

DPMF VDL2 MONITORING FLIGHT REPORT

May 2018 DPMF flight

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1 Summary

Twice a year, the DPMF is conducting VDL monitoring flights in order to monitor the European Data Link Services (DLS) deployment.

This report highlights the multi-frequency deployment and the rise of the observed traffic:

1. The CSC is progressively offloaded to alternate frequencies. 58% of the observed traffic is now taking place on the alternate frequencies and a significant movement of the CSC traffic to the alternate frequencies is observed above the Paris and London areas.
2. An increase of 99% of the traffic (in kB) is observed between April 2017 and May 2018 (spring periods) mainly due to the number of aircraft observed during the flight (152 in April 2017 and 318 in May 2018).

ARINC has performed a significant move of traffic between the CSC to its alternate frequency. This gives rise to an increase in the number of collisions due to the mixed use of this frequency (terminal and en-route), and without the deployment of a dedicated en-route frequency, will result in the future in poor channel behaviour.

Interference of different sources is still observed and some of them might have a significant impact depending on how close an interfered station is to the interference source.

As the monitoring flights intended to analyse VHF Data Link at the airborne side, some effort has been made to distinguish between airborne traffic (E-R) and ground traffic (Terminal) which is expected to be different in nature. Since 2017, frequency assignment have been set according to these two categories (see ICAO Doc11 [7]) and our analysis is based on these assignments whatever its real use.

From a RF point of view the analysis of terminal frequencies from an airborne monitoring aircraft is not really representative and may lead to misinterpretation. This is why, when analysing the VDL traffic observed from the monitoring flights, the traffic on frequencies conveying E-R traffic is provided separately but always together with the total observed traffic observed by the monitoring aircraft.

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 May 3rd, 2018¹ 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.

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. Because of the burst collisions, occupancy is always lower than the real traffic being sent by the stations. This report provides with a mean airborne channel occupancy, and also with airborne channel occupancy statistics based on one second integrated values. The latter is supposed 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 AVLC frame size in kB summed by periods. It is expressed in this report as a traffic rate in kbits/s computed using 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.

¹ The initial flight was scheduled April 13th, 2018 but was cancelled due to the experiment power bus distribution failure.

3 Measurement setup and method of analysis

Measurements were performed using NLR²'s Cessna Citation II flying across Europe at FL370. The setup can be found in the annex 1.

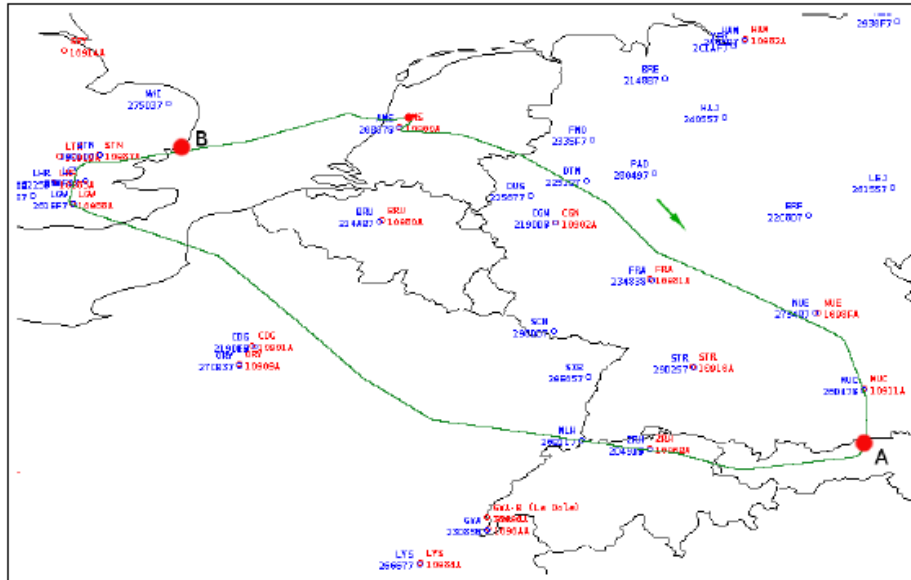


Figure 1 : Typical flight route.

The analysis is performed using dedicated software tools³.

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 with various statistics depending the ACSPs, AVLC frame types, time-stamps or plane location. Only correctly demodulated frames are used for the analysis.

² Nationaal Lucht-en Ruimtevaartlaboratorium (NL).

³ These are the same tools as used for the previous reports.

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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))

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 3. 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 between points A-B (see Figure-1) since 2015. Tables are split into spring and summer flights due the seasonal variation of traffic.

Table 1 : Average occupancy for summer flights.

Frequency / assignment		08.2015	08.2016	07.2017
136.975 MHz	CSC	20.35%	26.23%	31.02%
136.875 MHz	SITA Ter.	1.84%	6.33%	8.69%
136.825 MHz	ARINC E-R	0.02%	1.69%	0.00%
136.775 MHz	SITA E-R	0.01%	0.63%	4.33%
136.725 MHz	ARINC Ter. ⁴	0.40%	0.82%	3.01%

Table 2 : Average occupancy for spring flights

Frequency / assignment		04.2017	05.2018
136.975 MHz	CSC	18.82%	18.03%
136.875 MHz	SITA Ter.	5.20%	6.80%
136.825 MHz	ARINC E-R	0.31%	0.18%
136.775 MHz	SITA E-R	1.29%	2.84%
136.725 MHz	ARINC Ter.	1.49%	11.50%

⁴ We use the ICAO EUR Doc 011 [7] frequency assignment name instead of “ARINC alternate” to highlight the fact that this frequency has been assigned for terminal use.

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Note: 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.

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 first one for May 2018 and the second one for April 2017, showing hence the evolution of traffic between the two spring periods.

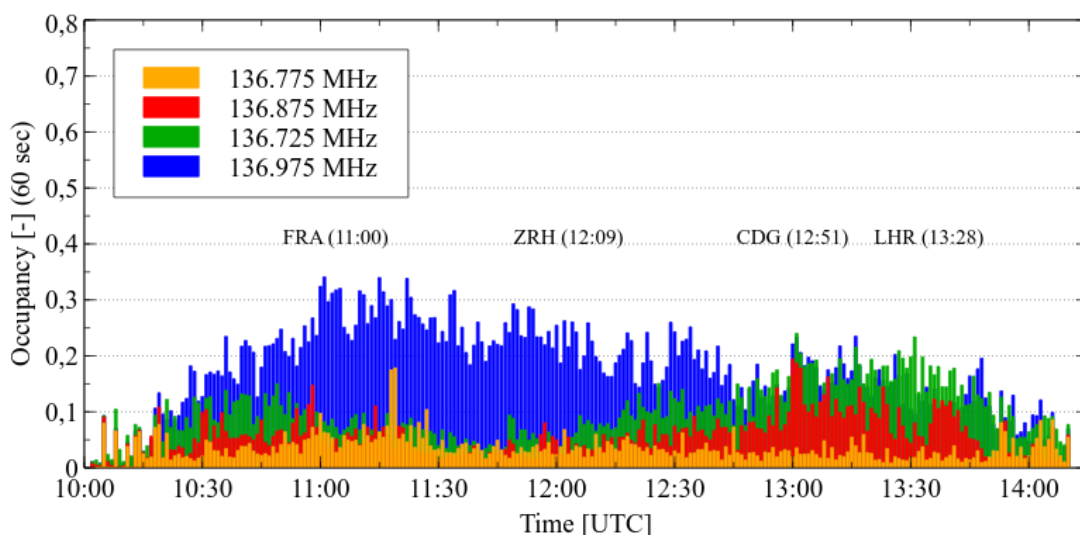


Figure 2 : May 2018 occupancy over time.

