

DPMF VDL2 MONITORING FLIGHT REPORT

August 2018 DPMF flight

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Author(s)			
Christophe Visée			
Contact Person(s)	Tel/email	Unit	
Christophe Visée		NMD/NS/CFC	

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1 Summary

Twice a year, the DPMF is conducting VDL 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:

1. The CSC is progressively offloaded. 64% of the observed traffic is now taking place on the alternate frequencies.
2. An increase of traffic of 14% is observed between July 2017 and August 2018.

The VDL equipage aircraft rate is estimated 46%.

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 2nd, 2018 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 to distinguish between airborne traffic (E-R) and ground traffic (Terminal) which is expected to be different in nature. Since 2017, frequency assignments have been set according to these two categories (see ICAO Doc11 [7]) and the designation of the frequencies in this report is based on these.

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. However as the monitored terminal traffic is part of the real traffic it is recorded as being part of it.

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 observed as these are part of the real and observed traffic.

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 a mean airborne channel occupancy, and also an airborne channel occupancy statistics 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) by periods. It is also expressed in this report as a traffic rate in kbits/s computed as an average per

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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 NLR¹'s Cessna Citation II flying across Europe at FL370. The setup can be found in the annex 1.

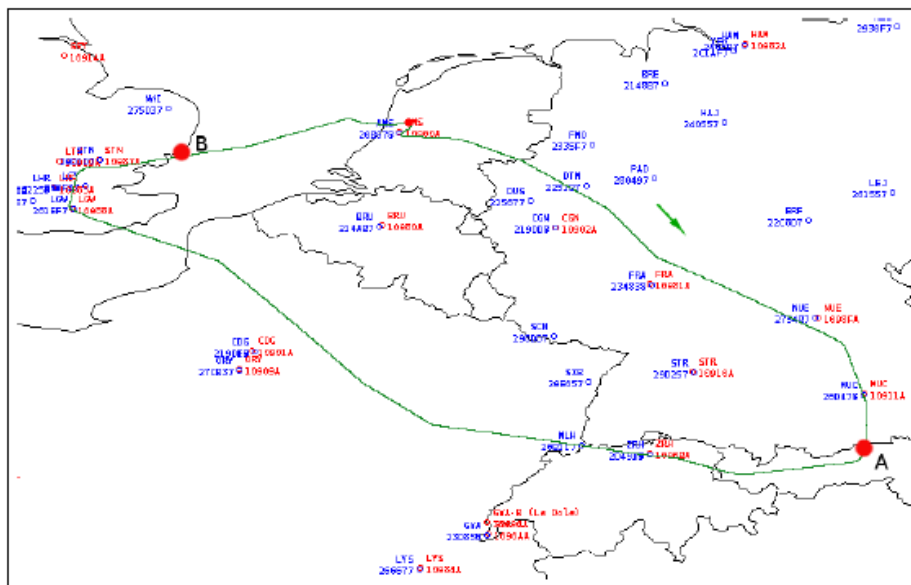


Figure 1 : Typical flight route.

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

¹ Nationaal Lucht-en Ruimtevaarlaboratorium (NL).

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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 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 / assignment		08.2015	08.2016	07.2017	08.2018
136.975 MHz	CSC	20.35%	26.23%	31.02%	23.12%
136.875 MHz	SITA Ter.	1.84%	6.33%	8.69%	7.75%
136.825 MHz	ARINC E-R	0.02%	1.69%	0.00%	0.22%
136.775 MHz	SITA E-R	0.01%	0.63%	4.33%	4.53%
136.725 MHz	ARINC Ter.	0.40%	0.82%	3.01%	19.52%

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%

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

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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.

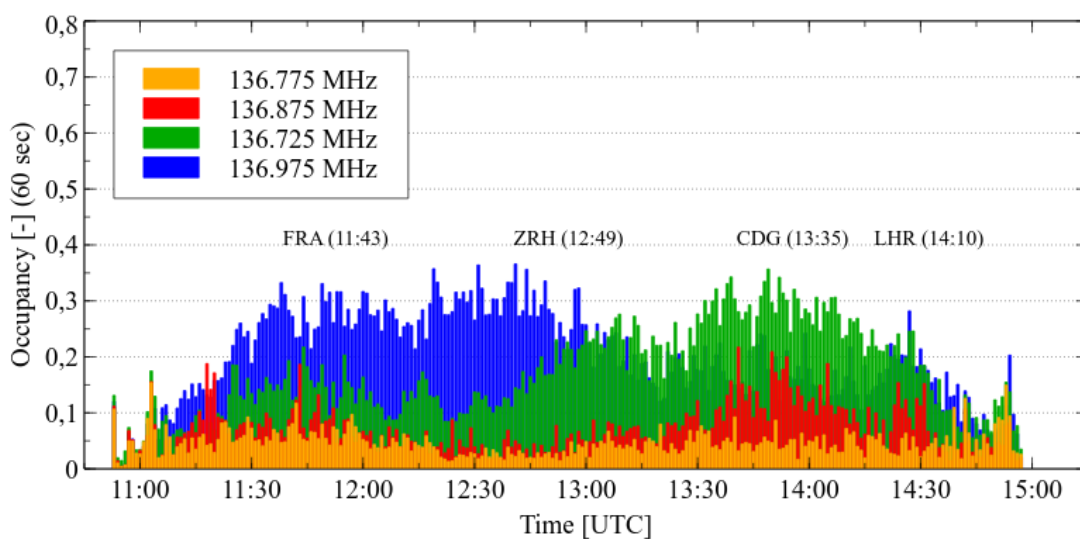


Figure 2 : Occupancy in function of time on 02/08/2018.

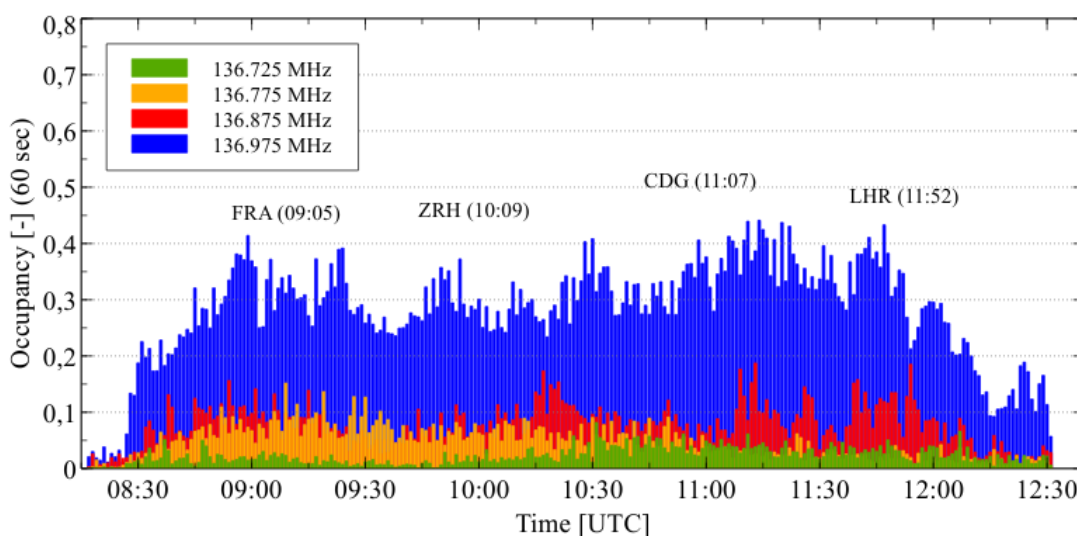


Figure 3 : Occupancy in function of time on 27/07/2017.

