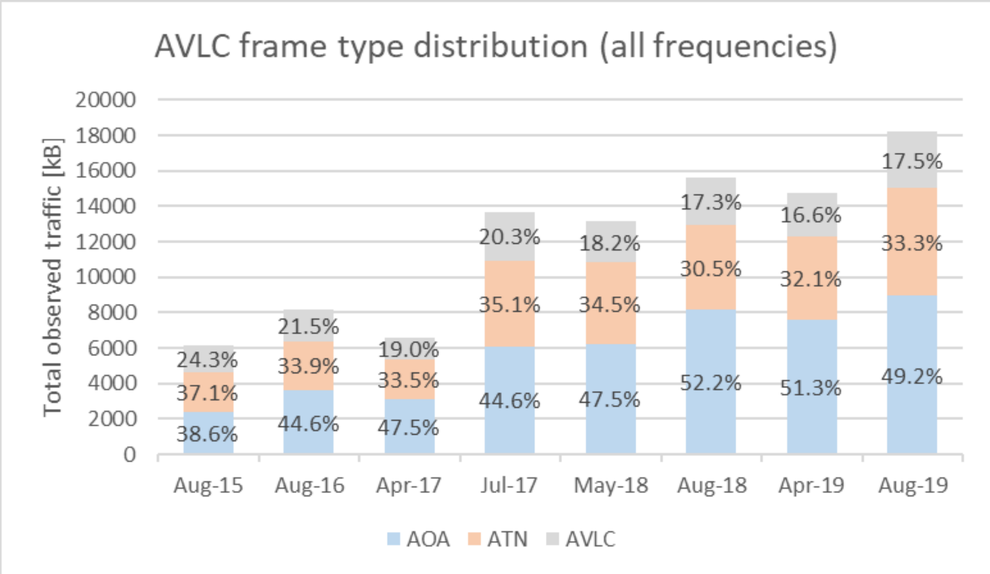


Figure 4-9 : AVLC frame distribution over time

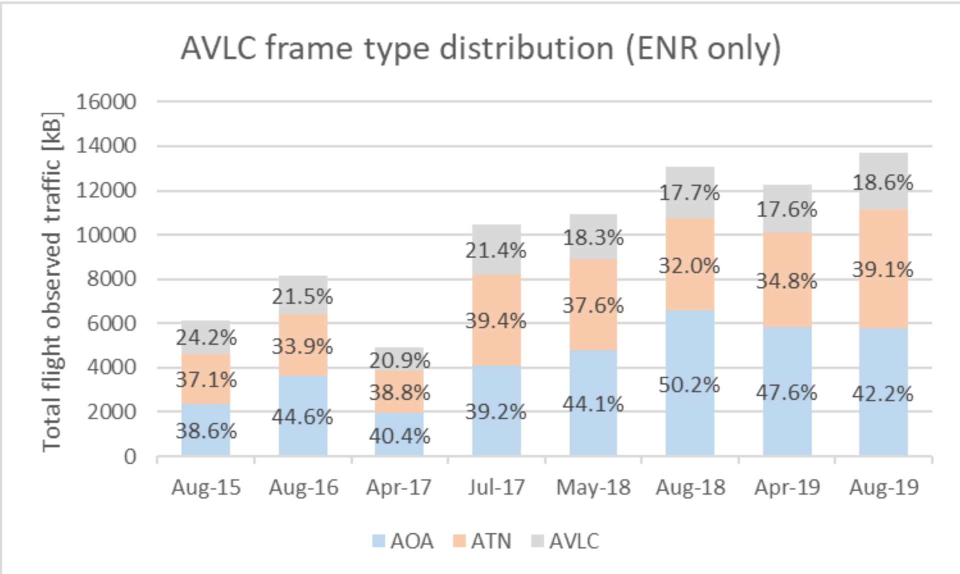


Figure 4-10: AVLC frame distribution over time for frequencies conveying E-R traffic

[10] CSC, SITA ENR and ARINC TER.
[11] As discussed in [8].

Note 1: 45% of the AVLC protocol related frames conveys RR frames. These could be equally split into AOA and X.25 traffic as they are directly related to the transfer of these frames at the AVLC layer but are kept into a separate category as they do not specifically convey AOA or X.25 data.

Note 2: An increase of 14% of the global traffic (all channels) is observed between August 2018 and August 2019 while an increase of only 4% is observed on ENR related channels for the same period.

Note 3: AOA is responsible for 60% of the global traffic volume observed.

Note 4: The Average Annual Growth Rate (AAGR) of the ATN traffic volume has increased to 27% while the AAGR of the AOA traffic volume has decreased to 10% (see section 4.3.9).

4.3.7 Global peak and median traffic rate (kbits/s) per AVLC frame type

The following graphs shows the median and 95th percentile traffic rate for the three categories of AVLC frames computed over all the frequencies. ,…). Graphs are provided for all frequencies (top graph) and for frequencies only conveying ENR[12] traffic only (bottom graph)[13].