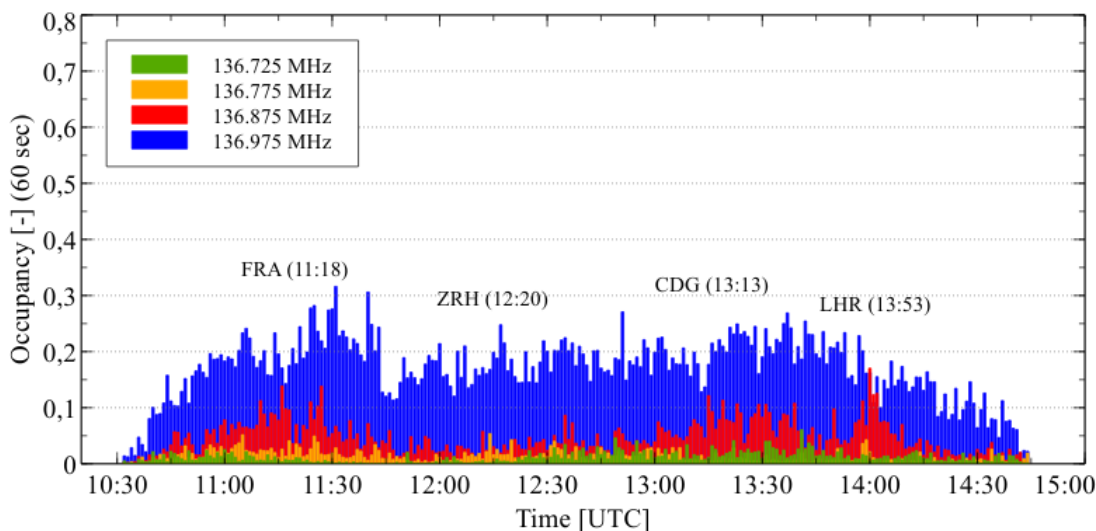


Figure 3 : April 2017 occupancy over time.

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4.1.3 One second occupancy statistics

Using an integration time of one second⁵, the following table⁶ summarizes occupancy statistics for the different frequencies since 2015.

Note: Statistics for the SITA Terminal frequency are not displayed in the following table as the measurement location (aircraft at FL370) does not reflect the real behaviour of the channel.

Table 3 : One second occupancy statistics for the summer flights

FREQUENCY/ ASSIGNATION		08.2015	08.2016	07.2017
136.975 MHZ CSC	Mean	22.53%	28.80%	32.10%
	Mode	19.57%	19.95%	28.23%
	P5	7.80%	10.55%	15.74%
	P50	20.95%	26.37%	31.05%
	P95	42.60%	53.80%	51.86%
136.775 MHZ SITA E-R	Mean	0.01%	0.41%	5.40%
	Mode	0.00%	0.00%	0.00%
	P5	0.00%	0.00%	0.00%
	P50	0.00%	0.00%	3.51%
	P95	0.00%	0.00%	17.99%
136.725 MHZ ARINC TER.	Mean	0.39%	0.56%	2.53%
	Mode	0.00%	0.00%	0.00%
	P5	0.00%	0.00%	0.00%
	P50	0.00%	0.00%	1.22%
	P95	0.00%	2.49%	10.13%

⁵ This is closer to what VDRs are supposed to provide.

⁶ Greyed cells refers to measurements for which no VDL2 signal was found.

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Table 4 : One second occupancy statistics for the spring flights

FREQUENCY/ ASSIGNATION		04.2017	05.2018
136.975 MHZ CSC	Mean	19.01%	20.71%
	Mode	13.86%	13.37%
	P5	5.91%	5.92%
	P50	17.34%	19.82%
	P95	37.96%	38.98%
136.775 MHZ SITA E-R	Mean	1.48%	3.67%
	Mode	0.00%	0.00%
	P5	0.00%	0.00%
	P50	0.07%	2.29%
	P95	6.02%	11.29%
136.725 MHZ ARINC TER.	Mean	1.24%	10.50%
	Mode	0.00%	0.00%
	P5	0.00%	0.61 %
	P50	0.00%	8.94%
	P95	6.87%	25.87%

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4.2 Airborne collision rate

Using a dataset of 120 one-second 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 5 : Collision rate for summer flights

Frequency / assignment		08.2015	08.2016	07.2017
136.975 MHz	CSC	47.85%	42.57%	50.28%
136.875 MHz	SITA Ter.	6.43%	16.31%	16.26%
136.825 MHz	ARINC E-R	-	-	-
136.775 MHz	SITA E-R	-	-	7.52%
136.725 MHz	ARINC Ter.	-	0.00%	9.92%

Table 6 : Collision rate for the spring flights

Frequency / assignment		04.2017	05.2018
136.975 MHz	CSC	36.71%	37.48%
136.875 MHz	SITA Ter.	17.29%	15.43%
136.825 MHz	ARINC E-R	-	-
136.775 MHz	SITA E-R	2.99%	5.49%
136.725 MHz	ARINC Ter.	6.12%	20.73%

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 reality. However, the values are still presented as they are good examples of the hidden transmitter problem phenomenon.

Note 2: The reader shall note the significant increase of the collision rate on ARINC alternate frequency.

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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/s⁷, 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 traffic⁸. The Median and the 95th percentile values are used to estimate the “mean” and “peak” traffic on the different channels.

Tabulated values related to the following graphs can be found in the annexe 2.

4.3.1 Share of channels by ACSPs

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

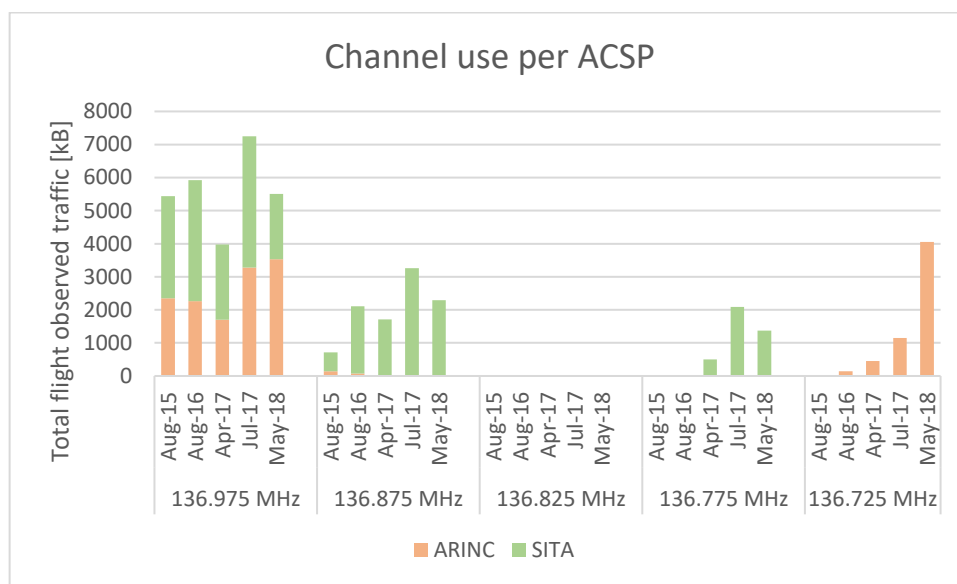


Figure 4 : Traffic distribution between ACSP per frequency

Note: 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.