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4.1.3 One second occupancy statistics

Using an integration time of one second², the following table³ 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	08.2018
136.975 MHZ CSC	Mean	22.53%	28.80%	32.10%	23.15%
	Mode	19.57%	19.95%	28.23%	23.71%
	P5	7.80%	10.55%	15.74%	7.12%
	P50	20.95%	26.37%	31.05%	22.12%
	P95	42.60%	53.80%	51.86%	42.34
136.775 MHZ SITA E-R	Mean	0.01%	0.41%	5.40%	4.53%
	Mode	0.00%	0.00%	0.00%	0.00%
	P5	0.00%	0.00%	0.00%	0.00%
	P50	0.00%	0.00%	3.51%	2.92%
	P95	0.00%	0.00%	17.99%	14.61%
136.725 MHZ ARINC TER.	Mean	0.39%	0.56%	2.53%	14.48%
	Mode	0.00%	0.00%	0.00%	0.00%
	P5	0.00%	0.00%	0.00%	4.07%
	P50	0.00%	0.00%	1.22%	18.40%
	P95	0.00%	2.49%	10.13%	38.33%

² This is closer to what VDRs are supposed to provide.

³ 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	08.2018
136.975 MHz	CSC	47.85%	42.57%	50.28%	37.10%
136.875 MHz	SITA Ter.	6.43%	16.31%	16.26%	15.82%
136.825 MHz	ARINC E-R	-	-	-	-
136.775 MHz	SITA E-R	-	-	7.52%	5.91%
136.725 MHz	ARINC Ter.	-	0.00%	9.92%	29.51%

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 the expected reality. We expect almost very few collisions on a terminal frequency at a specific airport as most aircrafts (on ground) and VGSs sees each other whereas 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: The reader shall note the significant increase of the collision rate on ARINC terminal 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/s⁴, 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 traffic⁵. 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.

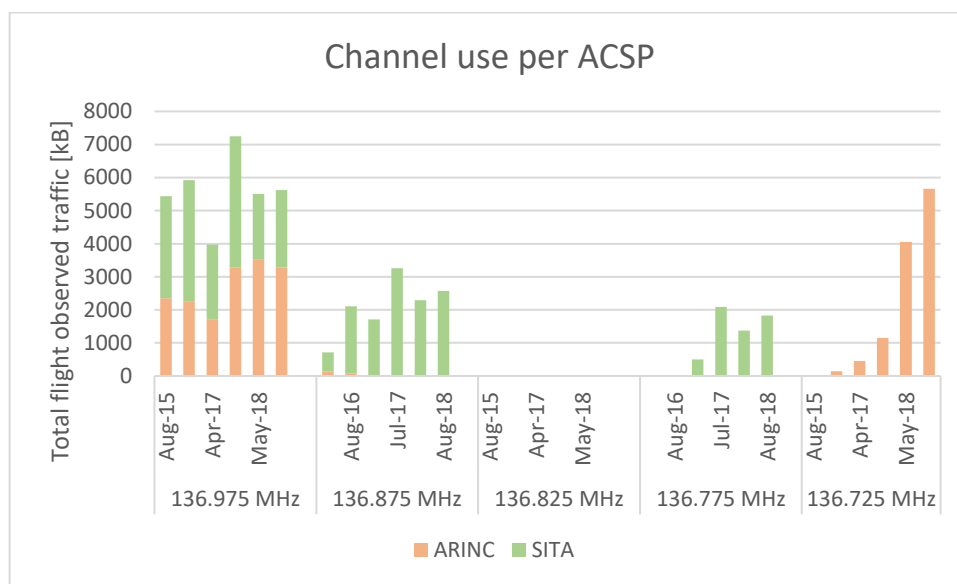


Figure 4 : Traffic distribution between ACSP per frequency

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.

⁴ The traffic rate is expressed as : $Rate [kbits/s] = 8 * \frac{Traffic [kB/minute]}{60}$

⁵ 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.

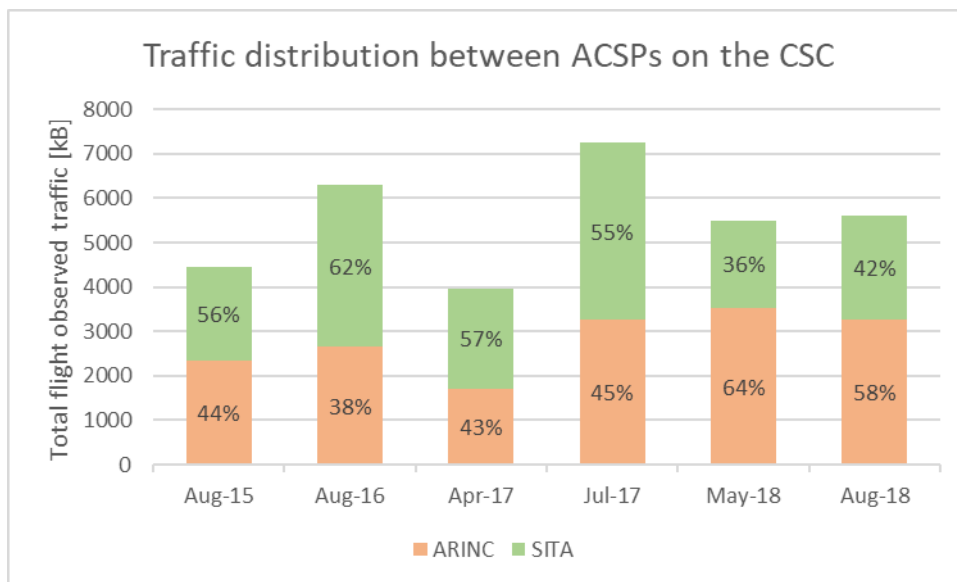


Figure 5 : Traffic distribution between ACSPs on the CSC

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.