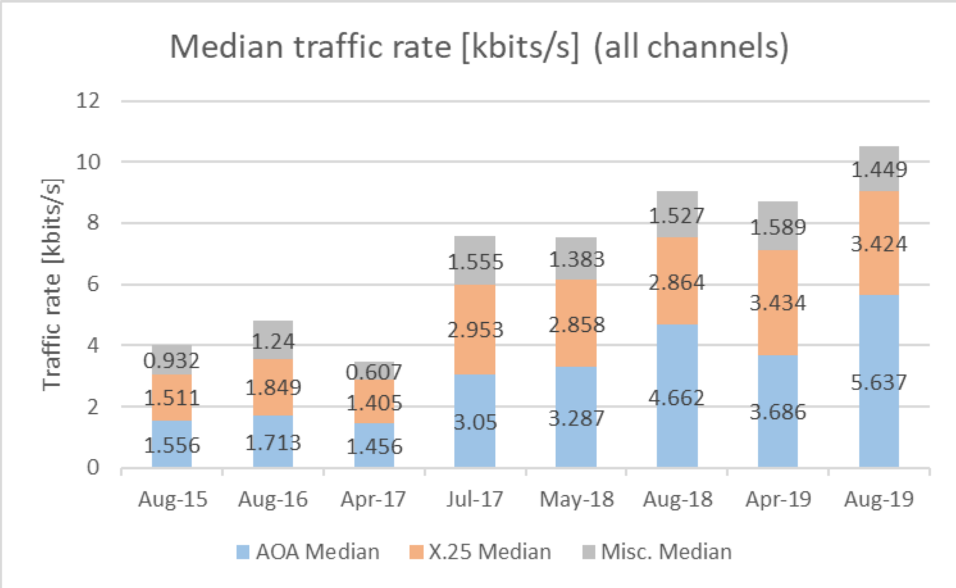


Figure 4-11 : Median traffic rate

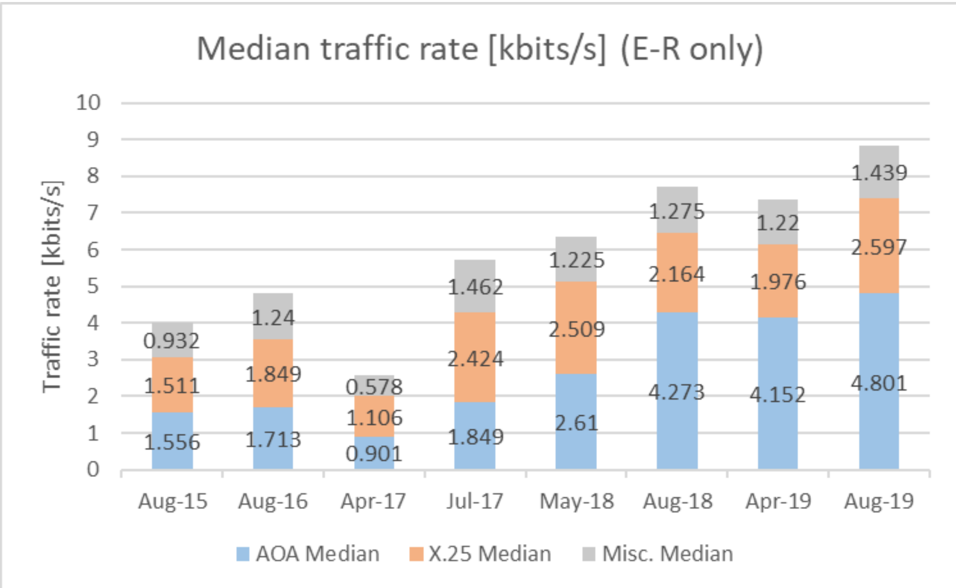


Figure 4-12: Median traffic rate for frequencies conveying E-R traffic

[12] CSC, SITA ENR and ARINC TER.

[13] As discussed in [8].