⁷ The traffic rate is expressed as : $Rate [kbits/s] = 8 * \frac{Traffic [kB/minute]}{60}$

⁸ 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.

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

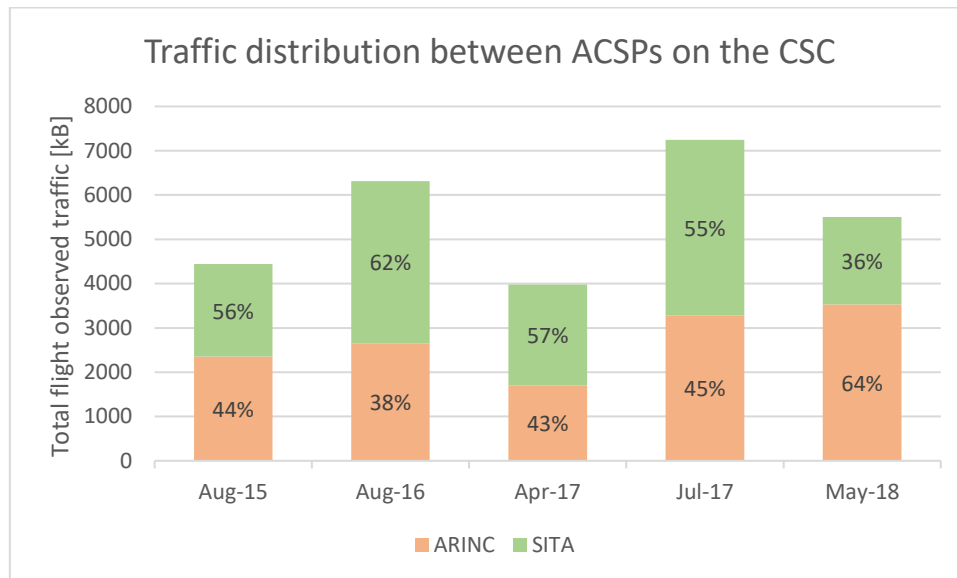


Figure 5 : Traffic distribution between ACSPs on the CSC

4.3.2 CSC offload

The following graph summarizes the percentage of traffic between the CSC and the alternate frequencies (split between the two ACSPs), highlighting the traffic offload from the CSC with time.

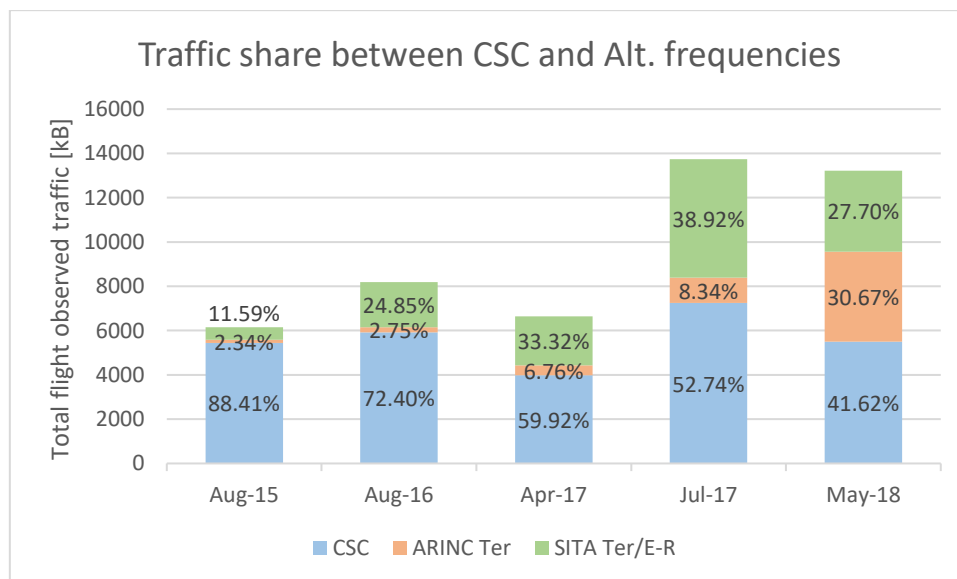


Figure 6 : Partition of the total traffic between the CSC and the alternate frequencies

4.3.3 Distribution of AVLC frame type

The following graph 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 “Misc.” frames convey AVLC protocol related packets (RR, SREJ, XID,...).

Note: 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.

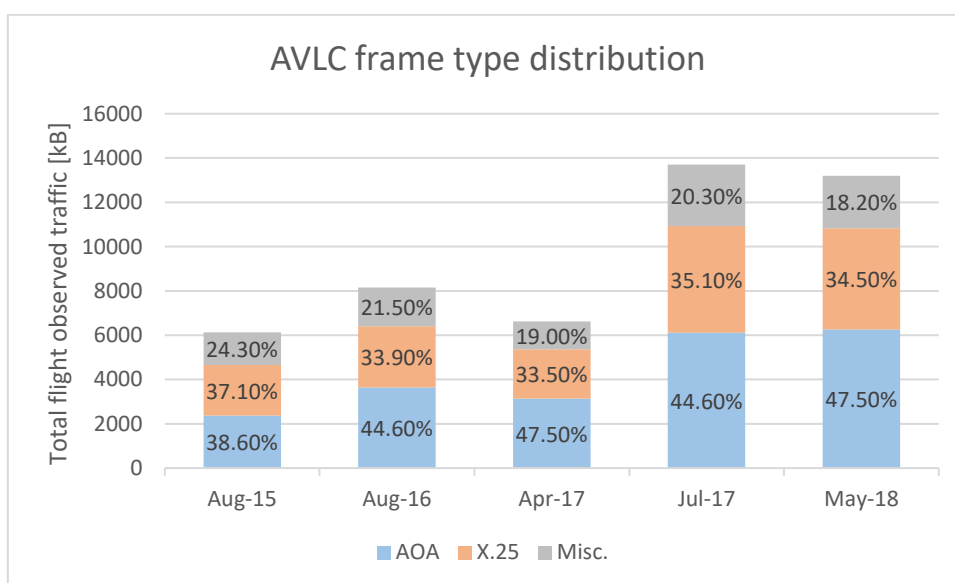


Figure 7 : AVLC frame distribution over time

The graph above is taking into account the measured ground traffic on the SITA terminal frequency. As the latter is measured at FL370 instead of on the ground, the traffic generated on this frequency is not correctly represented.

