AeroMACS Verification Plan & Report - Phase 2

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Abstract

The general purpose of the 15.02.07 is to verify the AeroMACS Data Link. This document describes the verification plan applied within the 15.02.07 Project for phase 2 testing and the corresponding tests report.

AeroMACS phase 2 integration and testing activities includes:

- Laboratory tests,
- Toulouse airport tests.

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This deliverable consists of SJU foreground.

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Executive summary

The goal of project 15.02.07, in strong collaboration with Project 9.16, is to define, validate and demonstrate the technical standard based upon existing IEEE 802.16e of the future airport surface data link as foreseen by the aviation community and ICAO. Therefore, it includes the modification of the IEEE 802.16e standard and the developing of a new AeroMACS profile dedicated for airport surface datalink for ATC / AOC services, in order to be compliant with SESAR / ICAO FCI recommendations.

The mentioned evaluation assessed the performance and capacity of the technology by means of analytical work and simulations in order to develop design specifications. Moreover, prototypes were defined and developed to demonstrate results through measurements and trials, in a strong coordination with the appropriate standardisation bodies.

Therefore, 9.16 and 15.02.07 projects are contributing to the development of an aviation technical standard to be recognised by ICAO in direct and strong cooperation with Eurocae WG82 and RTCA SC 223.

The purpose of the present document is to establish project 15.02.07 “Verification plan and report” corresponding to the “Verification Objectives” described in document D05.2. (cf. [1]) and identified for phase 2 test campaigns.

1 Introduction

1.1 Purpose of the document

The purpose of the Verification Plan & Report is to describe the phase 2 verification test cases and to gather corresponding test results achieved within the 15.02.07 project in order to assess the AeroMACS Data Link thanks to the use of Mobile Stations (MS) mock-ups and Ground Stations (GS) prototypes.

Verification test cases are derived from the Verification Objectives (VO) defined in the D05.2 document (see [1]). They cover following aspects:

- MS/BS Interoperability, including AeroMACS Profile,
- RF specification and performances,
- RF performances in real environments.

Within the 15.02.07 project, verification tests consist in:

- Laboratory tests, held in SELEX and THALES premises, with both partners pieces of equipment,
- Field tests, held in Toulouse Airport, by THALES & DSNA.

The 15.02.07 Verification Activity has been divided in two separate Working Activities described in the D05.2 document (see [1]):

- Phase 1 is related to Laboratory Tests that verify the main part of the MS/BS Interoperability and RF performances objectives. This was completed through task T06 in 2013 and concluded by deliverable D06.
- Phase 2 is related both to Laboratory Tests and Toulouse Airport Tests. They are reported in present D10 document. Indeed, this document is the deliverable related to P15.02.07. “integration & testing - phase 2”, supported by tasks T010 and T011.

1.2 Intended readership

This document is intended to be used primarily by the partners of the 15.02.07 Project. However, for coordination reasons, also Projects SESAR 9.16, SANDRA SP6 and SANDRA SP7 could take this deliverable into account.

The document is also useful for standardization groups, and in particular for AeroMACS SARPS validation.

Other operational/system projects could make use of the deliverables of 15.02.07/9.16 projects.

1.3 Structure of the document

The structure of the document is based on 8 chapters:

- Chapter 1 is an introduction describing the purpose of the document and the intended readership.
- Chapter 2 describes the context of the Verification.
- Chapter 3 defines the verification approach, describing how the verification scenarios will be implemented in the various test locations (Manufacturers Laboratories, Toulouse Airports).
- Chapter 4 details verification activities and means
- Chapter 5 provides a summary of the verification test results
- Chapter 6 consists of the conclusion and recommendations

- Chapter 7 provides the detailed tests cases related to the verification objectives of the SESAR 15.02.07 project for phase 2
- Chapter 8 lists the reference documents
- .