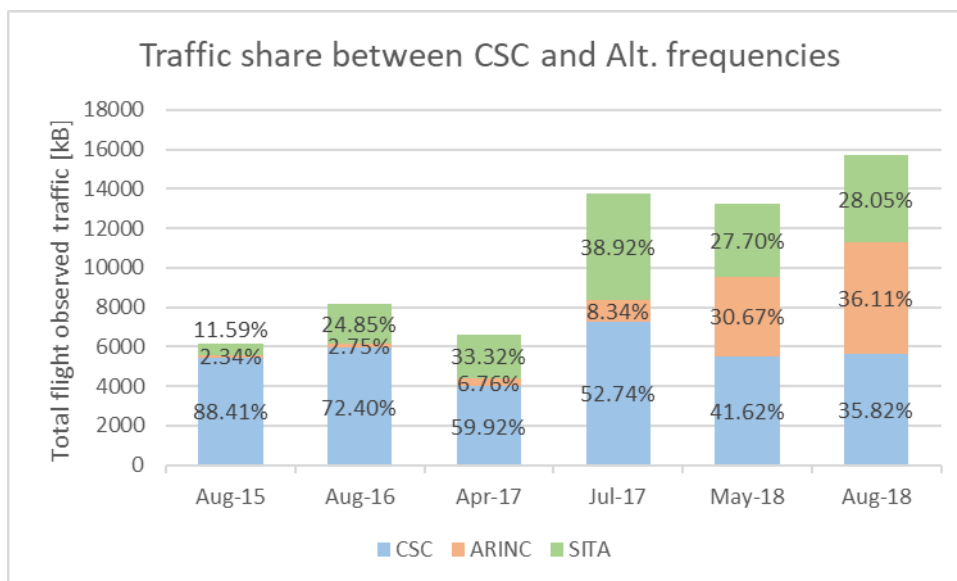


Figure 6 : Partition of the total traffic between the CSC and the alternate frequencies

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4.3.3 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 “Misc.” frames convey AVLC protocol related packets (RR, SREJ, XID,...). Graphs are provided for all the channels and for the frequencies conveying E-R traffic only (as discussed in [8]).

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.

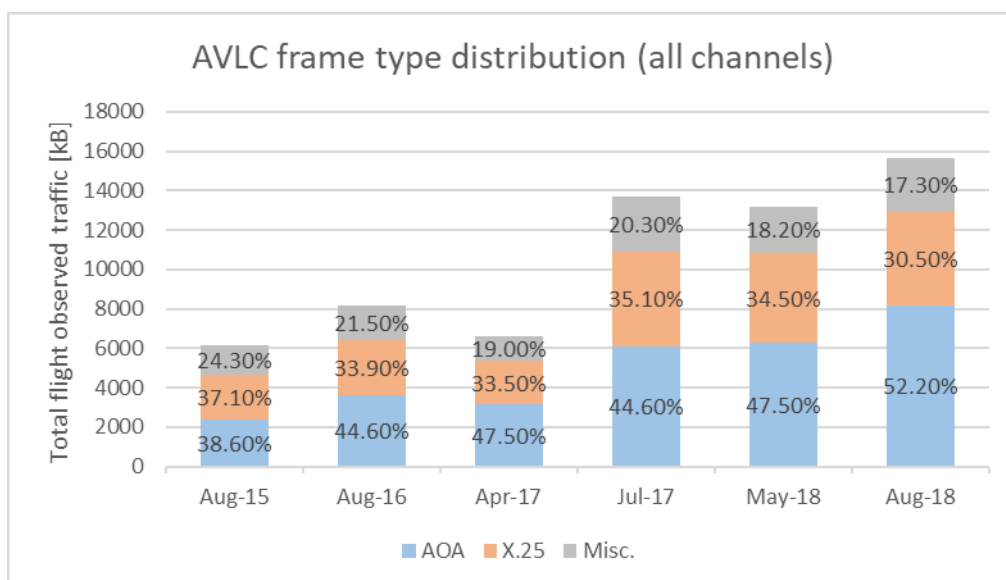


Figure 7 : AVLC frame distribution over time

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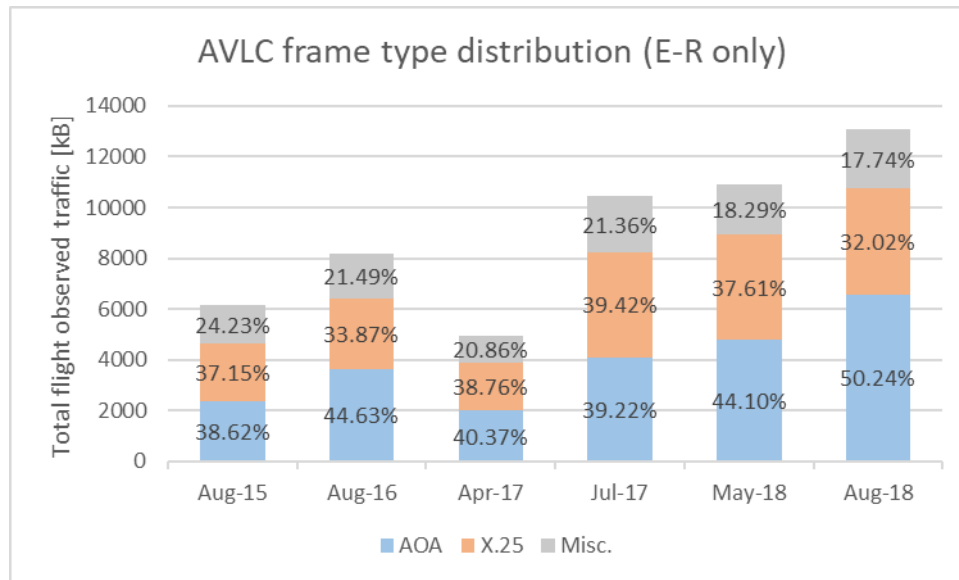


Figure 8: AVLC frame distribution over time for frequencies conveying E-R traffic

Note: An increase of 14.2% (all channels) and 25.2% (E-R only) of the global traffic is observed between July 2017 and August 2018.

4.3.4 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 the channels and for the frequencies conveying E-R traffic only (as discussed in [8]).