The following graph shows then the same distribution as above but only taking into account frequencies on which E-R traffic is observed (CSC, SITA E-R and ARINC Terminal). As the frequency assignment changed between 2016 and 2017, only changes for years after 2016 are considered.

Note: An increase of 99% (all traffic) and 122% (only E-R) of the global traffic is observed between April 2017 and May 2018.

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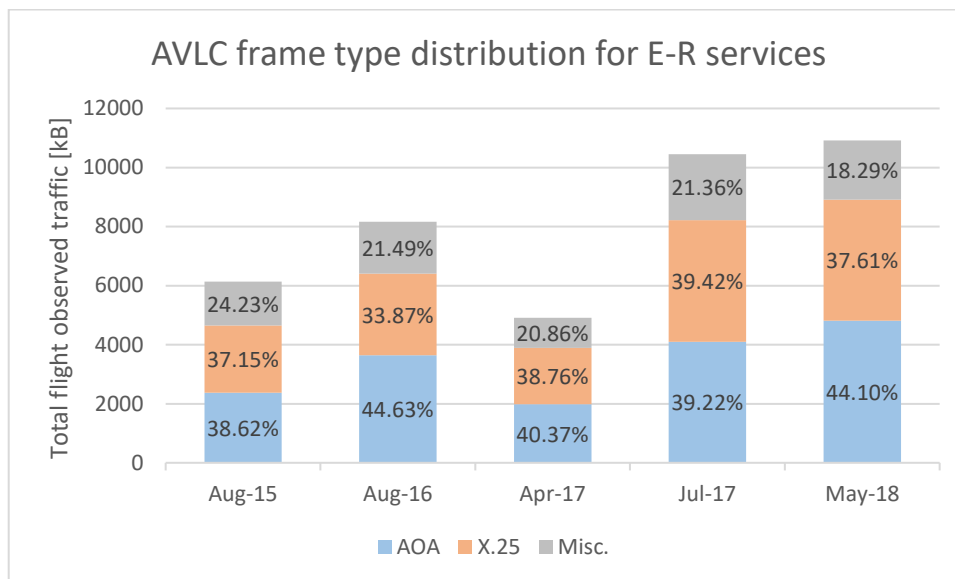


Figure 8: AVLC frame distribution over time for frequencies conveying E-R traffic

4.3.4

Global peak and median traffic rate (kb/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 considering the total observed traffic and the frequencies conveying E-R traffic only (as discussed above)

Note: An increase of 117% (all frequencies) and 146% (only E-R) of the median traffic rate is observed between April 2017 and May 2018. The increase of the 95th percentile is 90% (all frequencies) and 110% (only E-R).

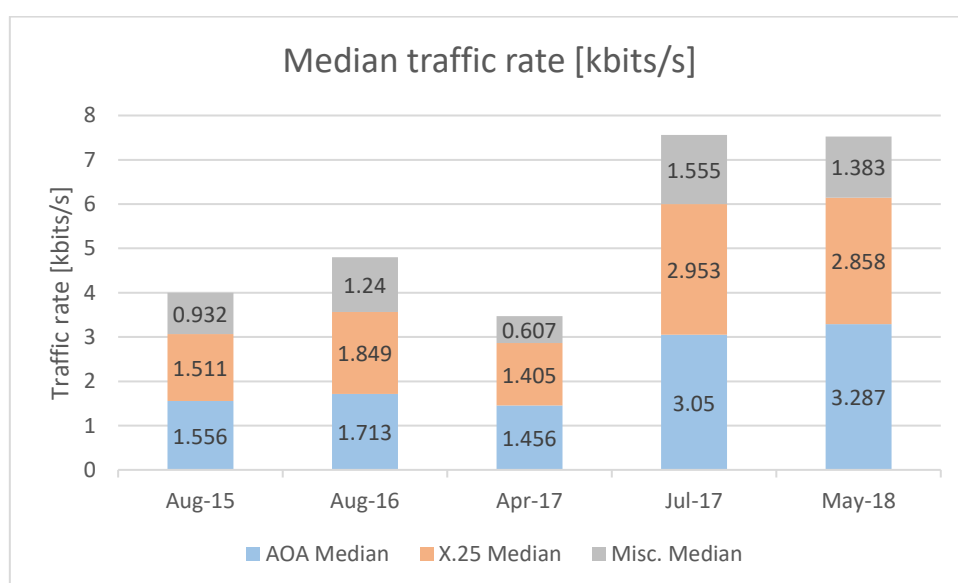


Figure 9 : Median traffic rate

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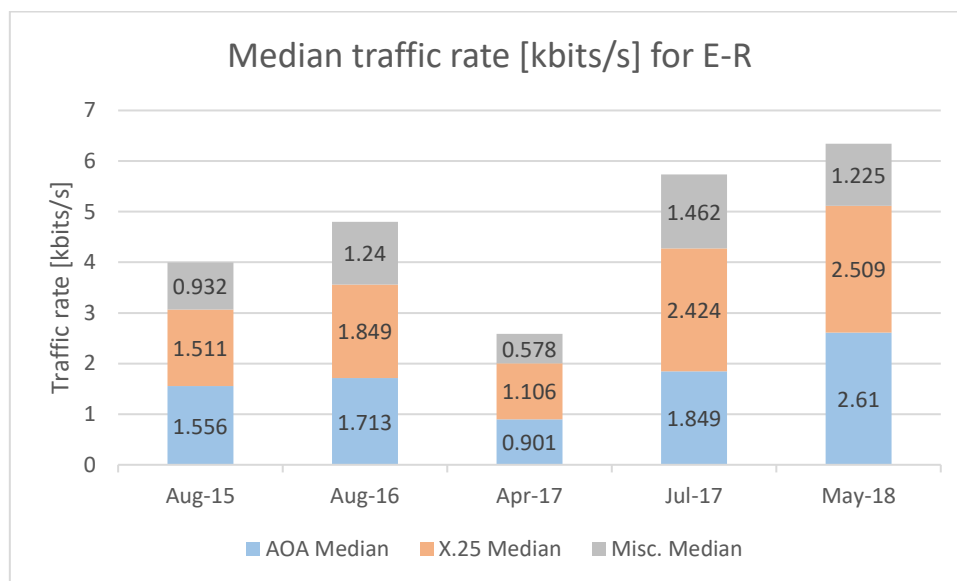