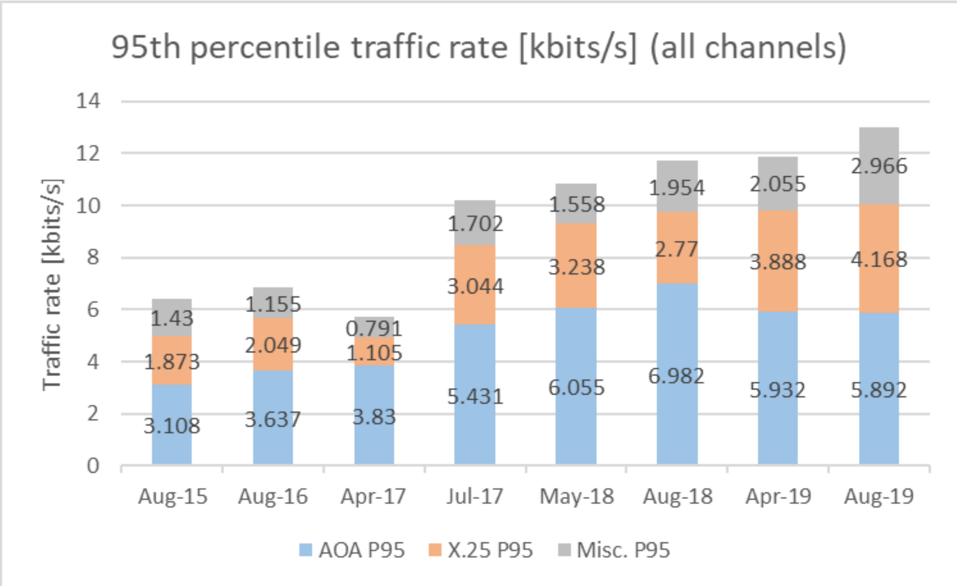


Figure 4-13 : 95th percentile traffic rate

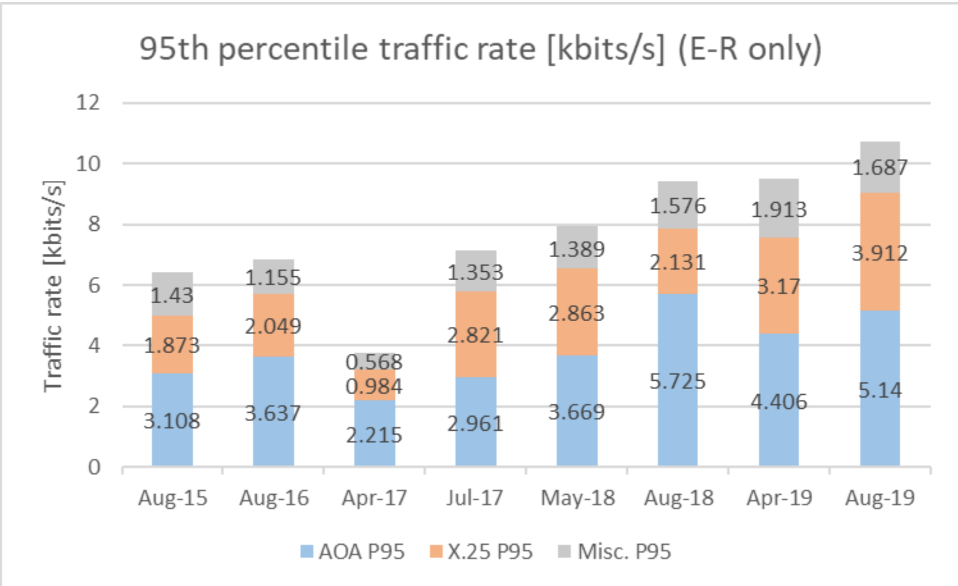


Figure 4-14: 95th percentile traffic rate for frequencies conveying E-R traffic

Note: An increase of 16% (all channels) and 14.6% (E-R only) of the median traffic rate is observed between August 2018 and August 2019. The increase of the 95th percentile is 11.3% (all channels) and 13.9% (E-R only).

4.3.8 Channel throughput

The following graphs shows the peak and median channel[14] throughputs (left scale in kbits/s and right scale in percentage related to 31.5 kbits/s) measured per frequency over a one-minute time window.