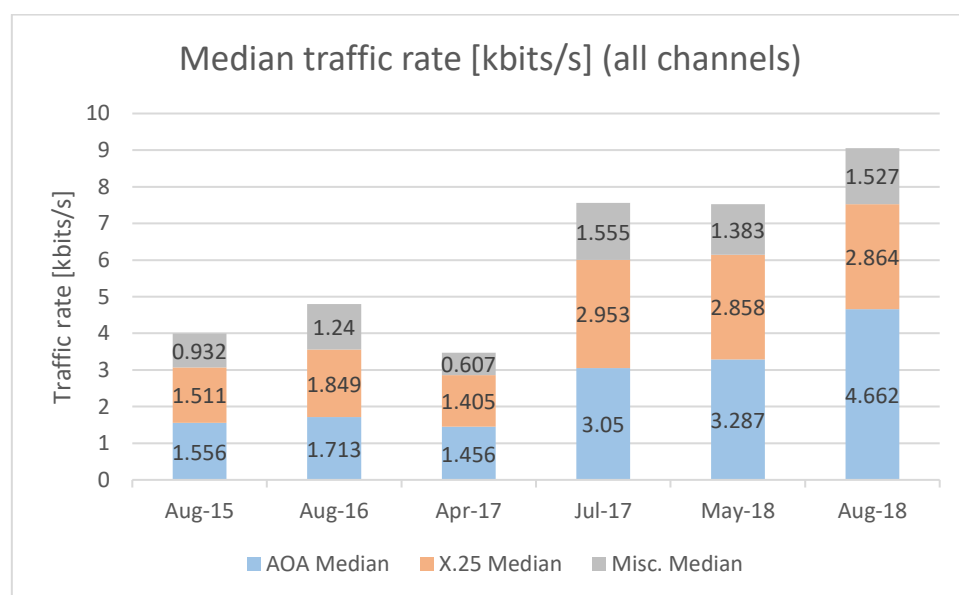


Figure 9 : Median traffic rate

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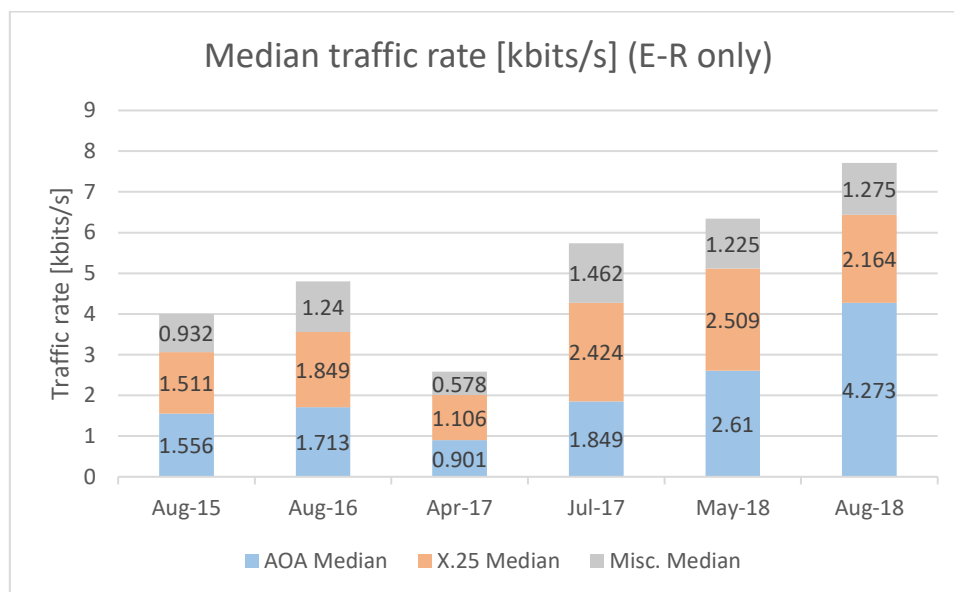


Figure 10: Median traffic rate for frequencies conveying E-R traffic

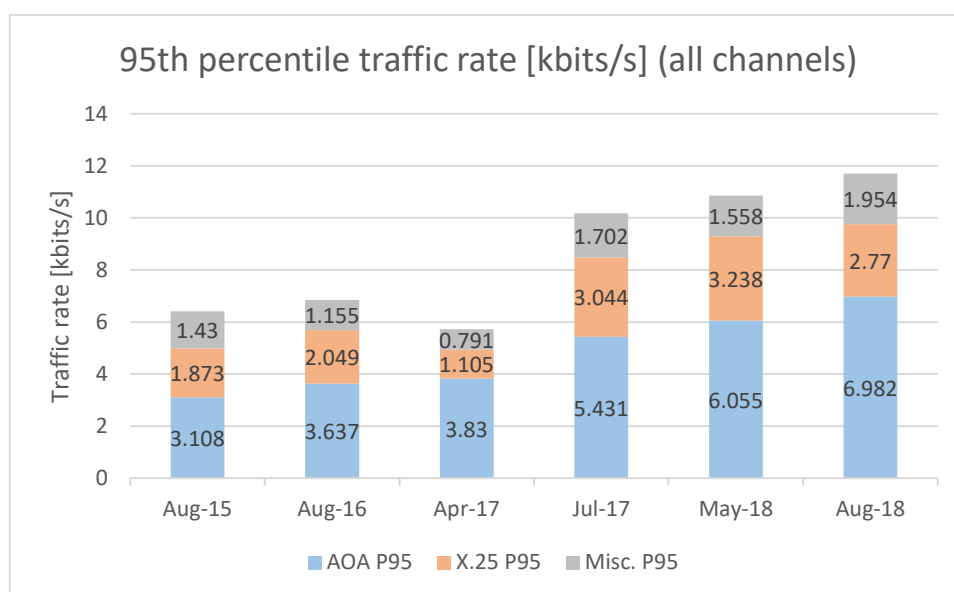


Figure 11 : 95th percentile traffic rate

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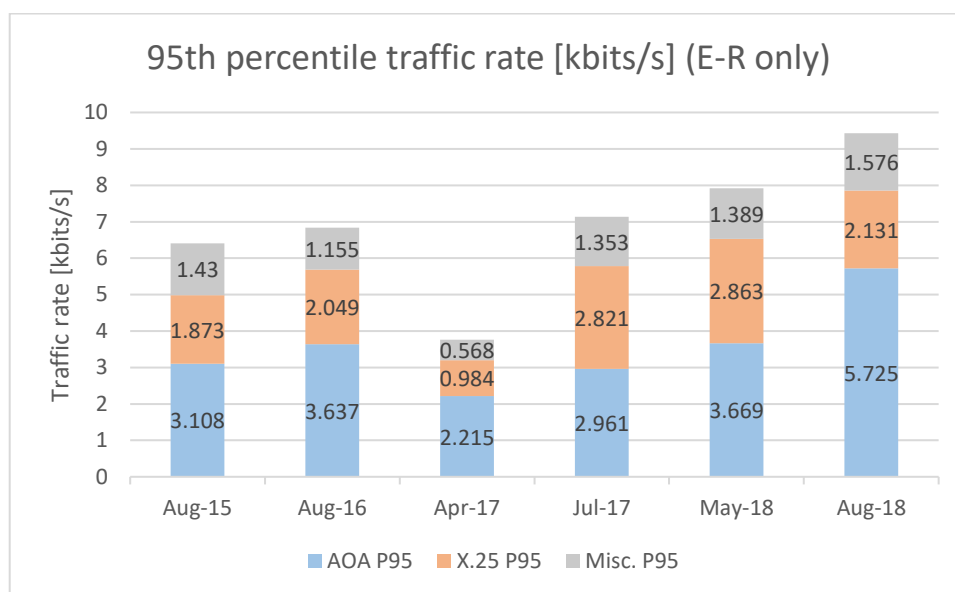


Figure 12: 95th percentile traffic rate for frequencies conveying E-R traffic

Note: An increase of 19.8% (all channels) and 34.4% (E-R only) of the median traffic rate is observed between July 2017 and August 2018. The increase of the 95th percentile is 15.0% (all channels) and 32.2% (E-R only).

DPMF VDL2 MONITORING FLIGHT REPORT**4.5 Distribution of aircraft using specific services**

The following table summarizes the percentage of observed aircrafts using specific services (AOC, ATN, or a mix of these). The considered aircrafts are at least exchanging more than 20 frames to be recorded.

Table 7 : Percentage of observed aircraft using specified services.