Figure 10: Median traffic rate for frequencies conveying E-R traffic

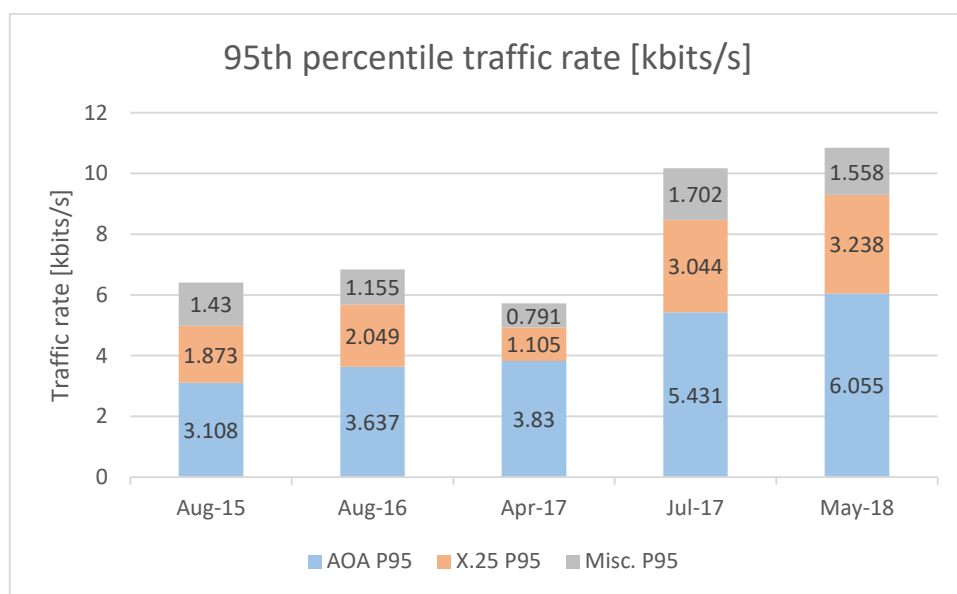


Figure 11 : 95th percentile traffic rate

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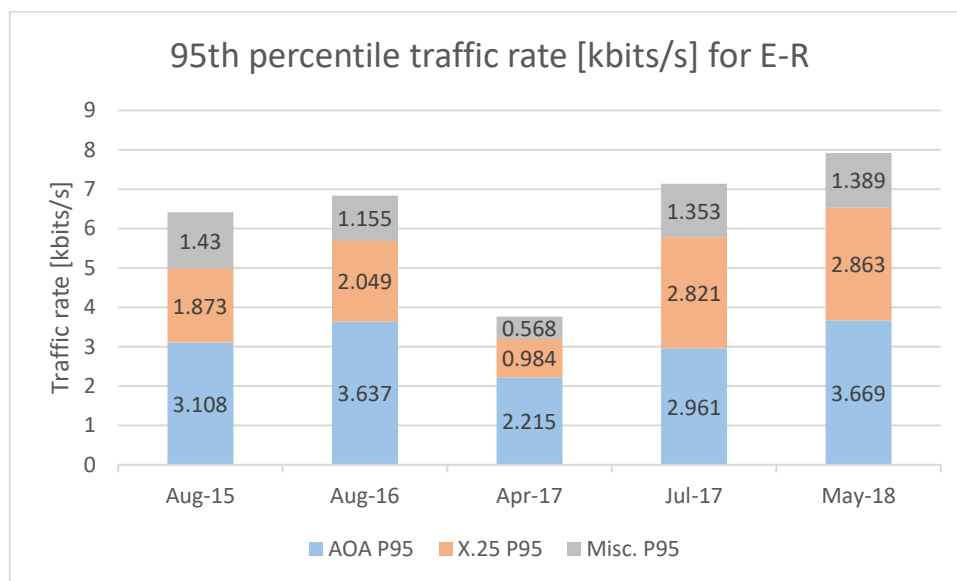


Figure 12: 95th percentile traffic rate for frequencies conveying E-R traffic

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4.4 Interferences

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

The following table summarizes the duration (MM:SS) of the interferences over the full flight duration.

Table 7 : Interference duration summary

	08.2015	08.2016	04.2017	07.2017	05.2018
<i>Modulated voice signals</i>	02:58	21:04	01:42	01:54	01:43
<i>RTTY-like signals</i>	00:34	00:14	02:27	00:28	01:00
<i>5-tones selcall</i>				00:23	00:42
<i>Industrial noise-like</i>	34:56	12:59	04:32	10:36	07:45
<i>Total</i>	38:53	34:17	08:41	13:21	11:10

Note: The satellite signals are no longer displayed nor analysed as their presence is known, regular and predictable⁹. 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.

4.4.1 Modulated voice signals

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

The transmission on the CSC seems to be unmodulated.

Transmissions on 136.775 MHz are of particular interest as within 2 minutes, 2 different planes tried to contact "London" on the frequency with ATC communications. As a mis-tuning is probably the source of the interference, how could two different plane mis-tune to the same frequency? Would this be an error of the air traffic controller? The reader should note that London ATC don't use frequencies¹⁰ whose digits are close to 136.775 MHz.

⁹ 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/>.

¹⁰ This was checked with the SAFIRE database at the time of writing.

DPMF VDL2 MONITORING FLIGHT REPORT**Table 8 : Modulated voice signal duration summary**

	<i>N. of transmissions</i>	<i>Duration (MM:SS)</i>	<i>Notes</i>
136.975 MHz	3	00:35	CSC
136.850 MHz	1	00:06	Guard channel
136.825 MHz	5	00:40	ARINC E-R.
136.775 MHz	4	00:22	SITA E-R

5 Discussion

Multi-frequency deployment

The CSC off-loading is still on-going. We observe that 58% of the traffic is now being performed on the alternate frequencies (Figure 6). The distribution of the remaining traffic on the CSC is 36% SITA and 64% ARINC; this is the first time that ARINC have more traffic than SITA on the CSC (Figure 5).

A significant increase of occupancy is observed on the ARINC E-R frequency mainly over Paris and London areas. At the same time, we observe a significant decrease of the occupancy on the CSC. These changes in occupancy reflect a significant move of ARINC's traffic from the CSC to its alternate frequency.

Global increase of traffic for the last summer periods

A significant increase of traffic is observed. For the last spring periods (April 2017 and May 2018), considering all the measured traffic, an increase of 99% is measured based on the total traffic observed during the flights and 117% based on the median traffic rate observed during one-minute periods. This factor 2 observed in the traffic is directly related to the number of aircrafts observed during the flight (152 in April 2017 and 318 in May 2018).

The measured median traffic rate during the May 2018 flight is 7.5 kbits/s. This is the same value as measured during July 2017, so it seems likely that a higher value will be seen during the August 2018 flight.

On the CSC, between April 2017 and May 2018, the increase of the observed traffic (throughput) is not accompanied with an increase of occupancy nor collision rate. An increase of the traffic would normally result in an increase of the occupancy and the collision rate.

Risk of poor performance on ARINC E-R frequency in the future

The ARINC 'terminal' frequency is currently being used by ARINC as a 'mixed' en-route and terminal frequency. This means there are a significant number of aircraft on the ground using the frequency which act as hidden transmitters. Also the fact that the ARINC alternate frequency needs to cover various airport surfaces rather than purely cover en-route airspace means that more alternate frequency ARINC VGSs are deployed than would be necessary for the en-route frequency. This creates additional groups¹¹ of transmitters which will substantially increase the probability of transmissions colliding.