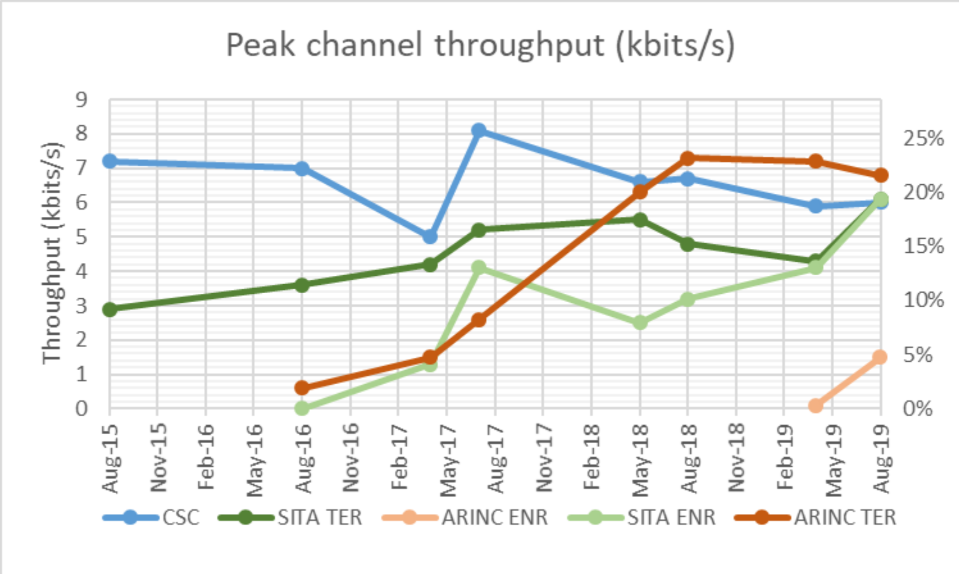


Figure 4-15 : Peak channel throughput

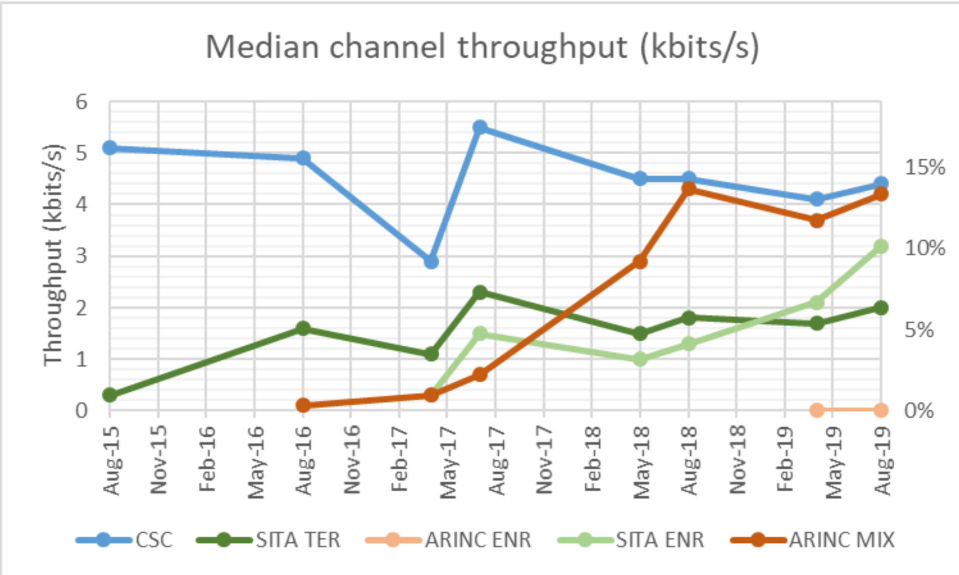


Figure 4-16 : Median channel throughput

[14] We consider here the bust length (in bits) instead of the AVLC size (in bytes).

4.4 AOA traffic

The following graph displays AOA traffic based on the ACARS labelling, hence providing the evolution of AOA traffic depending on the service type. The ACARS message types are grouped into the following categories in order to ease the analysis.

- The “protocol” category groups ACARS protocol related message that are mainly composed of acknowledgement blocks;
- “Link test” messages refers to ACARS link test messages mainly observed each time the aircraft makes an hand-over;
- “Peripheral H1” refers to ACARS messages sent/received to/from a peripheral[15] to the ACARS Management Unit (MU);
- “FIS” messages refers to Flight Information Services messages;
- “Predefined” messages are user-defined messages not standardized within ACARS specifications – their content cannot be analysed;
- “Remaining” messages refers to messages not belonging to the previous categories.

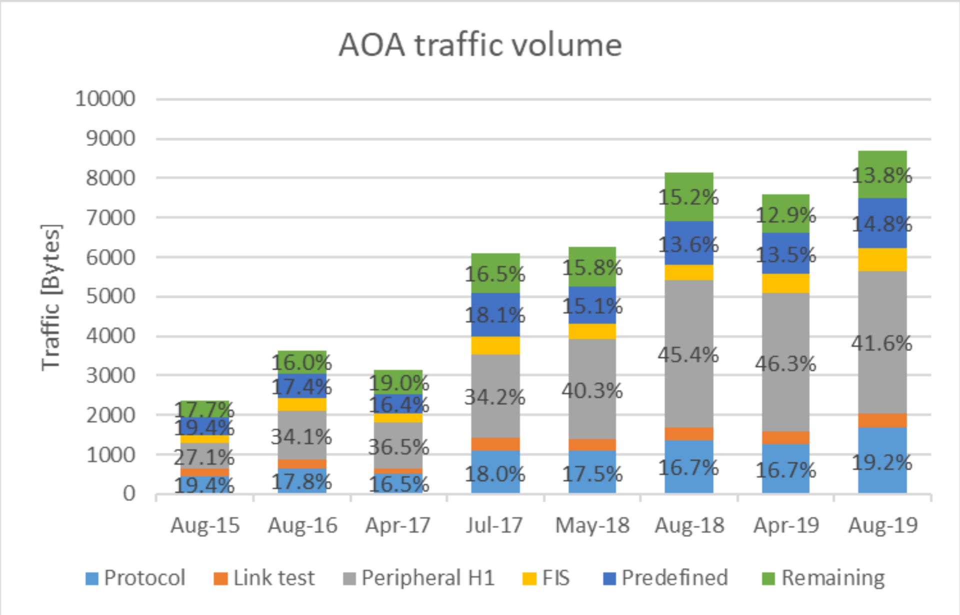


Figure 4-17 : AOA traffic repartition

Note 1: The main increase of AOA traffic volume since 2015 is due to “Peripheral H1” messages.

Note 2: The Average Annual Growth Rate (AAGR) of the observed AOA traffic volume has decreased since 2017. The observed AAGR was 60% between 2015 and 2017, 34% between 2017 and 2018 and now 10% since last year.

[15] Typically, these subsystems include (not exhaustive) the Optional Auxiliary Terminal (OAT), the Flight Management Computer (FMC), the Aircraft Condition Monitoring System (ACMS), and MIAM peripheral.

4.5 Interferences

The same kind of interferences as seen during the previous monitoring flights were observed across the VDL band.

The following table summarises the duration (mm:ss) of the observed interferences over the full flight duration.