	08/2015	08/2016	07/2017	08/2018
AOA only	16.71%	16.87%	16.46%	15.31%
ATN only	1.33%	1.17%	1.43%	1.25%
FANS-1/A only	0.00%	0.00%	0.00%	0.00%
AOA + FANS	2.58%	3.36%	4.81%	5.46%
AOA + ATN	53.96%	51.17%	42.29%	38.08%
AOA + ATN + FANS	0.44%	1.02%	1.35%	1.72%
AOA + ATN + TPDU	23.91%	25.03%	32.03%	36.11%
AOA + ATN + TPDU + FANS	0.36%	0.66%	1.03%	1.55%
ATN + TPDU	0.53%	0.56%	0.50%	0.50%

Notes (Clarifications for Table 7):

- *AOA means VDL equipped aircrafts observed to exchange AVLC frames containing ACARS blocks as defined in ARINC-618-620.*
- *FANS-1/A means VDL equipped aircrafts observed to exchange AVLC frames containing AOA blocks with labels defined as in EUROCAE ED-100A.*
- *ATN means VDL equipped aircrafts observed to exchange AVLC frames containing ISO8208 frames.*
- *TPDU means VDL equipped aircrafts observed to exchange AVLC frames containing TP4 level frames implying they are performing CPDLC over the ATN.*

The following observations can be made based on Table 7 for August 2018:

- 15% of the VDL equipped aircrafts are only performing AOC communications
- 77% of the VDL equipped aircrafts have ATN capability
- 36% of the VDL equipped aircrafts are performing ATN CPDLC
- 38% of the VDL equipped aircrafts have ATN capability and are not using CPDLC
- 1.5% of the VDL equipped aircrafts are performing both FANS-1/A and ATN CPDLC

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4.6 Equipage rate

This section presents an estimation of the VDL equipped aircraft rate based on flight data provided by NM during the monitoring flight.

We make the assumption that equipped aircrafts will use VDL if equipped and that they are heard from the monitoring aircraft.

The equipage rate is computed by comparing the number of aircraft seen by the monitoring aircraft and the number of aircraft present within the theoretical radio coverage of the latter at the same moment.

The chosen location is set according to the highest measured traffic.

Table-8 summarizes the results.

Table 8 : Estimation of the VDL equipped aircraft rate

<i>Number of A/C measured</i>	359
<i>Number of A/C in the LOS (NM data)</i>	778
<i>VDL equipped Rate</i>	46%

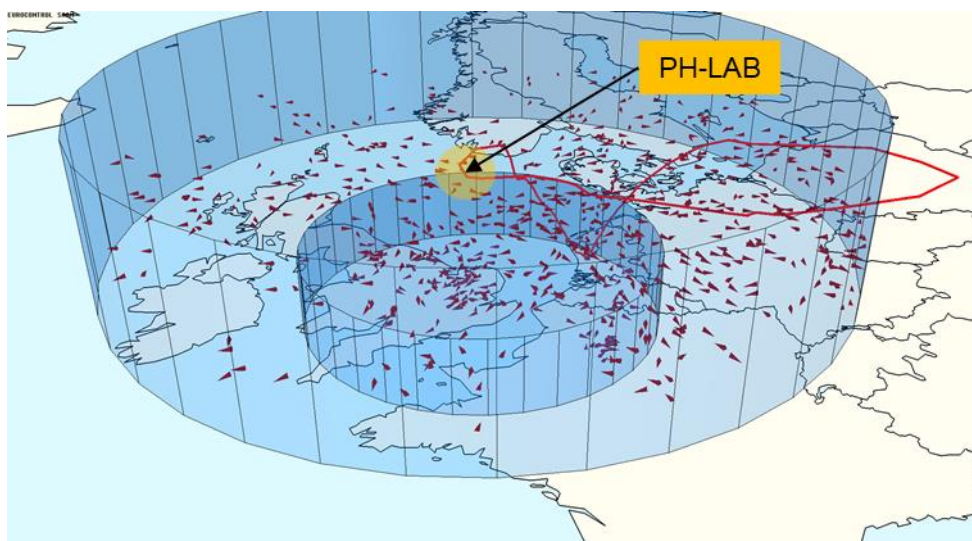


Figure 13 : Location of all the aircrafts flying within the monitoring aircraft's radio horizon when it is above London.

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4.7 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 9 : Interference duration summary

	08.2015	08.2016	04.2017	07.2017	05.2018	08.2018
<i>Modulated voice signals</i>	02:58	21:04	01:42	01:54	01:43	01:46
<i>RTTY-like signals</i>	00:34	00:14	02:27	00:28	01:00	00:00
<i>5-tones selcall</i>				00:23	00:42	00:48
<i>Industrial noise-like</i>	34:56	12:59	04:32	10:36	07:45	07:53
<i>Total</i>	38:53	34:17	08:41	13:21	11:10	10:27

Note: The satellite signals are no longer displayed nor analysed as their presence is known, regular and predictable⁶. 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.

4.7.1 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.

Table 10 : Modulated voice signal duration summary

	<i>N. of transmissions</i>	<i>Duration (MM:SS)</i>	<i>Notes</i>
136.950 MHz	24	01:43	Guard channel
136.875 MHz	1	00:03	SITA Ter.

⁶ 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 Discussion

Multi-frequency deployment

The CSC off-loading is still on-going. 64% of the observed traffic is now being performed on the alternate frequencies (figure 6). Since the beginning of the monitoring flights, this is first reduction of traffic observed on the CSC with a value of -22% of the observed traffic between July 2017 and August 2018.

The decrease of traffic on the CSC is also observed on the average airborne channel occupancy whose value dropped from 31% in July 2017 to 23% in August 2018. The collision rate on the CSC has also dropped from 50% in July 2017 to 37% in August 2018.

Global increase of traffic for the last summer periods

An increase of the global traffic (all frequencies) of 14% is observed between July 2017 and August 2018. This is far less than the observed increase (99%) between April 2017 and May 2018 [8]. When looking at the frequencies conveying only E-R traffic, this increase is 25%.

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

As highlighted in the last report [8], the increase of traffic on ARINC's terminal frequency is accompanied with an increase of the collision rate. Between July 2017 and August 2018, an increase of traffic of +-400% is observed on ARINC's alternate frequency together with an increase of the collision rate of +-200%. Figure 13 (as introduced in [8]) shows the observed evolution and the grey arrows are displaying the evolution between July 2017 and August 2018 for the three considered frequencies.

The observed traffic on ARINC's alternate frequency has now reach comparable values that was observed on the CSC in August 2015. Although the global efficiency is better than the CSC for the specified traffic rate (around 5 kbits/s), the number of VGSs involved is different. 69 VGSs were heard on the CSC in August 2015 and 20 VGSs are heard on ARINC's alternate frequency in August 2018. For the same kind of channel (mixed en-route and terminal) the increase of collisions is mainly due to the increase of the number of VGSs heard and due to the hidden transmitter phenomenon. The reader shall also note that the number of VGSs heard on the SITA en-route frequency was 28 in July 2017 for a lower collision rate, showing hence that the number of VGSs is not the only factor affecting the efficiency of the channel and that the "use" (en-route/terminal) is also an important factor.