In order to highlight this phenomenon, the following graph (Figure 13) displays the collision rate as a function of the peak traffic rate for the different channels over the different monitoring flights. For each of them a curve fit is used to characterize each type of channel on a wider set of values. The collision rate is known to be function of the number of groups of hidden terminals; the higher the number of groups of hidden terminals, the higher the collision rate. This is well

¹¹ A group is a set of transmitters that can see each other and so are able to sense when the channel is unoccupied and hence available for them to transmit without colliding with another transmission.

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illustrated in the following graph between the CSC and the SITA en-route frequencies (97 VGS are observed on the CSC for 28 on SITA E-R). It is also known that the higher the collision rate, the lower the channel capacity, resulting in a channel exhibiting poor performances – this is the lesson learned from the CSC. The graph is showing that ARINC E-R lies between the CSC and SITA E-R and that a) the performance of this channel can expect to degrade towards the CSC level of performance as the load increases and b) performance could be improved if the ARINC en-route frequency was deployed for en-route traffic and the ARINC terminal frequency was deployed to cover the necessary airports.

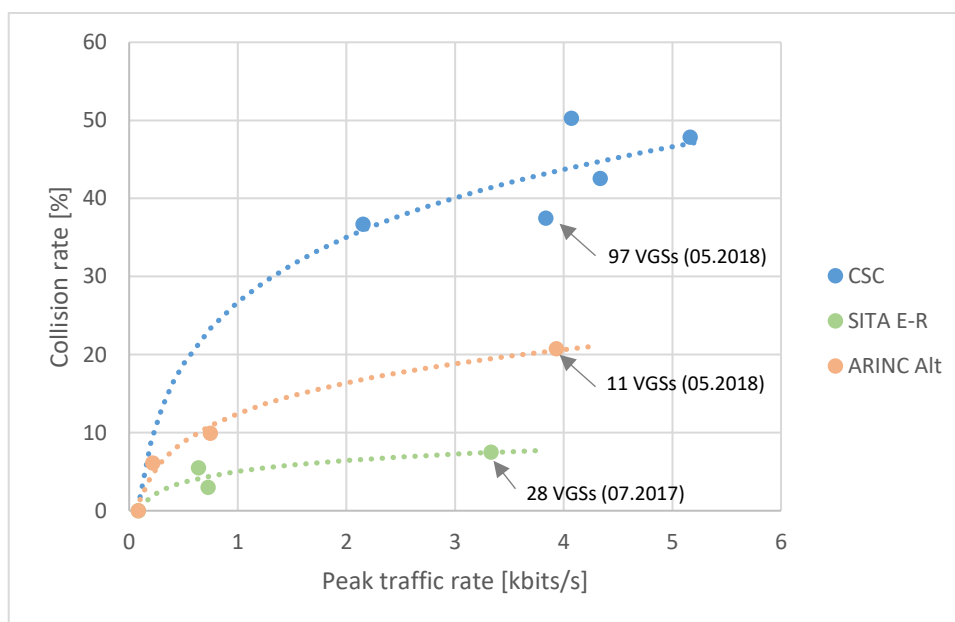


Figure 13 : Collision rate versus peak traffic rate

Interferences

Voice interference is still observed on the VDL band with a total duration of the communications being constant since May 2017. The CSC and SITA E-R frequencies are directly affected.

As it was already stated in the previous reports, the recurrent observations of voice communication on the VDL band let us think that it is happening frequently.

6 Conclusions and recommendations

The multi-frequency deployment has reach a state where 58% of the traffic is now being performed on the alternate frequencies.

A significant increase of traffic is observed: 99% between April 2017 and May 2018 and 68% between August 2016 and July 2017.

Comparing to July 2017, ARINC has made a significant move of traffic from the CSC to its alternate frequency. However, as a high collision rate is observed on this channel, it is now urgent for ARINC to deploy its terminal frequency in order to avoid facing a poorly performing channel, therefore losing all the benefits of the multi-frequency deployment.

Note: It should be recalled here that “*the assignments of alternate frequencies should be made on a temporary basis*” and that “*the assignment should be deleted if the frequencies are not used within one year*” [7].

Voice interference are still observed on the VDL band affecting at least two operational frequencies (136.975 MHz and 136.775 MHz).

7 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
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- [5] D. Isaac, The DPMF report catalogue, v0.1, 24.10.2017
- [6] ICAO, Annex 10 to the convention on international civil aviation: Volume III Communication systems, July 2007.
- [7] ICAO, EUR Frequency Management Manual for Aeronautical Mobile and Aeronautical Radio Navigation Services – ICAO EUR Doc 011 (2017), edition Dec.2017.

8 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.¹² 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 MHz¹³. The 4 hours of flights provided about 40 GB of data. IF-PAN spectrum data of 10 MHz were also recorded¹⁴.

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 dB μ V
Attenuation	OFF

The cable losses are summarized in the following table.

	Losses
<i>C.C.R.M. measurement box (splitter, filter, cables)¹⁵.</i>	7 dB
<i>Receiver-to-Plane RF cable (Suhner S 06132 D-10) (12m).</i>	1.17 dB
<i>Fuselage RF cables to antenna¹⁶.</i>	2.3 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.

¹² Centre de Contrôle des Radiocommunications des services Mobiles (BE)

¹³ This is the centre frequency of the VDL band.

¹⁴ 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.

¹⁵ Measured on April 13th, 2018. Previously measured 6.5 dB on May 20th, 2017.

¹⁶ Measured by NLR in August 2017.

Annex 2 - Tabulated values of chapter 3

A1.1 Service provider related data

Table 9 : Traffic partition per ACSP and per frequency for the summer flights

Frequency / assignment			08.2015	08.2016	07.2017
136.975 MHz	CSC	(ARINC)	44%	38%	45%
		(SITA)	56%	62%	55%
136.875 MHz	SITA Ter.	(ARINC)	80%	96%	100%
			20%	4%	0%
136.825 MHz	ARINC E-R		-	-	-
136.775 MHz	SITA E-R		-	-	100%
136.725 MHz	ARINC Ter.		-	100%	100%

Table 10 : Traffic repartition per ACSP and per frequency for the spring flights

Frequency / assignment			04.2017	05.2018
136.975 MHz	CSC	(ARINC)	43%	64%
		(SITA)	57%	36%
136.875 MHz	SITA Ter.		100%	100%
136.825 MHz	ARINC E-R		-	-
136.775 MHz	SITA E-R		0%	100%
136.725 MHz	ARINC Ter.		100%	100%

Table 11 : Global traffic partition per ACSP

Provider		08.2015	08.2016	04.2017	07.2017	08.2018
GLOBAL	CSC	89%	72%	60%	53%	42%
	Alt.	11%	28%	40%	47%	58%
ARINC	CSC	93%	91%	79%	74%	47%
	Alt.	7%	9%	21%	26%	53%
SITA	CSC	82%	64%	51%	43%	35%
	Alt.	18%	36%	49%	57%	65%

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A1.2 Number of station heard and their generated traffic

The following table summarizes, for each channel, the number of station heard (airborne/grounded aircraft, VGSs) and their respective generated traffic.