Since the scope of this document includes both the Verification Plan and Verification Report of the P.15.02.07 Integration and testing activities Phase 2, the document structure maps both SJU VP and VR templates as follows:

- Introduction sections: Chapters 1 and 2
- Verification Plan: Chapters 3 and 4
- Verification Report: Chapters 5, 6 and 7

1.4 Glossary of terms

For terminology clarification, the following terms are defined below:

- “Mock-up” : Part of MS test equipment
- “Prototype” : Base/Mobile station prototype equipment
- “System test platform”: Bring together several prototypes, mock-up and tools

1.5 Acronyms and Terminology

Term	Definition
ADD	Architecture Definition Document
A/C	AirCraft
ATS	Air Traffic Service
ATM	Air Traffic Management
BE	Best Effort
CINR	Carrier to Interference-plus-Noise Ratio
CQICH	Channel Quality Information Channel
DOD	Detailed Operational Description
E-ATMS	European Air Traffic Management System
E-OCVM	European Operational Concept Validation Methodology
FCH	Frame Control Header
GS **(BS)**	Ground Station (Base Station in WiMAX terminology) Same meaning as BS

Term	Definition
IOT	Inter-Operability Tests
IRS	Interface Requirements Specification
INTEROP	Interoperability Requirements
LOS	Line Of Sight
MS	Mobile Station (Subscriber Station or CPE in WiMAX terminology)
NLOS	Non Line Of Sight
nLOS	Near Line Of Sight
nRTPS	Non-Real-Time Polling Service
OFA	Operational Focus Areas
OSED	Operational Service and Environment Definition
PCO	Point of COntrol
QOS	Quality Of Service
RSSI	Received Signal Strength Indicator
RTPS	Real-Time Polling Service
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SF	Service Flow
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency.
SPR	Safety and Performance Requirements
SUT	System Under Test
TAD	Technical Architecture Description
TS	Technical Specification
UGS	Unsolicited Grant Service
VALP	Validation Plan

Term	Definition
VALR	Validation Report
VALS	Validation Strategy
VP	Verification Plan
VR	Verification Report
VS	Verification Strategy

2 Context of the Verification

Project 15.02.07 is a technological project dealing with the adaptation of the WiMAX 802.16-2009 standard (in the aeronautical C band) and with the definition of a profile suited to airport surface communications supporting both ATS and AOC data exchanges.

In this context, the verification approach consists in assessing and collecting evidences on the suitability and performances of the proposed technology (AeroMACS) against the on-going standardization of the new generation of airport data link system, performed in close conjunction with RTCA SC223 and EUROCAE WG82.

The objective of the verification phase is thus to perform real evaluation using lab testing and field trials together with analysis and modelling to deliver the appropriate material for decision making and for preparation of pre-operational and implementation decisions.

3 Verification Approach

3.1 Verification Overview

As already stated, AeroMACS Data Link global overall verification is addressed by Project 15.02.07, but also by Projects 9.16, SANDRA SP6 and SANDRA SP7.

This document focuses on the verification test cases to be achieved within the 15.02.07 Project, namely:

- Lab tests: performances measurement related to the new AeroMACS profile and interoperability between different vendors pieces of equipment,
- Field tests: tests in real airport environment focussed on the ground segment datalink.

The table below gives an overview of main partners involved in lab and field tests within project 15.02.07 and close contributing to project 9.16:

	P 15.02.07	**P 9.16**
Lab. test	THALES, THALES Lab.	SELEX ES, Selex Lab.
	SELEX ES, Selex Lab.	
Field test	THALES + DSNA	SELEX ES + Airbus
	Toulouse airport	Toulouse airport
	Focus on ground component of AeroMACS	Focus on airborne component of AeroMACS

Table 1: Testing organization

3.2 Verification plan

Within the 15.02.07 / 9.16 projects, the planned verification consists in:

Performances measurement regarding the AeroMACS profile, by testing the GS with the MS originating from the same suppliers in laboratories (enclosed environment),

Interoperability evaluation of the prototypes, by cross-testing of GS with MS from different suppliers in laboratories,

Technology assessment, by carrying out tests in a real airport environment (Toulouse Airport).

To be able to achieve such objectives, SELEX and THALES built prototypes of a Ground Station (GS), and mock-ups of Mobile Stations (MS) able to communicate in the aeronautical C-Band (5091 – 5150 MHz) to be used both in laboratory and on the field. They are described in document D05.1 (Ref. [2]).

Additionally, test cases described in Section 7 are used to perform the tests on two different platforms:

Firstly lab tests, by connecting the pieces of equipment with the measurement devices on the table,

Secondly airport tests, by installing the MS in cars and the BS on a fix place in the Airport.

3.3 Verification Assumptions

Main assumptions to be able to perform the tests are:

Availability of MS/BS prototypes in C-Band of the involved partners for interoperability testing

Granted airport access:

Equipment vendors engineers trained to access Airport

Qualified drivers available to drive the cars in Airport area

Airport facilities shall be available for testing purpose without interfering with normal airport activities

Cars shall be available and equipped

Frequency compatibility with authorization provided by authorities in order to operate Airport tests.