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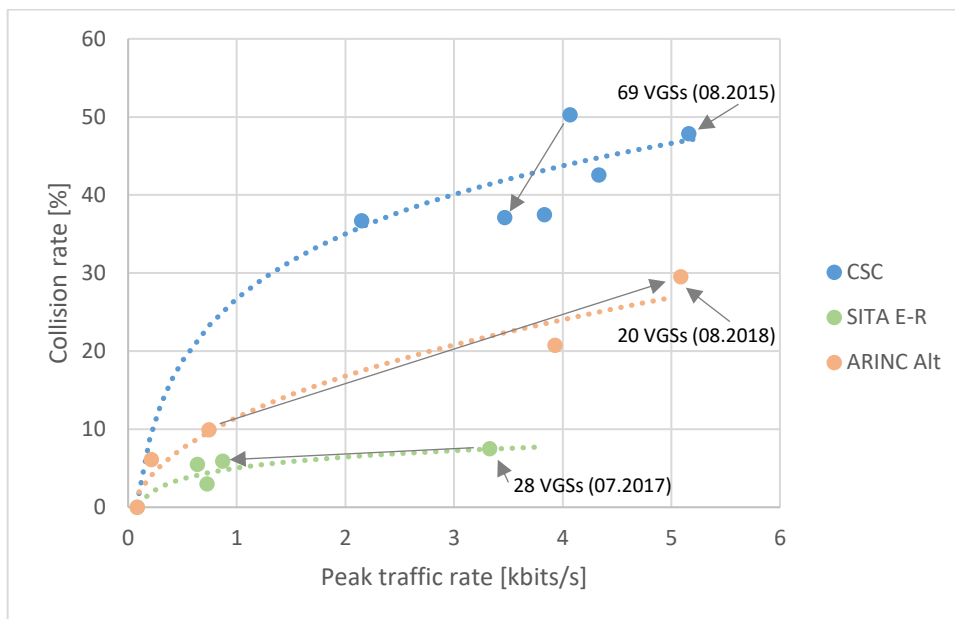


Figure 14 : Collision rate versus peak traffic rate. Each dot represent measured data for each flight on the considered frequencies. The arrows relate to the evolution between July 2017 and August 2018.

6 Conclusions and recommendations

The multi-frequency deployment is still on-going and 64% of the observed traffic is now being performed on the alternate frequencies. This deployment is mainly observed above Paris and London areas.

Since the beginning of the monitoring flights (2015) we observe the first decrease of traffic on the CSC during the summer periods (related to higher traffic). This reduction is measured 22% between July 2017 and August 2018. It is also observed on the airborne channel occupancy and collision rate.

An increase of the global traffic of 14% is observed between July 2017 and August 2018.

An estimation of the VDL equipped aircrafts was performed using data provided by the NM. During the peak traffic minute observed above London, 46% of the a/c flying within the theoretical radio coverage of the monitoring aircraft were performing VDL2 communications.

7 REFERENCES

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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, 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.

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.⁷ 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 MHz⁸. The 4 hours of flights provided about 40 GB of data. IF-PAN spectrum data of 10 MHz were also recorded⁹.

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
<i>C.C.R.M. measurement box (splitter, filter, cables)¹⁰.</i>	7 dB
<i>Receiver-to-Plane RF cable (Suhner S 06132 D-10) (12m).</i>	1.17 dB
<i>Fuselage RF cables to antenna¹¹.</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.

⁷ Centre de Contrôle des Radiocommunications des services Mobiles (BE)

⁸ This is the centre frequency of the VDL band.

⁹ 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.

¹⁰ Measured on April 13th, 2018. Previously measured 6.5 dB on May 20th, 2017.

¹¹ Measured by NLR in August 2017.

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Annex 2 - Tabulated values of chapter 3

A1.1 Service provider related data

Table 11 : Traffic partition per ACSP and per frequency for the summer flights

Frequency / assignment			08.2015	08.2016	07.2017	08.2017
136.975 MHz	CSC	(ARINC)	44%	38%	45%	58%
		(SITA)	56%	62%	55%	42%
136.875 MHz	SITA Ter.		80%	96%	100%	100%
		(ARINC)	20%	4%	0%	
136.825 MHz	ARINC E-R		-	-	-	-
136.775 MHz	SITA E-R		-	-	100%	100%
136.725 MHz	ARINC Ter.		-	100%	100%	100%

Table 12 : 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 13 : Global traffic partition per ACSP

Provider		08.2015	08.2016	04.2017	07.2017	05.2018	08.2018
GLOBAL	CSC	89%	72%	60%	53%	42%	36%
	Alt.	11%	28%	40%	47%	58%	64%
ARINC	CSC	93%	91%	79%	74%	47%	37%
	Alt.	7%	9%	21%	26%	53%	63%
SITA	CSC	82%	64%	51%	43%	35%	35%
	Alt.	18%	36%	49%	57%	65%	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 14 : Number of station and their generated traffic per frequency and per station type

		08.2015	08.2016	04.2017	07.2017	05.2018	08.2018
136.975 MHz CSC	AIR	1284	1628	1356	1742	1511	1558
		2537 kB	3758 kB	1960 kB	4326 kB	3014 kB	3198 kB
	GND	411	472	365	525	487	492
		283 kB	283 kB	327 kB	465 kB	480 kB	458 kB
	VGS	69	88	79	88	97	107
		1749 kB	1892 kB	1689 kB	2452 kB	2011 kB	1962 kB
136.875 MHz SITA Ter.	AIR	63	223	238	412	368	398
		135 kB	354 kB	255 kB	666 kB	841 kB	874 kB
	GND	127	434	334	536	284	303
		247 kB	901 kB	814 kB	1317 kB	757 kB	831 kB
	VGS	18	29	24	28	25	26
		330 kB	857 kB	637 kB	1277 kB	693 kB	868 kB
136.775 MHz SITA E-R	AIR	0	0	169	443	390	466
		0 kB	0 kB	269 kB	1166 kB	915 kB	1302 kB
	GND	0	0	22	52	15	20
		0 kB	0 kB	33 kB	105 kB	8 kB	23 kB
	VGS	0	1	11	16	17	20
		0 kB	3 kB	202 kB	814 kB	451 kB	501 kB
136.725 MHz ARINC Ter.	AIR	0	61	166	232	467	662
		0 kB	83 kB	250 kB	753 kB	2415 kB	3158 kB
	GND	0	9	26	45	163	233
		0 kB	1 kB	6 kB	12 kB	345 kB	742 kB
	VGS	0	5	7	7	11	13
		0 kB	60 kB	192 kB	380 kB	1296 kB	1763 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 15 : Traffic repartition per frequency and AVLC frame type

		08.2015	08.2016	04.2017	07.2017	05.2018	08.2018
136.975 MHz CSC	AOA	37.2%	38.1%	38.9%	36.3%	42.9%	45.6%
	X.25	38.9%	38.1%	39.7%	41.1%	37.1%	34.1%
	Misc.	23.9%	23.8%	21.4%	22.5%	20.0%	20.3%
136.875 MHz SITA Ter.	AOA	52.5%	62.4%	67.6%	61.4%	63.2%	62.1%
	X.25	26.3%	21.2%	18.3%	21.4%	20.2%	22.8%
	Misc.	21.2%	16.4%	14.1%	17.2%	16.6%	15.1%
136.775 MHz SITA E-R	AOA	-	0%	52.9%	49.5%	38.5%	48.7%
	X.25	-	0%	25.1%	29.8%	38.4%	31.1%
	Misc.	-	100%	22.0%	20.8%	23.1%	20.1%
136.725 MHz ARINC Ter.	AOA	-	31.6%	35.3%	35.8%	47.5%	55.3%
	X.25	-	41.6%	45.3%	46.0%	37.8%	30.3%
	Misc.	-	26.7%	19.4%	18.2%	14.7%	14.4%