Table 12 : Number of station and their generated traffic per frequency and per station type

		08.2015	08.2016	04.2017	07.2017	05.2018
136.975 MHz CSC	AIR	1284	1628	1356	1742	1511
		2537 kB	3758 kB	1960 kB	4326 kB	3014 kB
	GND	411	472	365	525	487
		283 kB	283 kB	327 kB	465 kB	480 kB
	VGS	69	88	79	88	97
		1749 kB	1892 kB	1689 kB	2452 kB	2011 kB
136.875 MHz SITA Ter.	AIR	63	223	238	412	368
		135 kB	354 kB	255 kB	666 kB	841 kB
	GND	127	434	334	536	284
		247 kB	901 kB	814 kB	1317 kB	757 kB
	VGS	18	29	24	28	25
		330 kB	857 kB	637 kB	1277 kB	693 kB
136.775 MHz SITA E-R	AIR	0	0	169	443	390
		0 kB	0 kB	269 kB	1166 kB	915 kB
	GND	0	0	22	52	15
		0 kB	0 kB	33 kB	105 kB	8 kB
	VGS	0	1	11	16	17
		0 kB	3 kB	202 kB	814 kB	451 kB
136.775 MHz ARINC Ter.	AIR	0	61	166	232	467
		0 kB	83 kB	250 kB	753 kB	2415 kB
	GND	0	9	26	45	163
		0 kB	1 kB	6 kB	12 kB	345 kB
	VGS	0	5	7	7	11
		0 kB	60 kB	192 kB	380 kB	1296 kB

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A1.3 Partition of AVLC frame type

The following table summarizes, for the four channels, the repartition of AVLC frame type. AOA frames convey ARINC-620 packets, X.25 frames convey ATN packets, while "Misc." frames convey AVLC protocol related packets (RR, SREJ, XID,...).

Table 13 : Traffic repartition per frequency and AVLC frame type

		08.2015	08.2016	04.2017	07.2017	05.2018
136.975 MHz CSC	AOA	37.2%	38.1%	38.9%	36.3%	42.9%
	X.25	38.9%	38.1%	39.7%	41.1%	37.1%
	Misc.	23.9%	23.8%	21.4%	22.5%	20.0%
136.875 MHz SITA Ter.	AOA	52.5%	62.4%	67.6%	61.4%	63.2%
	X.25	26.3%	21.2%	18.3%	21.4%	20.2%
	Misc.	21.2%	16.4%	14.1%	17.2%	16.6%
136.775 MHz SITA E-R	AOA	-	0%	52.9%	49.5%	38.5%
	X.25	-	0%	25.1%	29.8%	38.4%
	Misc.	-	100%	22.0%	20.8%	23.1%
136.725 MHz ARINC Ter.	AOA	-	31.6%	35.3%	35.8%	47.5%
	X.25	-	41.6%	45.3%	46.0%	37.8%
	Misc.	-	26.7%	19.4%	18.2%	14.7%

The following table summarizes the global repartition of the AVLC frame types, all channels confound. For the AOA type, the proportion for ARINC and SITA is provided between brackets.

Table 14 : Global traffic repartition per AVLC frame type

	08.2015	08.2016	04.2017	07.2017	05.2018
AOA	38.6%	44.6%	47.5%	44.6%	47.5%
(ARINC-SITA)	(11.2%-27.4%)	(12.0%-32.6%)	(12.4%-35.1%)	(11.8%-32.9%)	(28.3%-19.2%)
X.25	37.1%	33.9%	33.5%	35.1%	34.5%
Misc.	24.3%	21.5%	19.0%	20.3%	18.2%

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A1.4 Global peak and median traffic rate (kbits/s) per AVLC frame type

Rate in kbits/s		08.2015	08.2016	04/2017	07.2017	05.2018
Global	P95	6.411	6.841	5.726	10.178	10.851
	Median	4.000	4.803	3.469	7.558	7.528
AOA	P95	3.108	3.637	3.830	5.431	6.055
	Median	1.556	1.713	1.456	3.050	3.287
X.25	P95	1.873	2.049	1.105	3.044	3.238
	Median	1.511	1.849	1.405	2.953	2.858
Misc.	P99	1.430	1.155	0.791	1.702	1.558
	Median	0.932	1.240	0.607	1.555	1.383

A1.5 Peak and median traffic rate (kbits/s) per frequency and per AVLC frame type

Peak rate in kbits/s			08.2015	08.2016	04.2017	07.2017	05.2018
136.975 MHz CSC	Global	P95	5.162	4.335	2.152	4.070	3.834
		Median	2.787	4.200	2.029	3.860	3.715
	AOA	P95	2.169	1.674	0.878	1.385	1.712
		Median	0.920	1.447	0.638	1.293	1.561
	X.25	P95	1.764	1.743	0.776	1.802	1.502
		Median	1.164	1.660	1.000	1.664	1.495
	Misc.	P95	1.229	0.918	0.498	0.883	0.620
		Median	0.703	1.094	0.392	0.903	0.659

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136.875 MHz SITA Ter.	Global	P95	1.249	2.422	2.631	2.034	2.446
		Median	1.213	0.566	1.044	2.041	0.946
	AOA	P95	0.939	1.938	2.330	1.171	1.908
		Median	0.637	0.256	0.706	1.246	0.600
	X.25	P95	0.109	0.273	0.142	0.495	0.287
		Median	0.347	0.166	0.215	0.521	0.173
	Misc.	P95	0.201	0.212	0.159	0.368	0.251
		Median	0.229	0.144	0.124	0.274	0.173
136.775 MHz SITA E-R	Global	P95	-	-	0.727	3.329	0.638
		Median	-	-	0.117	0.544	0.955
	AOA	P95	-	-	0.576	2.535	0.226
		Median	-	-	0.040	0.119	0.186
	X.25	P95	-	-	0.093	0.442	0.275
		Median	-	-	0.037	0.252	0.454
	Misc.	P99	-	-	0.058	0.351	0.137
		Median	-	-	0.039	0.173	0.315
136.725 MHz ARINC Ter.	Global	P95	-	0.084	0.215	0.745	3.932
		Median	-	0.037	0.279	1.113	1.192
	AOA	P95	-	0.025	0.046	0.340	2.208
		Median	-	0.011	0.073	0.392	0.939
	X.25	P95	-	0.033	0.094	0.305	1.173
		Median	-	0.023	0.153	0.516	0.736
	Misc.	P95	-	0.026	0.076	0.100	0.551
		Median	-	0.003	0.053	0.205	0.237

DPMF VDL2 MONITORING FLIGHT REPORT**A1.6 Global peak and median traffic evolution per AVLK frame type for the summer flights**