Table 5 : Interference duration summary

	08.2015	*08.2016*	*04.2017*	*07.2017*	*05.2018*	*08.2018*	*04.2019*	*08.2019*
Voice signals	02:58	21:04	01:42	01:54	01:43	01:46	11:14	18:05
RTTY signals	00:34	00:14	02:27	00:28	01:00	00:00	00:00	00:00
5-tones selcall				00:23	00:42	00:48	00:22	00:09
Industial noise	34:56	12:59	04:32	10:36	07:45	07:53	09:54	01:45
Total	*38:53*	*34:17*	*08:41*	*13:21*	*11:10*	*10:27*	*21:30*	*19:59*

Note: The satellite signals are no longer displayed nor analysed as their presence is known, regular and predictable[16]. The two satellites identified by the Leeheim (D) satellite monitoring station in 2015 have an average pass of 2 hours every 60 hours each, resulting in an interfering signal to be present about 3.3% of the time.

4.5.1 Modulated voice signals

Voice communications are still present on the VDL band. The following tables summarizes their duration according to the channels they were observed on.

Table 6 : Modulated voice signal duration summary

	N. of transmissions	*Duration (MM:SS)*	*Notes*
136.975 MHz	5	00:12	CSC
136.950 MHz	344+	17:14+	Guard channel
136.825 MHz	4	00:25	ARINC ENR
136.800 MHz	4	00:06	Guard channel
136.775 MHz	2	00:08	SITA ENR

[16] The satellite passes can be computed using NORAD TLEs. A Two Line Element set (TLE) is a data format to encode orbital elements of an earth-orbiting object within two lines of ASCII text and used to estimate the position of the object using prediction formulae. The North American Aerospace Defence Command (NORAD) tracks all detectable earth-orbiting objects and the non-classified objects TLEs are made available on the website: https://www.celestrak.com/NORAD/elements/.

5 Conclusions

This report presents the results of the 8th monitoring flight that took place on August 6th 2019.

The key points are summarised below and further discussed in the following paragraphs:

11. 70% of the observed traffic volume is now taking place on the alternate frequencies.
12. Since last year, an increase of 26% in the traffic volume is observed on the alternate frequencies while it is considered constant (-0.64%) on the CSC.
13. An increase of 14% of the global traffic volume and 16% of the median traffic rate is observed between August 2018 and August 2019.
14. The traffic volume on the CSC is split 77% ARINC and 23% SITA.
15. 85% of the aircrafts on SITA's network are observed on its alternate frequencies while for ARINC the figure is 62%.
16. AOA represent 60% of the observed global traffic volume.
17. The Average Annual Growth Rate (AAGR) of the observed ATN traffic volume has increased to 27% (2018-2019) compared to the -1% observed during the period 2017-2018.
18. The AAGR of the AOA traffic volume has decreased to 10% (2018-2019) compared to the 34% observed during the period 2017-2018.
19. Voice communications are still heard on VDL2 frequencies.
20. ENAV is observed to have started deploying multi-frequency.

Multi-frequency deployment

The multi-frequency deployment is still on-going and 70% of the observed traffic volume is now being performed on the alternate frequencies.

The traffic on the CSC is continuously decreasing since July 2017. The median measured throughput has fallen from 4.5 kbits/s in August 2018 to 4.4 kbits/s.

The number of aircraft heard on the alternate frequencies has increased and represent today 73% (85% for SITA and 62% for ARINC) of the total number of aircraft heard during the monitoring flight. The major increase is observed on SITA's network due to its phase 2 CVME deployment. An increase of 50% in the number of aircraft on SITA's alternate frequency is observed since last year. This results in an increase of traffic on SITA's ENR frequency of a factor 3 leading to an increase in the collision rate of a factor of 4.

ARINC stations are heard on SITA's alternate frequencies showing that ENAV has started to deploy multi-frequency.

Traffic volume

An increase of 14% of the global traffic volume is observed between August 2018 and August 2019 (section 4.3.3).

The Average Annual Growth Rate (AAGR) of the observed ATN traffic has increased from -1% (2017-2018) to 27% (2018-2019). This might be explained by the increasing number of aircraft being equipped with ATN capabilities in order to be compliant with the Regulation (EC) No 310/2015 amending the Regulation (EC) No 29/2009 laying down requirements on data link services for the single European sky and repealing Implementing Regulation (EU) No 441/2014.

While AOA traffic represents 60% of the global traffic volume observed (section 4.3.3) its AAGR has decreased from 34% (2017-2018) to 10% (2018-2019). No explanation is provided for now but initial investigations shows a decrease in the growth of the volume of the "*Peripheral H1*" data type that has also been responsible for the high growth observed on the AOA traffic volume since 2015.

85% of the traffic volume heard on SITA's network is exchanged on its alternate frequencies. 62% of the traffic volume heard on ARINC's network is exchanged on its alternate frequency.

The median of the global traffic rate has increased by 16% between August 2018 and August 2019 (section 4.3.5).

Interferences

A significant voice interference was heard on the 136.950 MHz during 2/3 of the flight.