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

Table 16 : Global traffic repartition per AVLC frame type

	08.2015	08.2016	04.2017	07.2017	05.2018	08.2018
AOA (ARINC- SITA)	38.6% (11.2%- 27.4%)	44.6% (12.0%- 32.6%)	47.5% (12.4%- 35.1%)	44.6% (11.8%- 32.9%)	47.5% (28.3%- 19.2%)	52.2% (31.1%- 21.1%)
X.25	37.1%	33.9%	33.5%	35.1%	34.5%	30.5%
Misc.	24.3%	21.5%	19.0%	20.3%	18.2%	17.3%

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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	08.2018
Global	P95	6.411	6.841	5.726	10.178	10.851	11.706
	Median	4.000	4.803	3.469	7.558	7.528	9.053
AOA	P95	3.108	3.637	3.830	5.431	6.055	6.982
	Median	1.556	1.713	1.456	3.050	3.287	4.662
X.25	P95	1.873	2.049	1.105	3.044	3.238	2.770
	Median	1.511	1.849	1.405	2.953	2.858	2.864
Misc.	P99	1.430	1.155	0.791	1.702	1.558	1.954
	Median	0.932	1.240	0.607	1.555	1.383	1.527

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	08.2018
136.975 MHz CSC	Global	P95	5.162	4.335	2.152	4.070	3.834	3.469
		Median	2.787	4.200	2.029	3.860	3.715	4.355
	AOA	P95	2.169	1.674	0.878	1.385	1.712	1.657
		Median	0.920	1.447	0.638	1.293	1.561	1.916
	X.25	P95	1.764	1.743	0.776	1.802	1.502	1.075
		Median	1.164	1.660	1.000	1.664	1.495	1.556
	Misc.	P95	1.229	0.918	0.498	0.883	0.620	0.736
		Median	0.703	1.094	0.392	0.903	0.659	0.884

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136.875 MHz SITA Ter.	Global	P95	1.249	2.422	2.631	2.034	2.446	2.276
		Median	1.213	0.566	1.044	2.041	0.946	1.104
	AOA	P95	0.939	1.938	2.330	1.171	1.908	1.249
		Median	0.637	0.256	0.706	1.246	0.600	0.871
	X.25	P95	0.109	0.273	0.142	0.495	0.287	0.653
		Median	0.347	0.166	0.215	0.521	0.173	0.140
	Misc.	P95	0.201	0.212	0.159	0.368	0.251	0.375
		Median	0.229	0.144	0.124	0.274	0.173	0.094
136.775 MHz SITA E-R	Global	P95	-	-	0.727	3.329	0.638	0.872
		Median	-	-	0.117	0.544	0.955	0.656
	AOA	P95	-	-	0.576	2.535	0.226	0.449
		Median	-	-	0.040	0.119	0.186	0.125
	X.25	P95	-	-	0.093	0.442	0.275	0.216
		Median	-	-	0.037	0.252	0.454	0.263
	Misc.	P99	-	-	0.058	0.351	0.137	0.207
		Median	-	-	0.039	0.173	0.315	0.269
136.725 MHz ARINC Ter.	Global	P95	-	0.084	0.215	0.745	3.932	5.089
		Median	-	0.037	0.279	1.113	1.192	2.937
	AOA	P95	-	0.025	0.046	0.340	2.208	3.627
		Median	-	0.011	0.073	0.392	0.939	1.751
	X.25	P95	-	0.033	0.094	0.305	1.173	0.826
		Median	-	0.023	0.153	0.516	0.736	0.906
	Misc.	P95	-	0.026	0.076	0.100	0.551	0.636
		Median	-	0.003	0.053	0.205	0.237	0.280

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A1.6 Global peak and median traffic evolution per AVLK frame type for the summer flights

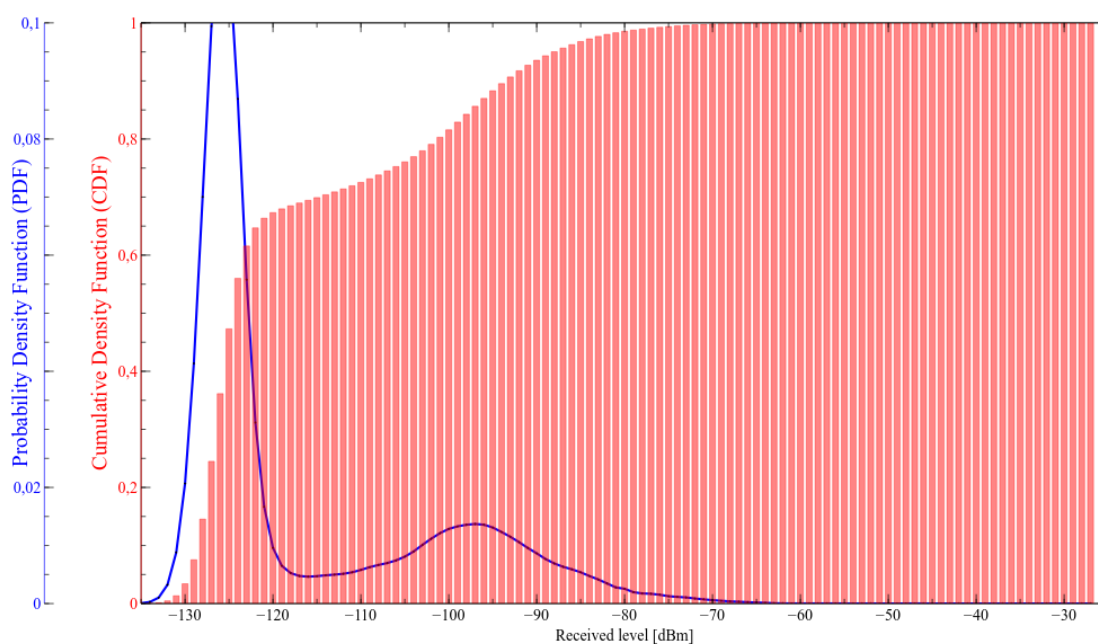
<i>Peak</i>		<i>08.2015</i>	<i>08.2016</i>	<i>07.2017</i>	<i>08.2018</i>
Global growth	P95	-	6.7%	48.8%	15.0%
	Median	-	20.1%	57.4%	19.8%
AOA growth	P95	-	17.0%	49.3%	28.6%
	Median	-	10.1%	78.1%	52.9%
X.25 growth	P95	-	14.9%	48.6%	-9.0%
	Median	-	22.4%	59.7%	-3.0%
Misc. growth	P95	-	-19.2%	47.4%	14.8%
	Median	-	33.0%	25.4%	-1.8%

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:

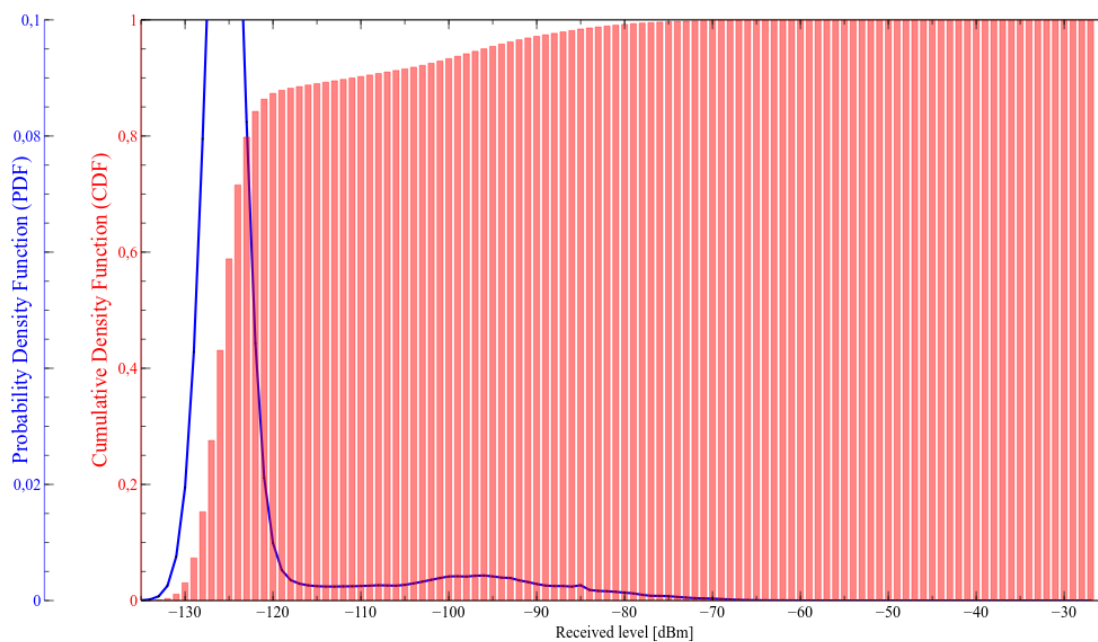
$$Occupancy [-] = 1 - CDF(Level_{threshold} [dBm])$$

A1.7 136.975 MHz

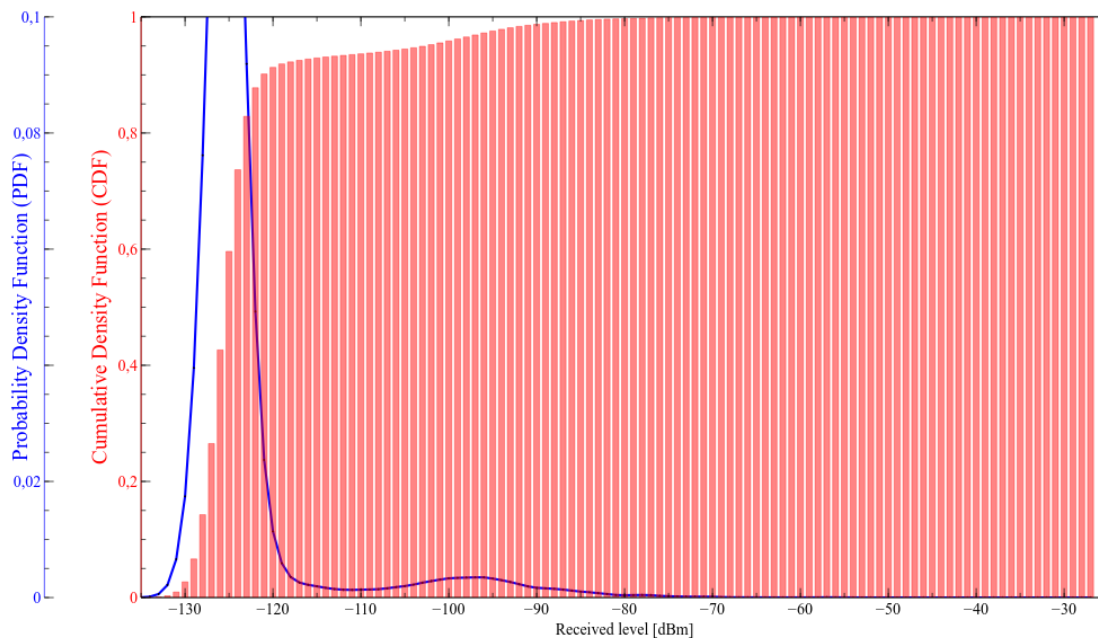


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A1.8 136.875 MHz

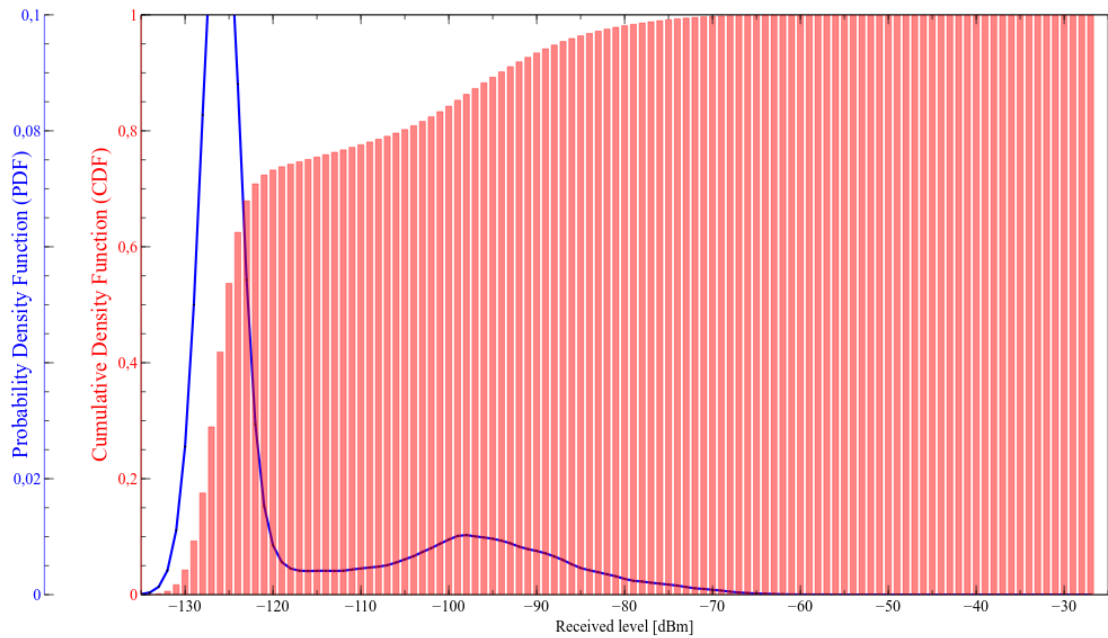


A1.9 136.775 MHz



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A1.10 136.725 MHz



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