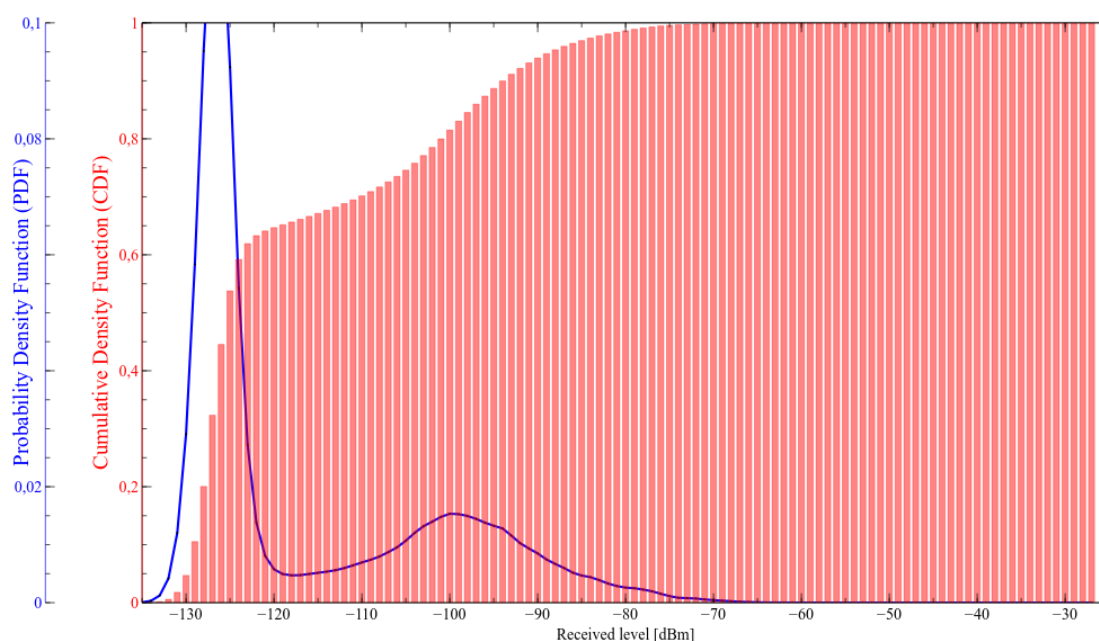
<i>Peak</i>		<i>08.2015</i>	<i>08.2016</i>	<i>07.2017</i>
Global growth	P95	-	6.7%	48.8%
	Median	-	20.1%	57.4%
AOA growth	P95	-	17.0%	49.3%
	Median	-	10.1%	78.1%
X.25 growth	P95	-	14.9%	48.6%
	Median	-	22.4%	59.7%
Misc. growth	P95	-	-19.2%	47.4%
	Median	-	33.0%	25.4%

Annex 3 - 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 :

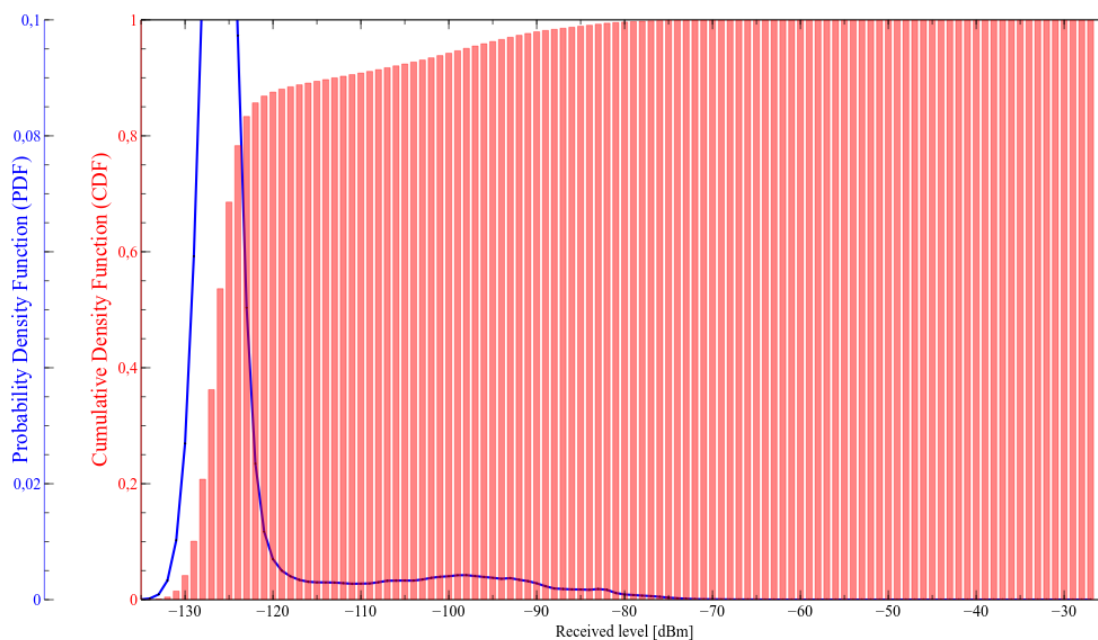
$$Occupancy [-] = 1 - CDF(Level_{threshold} [dBm])$$

A1.7 136.975 MHz

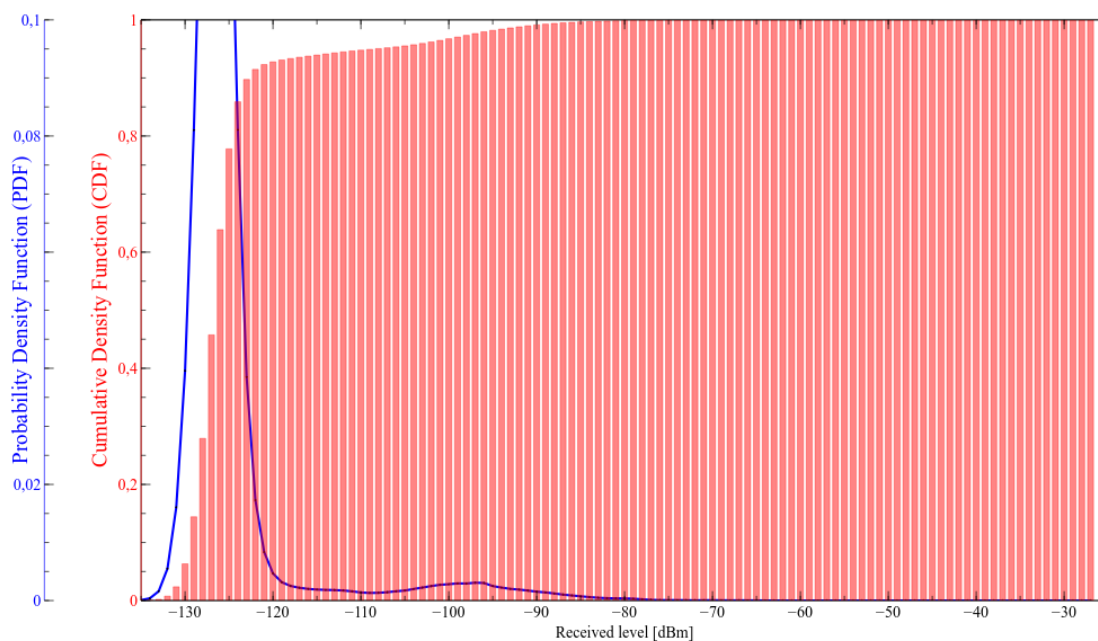


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A1.8 136.875 MHz



A1.9 136.775 MHz



A1.10 136.725 MHz

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