6 REFERENCES

[1] Ch. VISEE, VDL2 Flight test analysis for EUROCONTROL CRO, Preliminary report, C.C.R.M., 2015.

[2] Ch. VISEE, VDL2 Flight test analysis for EUROCONTROL CRO – 2016 test flight analysis – Comparison with 2015 results, C.C.R.M., 2016

[3] Ch. VISEE, VDL2 Flight test analysis for EUROCONTROL CRO – April 2017 monitoring flight and comparison with previous flights, C.C.R.M., 2017

[4] Ch. VISEE, VDL2 Flight test analysis for EUROCONTROL DMPF – July 2017 monitoring flight and comparison with previous flights, C.C.R.M., 2017

[5] D. Isaac, The DPMF report catalogue, v0.2, 2019

[6] ICAO, Annex 10 to the convention on international civil aviation: Volume III Communication systems, July 2007.

[7] ICAO, AUR Frequency Management Manual for Aeronautical Mobile and Aeronautical Radio Navigation Services – ICAO EUR Doc 011 (2017), edition Dec.2017.

[8] Ch. VISEE, DMPF VDL 2 MONITORING FLIGHT REPORT, May 2018 DPMF test flight, July 2018.

[9] Ch. VISEE, VDL2 TRAFFIC MODELING AND FORECASTING, Methodology proposal and initial results, March 2019.

7 ABBREVIATIONS

Abbreviations and acronyms used in this document are available in the EUROCONTROL Air Navigation Inter-site Acronym List (AIRIAL) which may be found here:

http://www.eurocontrol.int/airial/definitionListInit.do?skipLogon=true&glossaryUid=AIRIAL

Annex 1 - Measurement setup

The measurement system provided by C.C.R.M.[17] contains a *Rhode & Schwarz* EM100 receiver connected to the DM C50-17 antenna located at the bottom rear of the fuselage (RH side), through a 3dB splitter and a tuneable band pass filter of 10%. Acquisition is performed using a laptop connected to the receiver and consist on IQ data recordings over a bandwidth of 500 kHz centred on 136.8375 MHz[18]. The 4 hours of flights provided about 40 GB of data. IF-PAN spectrum data of 10 MHz were also recorded[19].

The following summarizes the main receiver settings:

Centre Frequency	**136.8375 MHz**
IQ bandwidth	500 kHz
Sampling rate	640 kS/s
AGC	OFF
Reference level	50 dBµV
Attenuation	OFF

The cable losses are summarized in the following table.

	Losses
C.C.R.M. measurement box (splitter, filter, cables)[20].	6.96 dB
Receiver-to-Plane RF cable (MIL-C-17/175) (2m).	1.17 dB
Fuselage RF cables to antenna[21].	1.00 dB

Note: *Except elsewhere stated, level values used in this report refer only to the receiver's level without taking into account the losses from the previous table. The latter's are used to compute the level at the antenna port.*

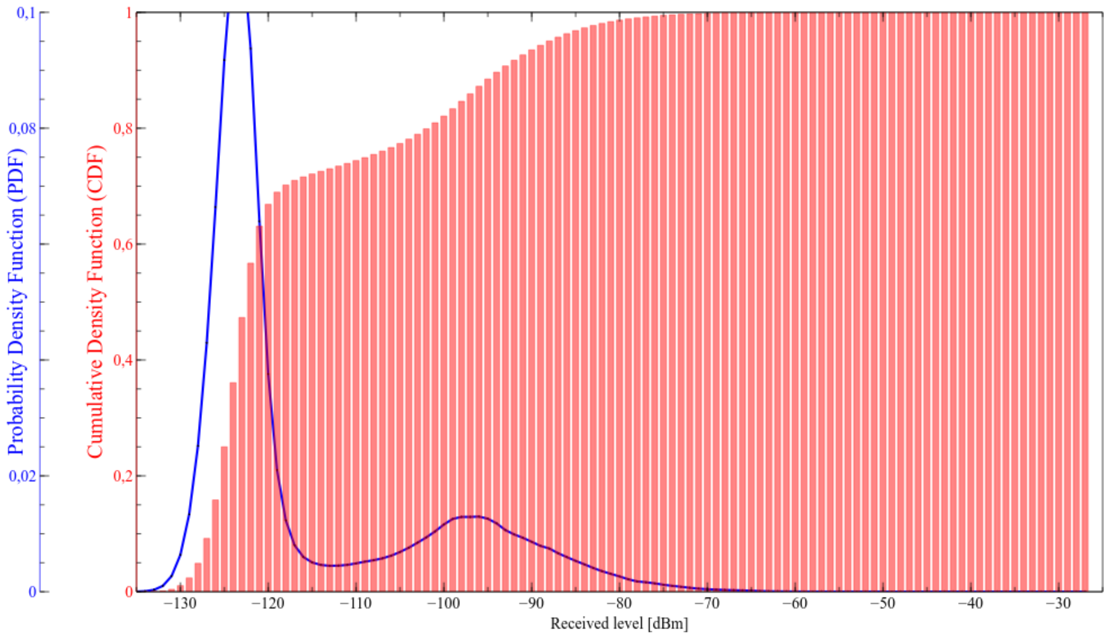
[17] Centre de Contrôle des Radiocommunications des services Mobiles (BE)
[18] This is the centre frequency of the VDL band.
[19] EM100 is capable of providing 10MHz of spectrum data centred on the receiver's frequency with a resolution bandwidth of 6.25 kHz. The latter is used for interference analysis coming from upper or lower the VDL band.
[20] Measured on August 5th, 2019. Previously measured 7 dB on April 13th 2018 and 6.5 dB on May 20th 2017.
[21] Measured by NLR in August 2018.

Annex 2 - Receiver level PDF and CDF curves

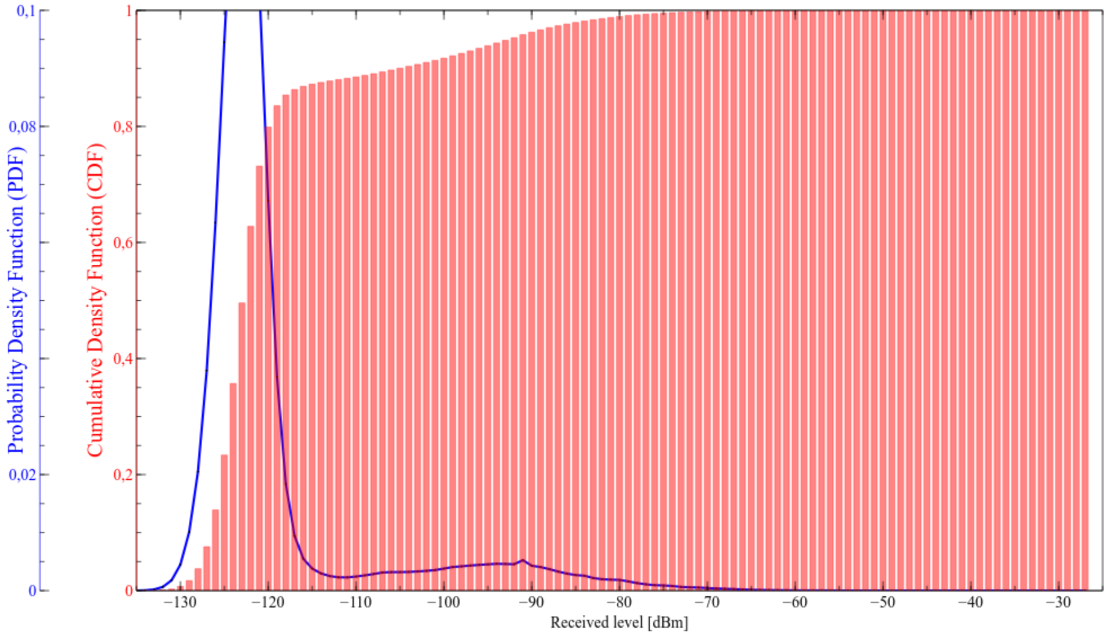
The following graphs provides with the PDF and CDF of the receiver's level. Occupancy at a specific level threshold can be calculated using the following formula:

$$Occupancy\ [-] = 1 - CDF(Level_{threshold}\ [dBm])$$

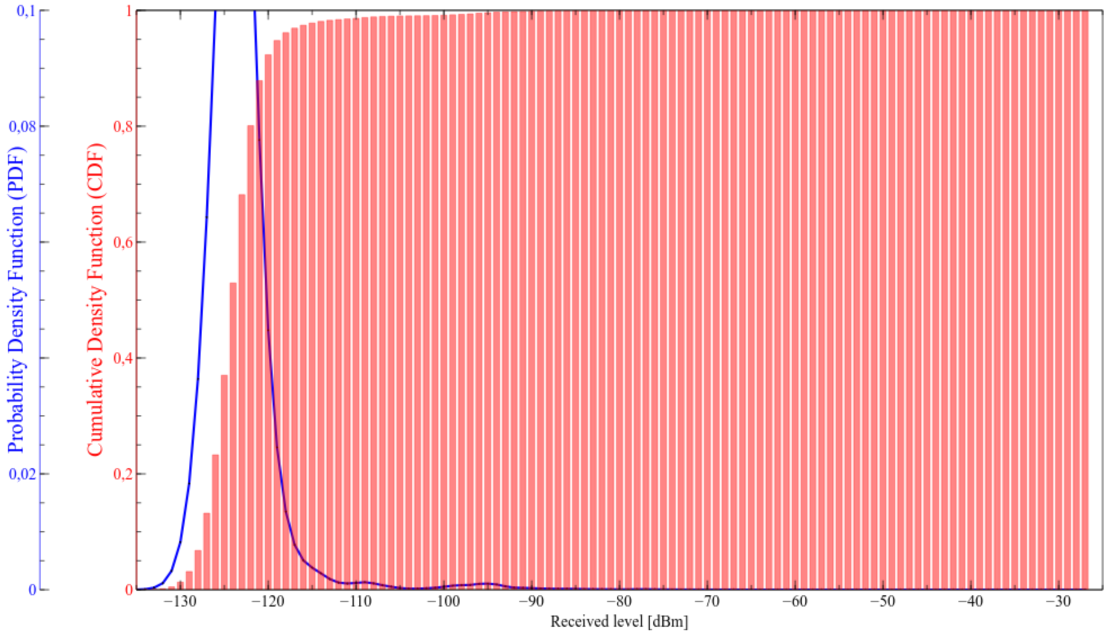
A1.1 136.975 MHz



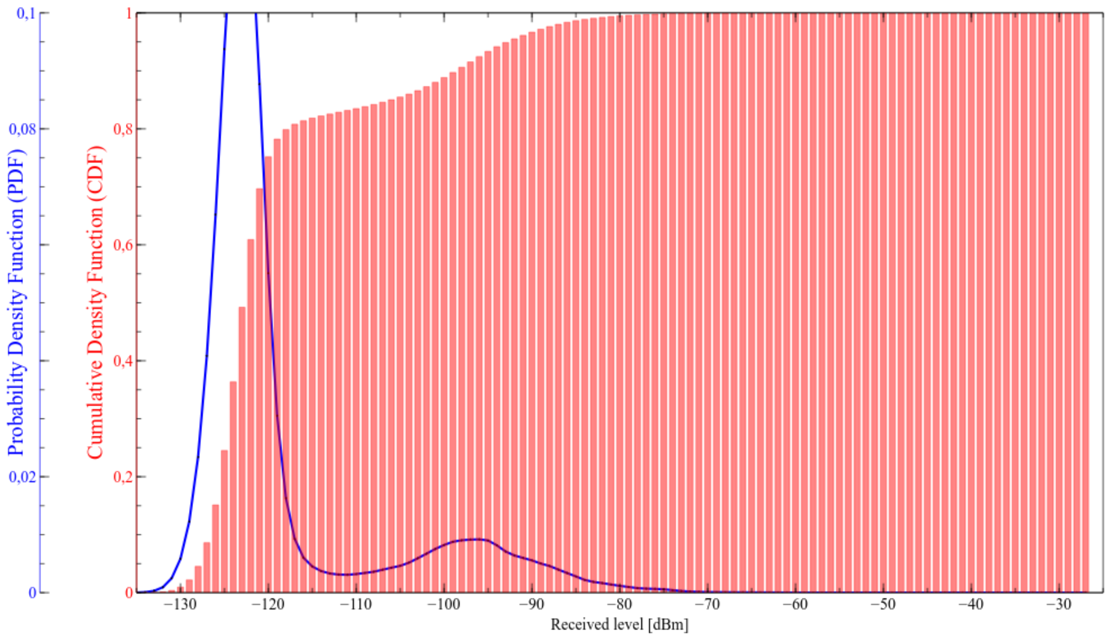
A1.2 136.875 MHz



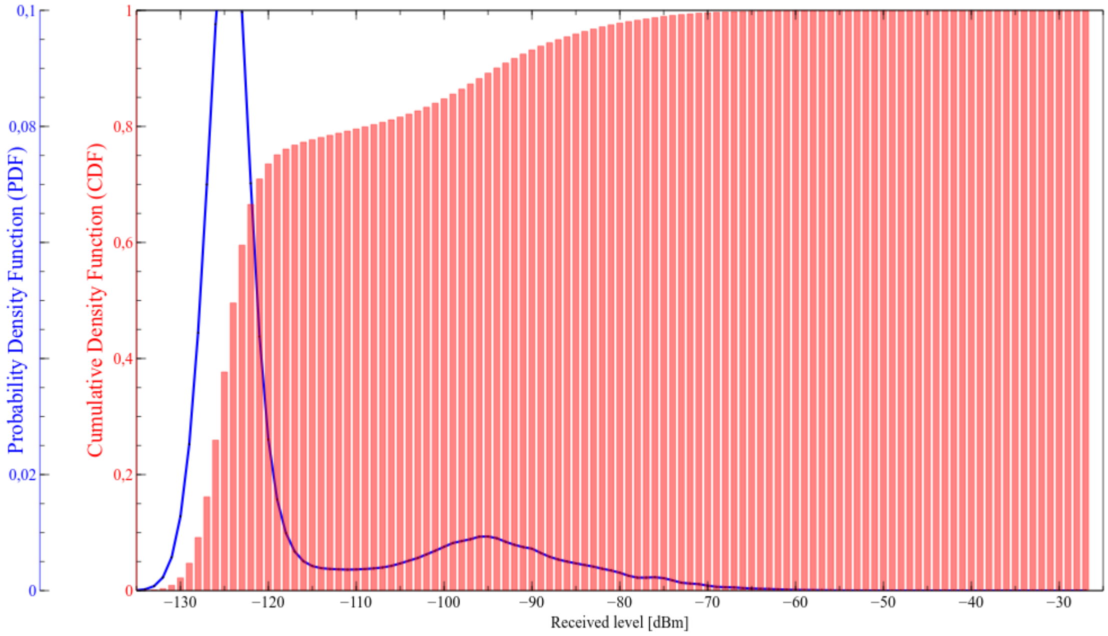
A1.3 136.825 MHz



A1.4 136.775 MHz



A1.5 136.725 MHz



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