3.4 Verification requirements

Verification requirements are defined in reference [1] “P 15.02.07 D05.2 - AeroMACS Verification Strategy”.

D05 describes the Verification Objectives (VO) to be reached within the 15.02.07 Project and identifies each VO by an ID and a title.

The VO concerning phase 2 testing are summarized hereafter in § 3.5 (while the VO corresponding to phase 1 testing were summarized in reference [3] (“P 15.02.07 D06 - AeroMACS integration & testing – phase 1”).

In § 4, test cases are identified in front of each VO to perform the corresponding verification activities.

3.5 Integration and preliminary Verification activities

3.5.1 Introduction

The preliminary verification activities are:

Verification strategy definition (see D05.2 [1]),

MS and BS prototypes development (see D05.1 [2]),

Test bed development/definition for laboratory testing (see § 3.5.2) and for airport test scenarios (see § 3.5.2.3).

3.5.2 Lab testing

3.5.2.1 Lab Test beds

Prior to lab testing, a test bed will be built with following elements:

GS , MS, antennas, GPS, network and IT elements (switch, PC), cables, attenuators

Laboratory test cases and related lab test means (spectrum analyser, protocol analyser, etc.) for Signal & Protocol measurement,

IP traffic generators.

The test bed will be configured to comply with the different lab tests scenario as depicted in the following pictures:

Lab_test_bed_01: to perform RF measurements and interoperability evaluation in THALES labs

Lab_test_bed_02: to perform RF measurements and interoperability evaluation in SELEX labs

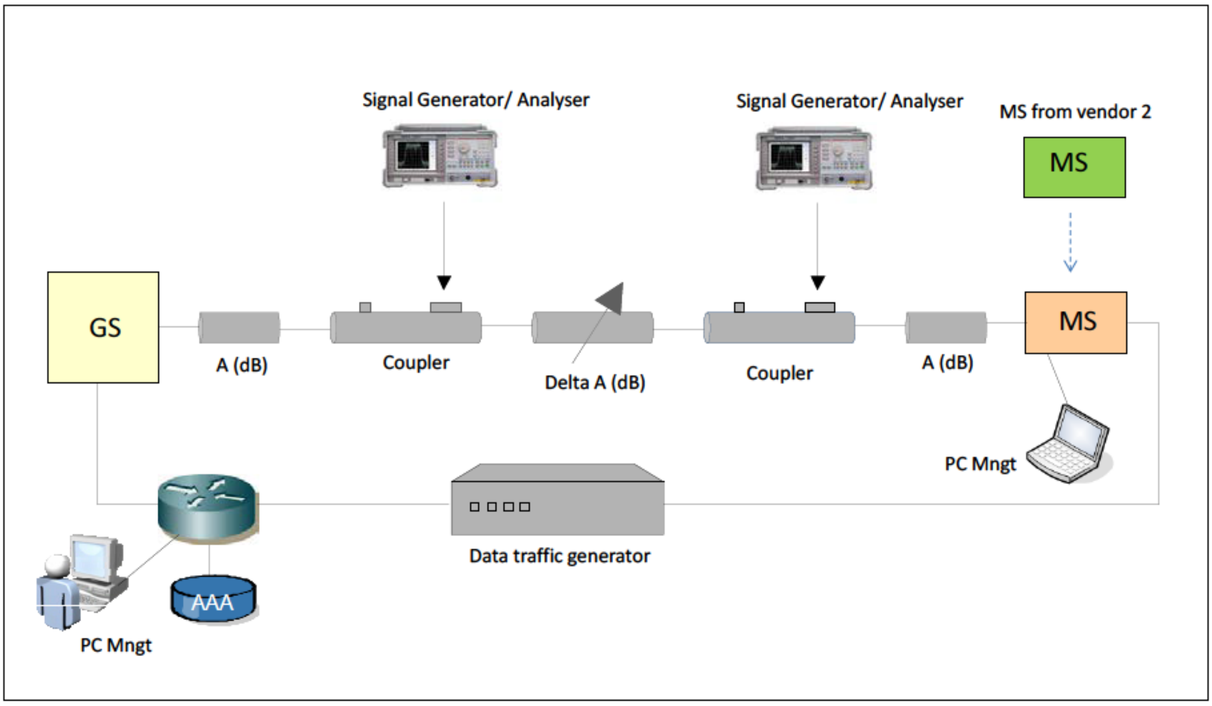


Figure 3-1 : Lab_test_bed_01 (THALES)

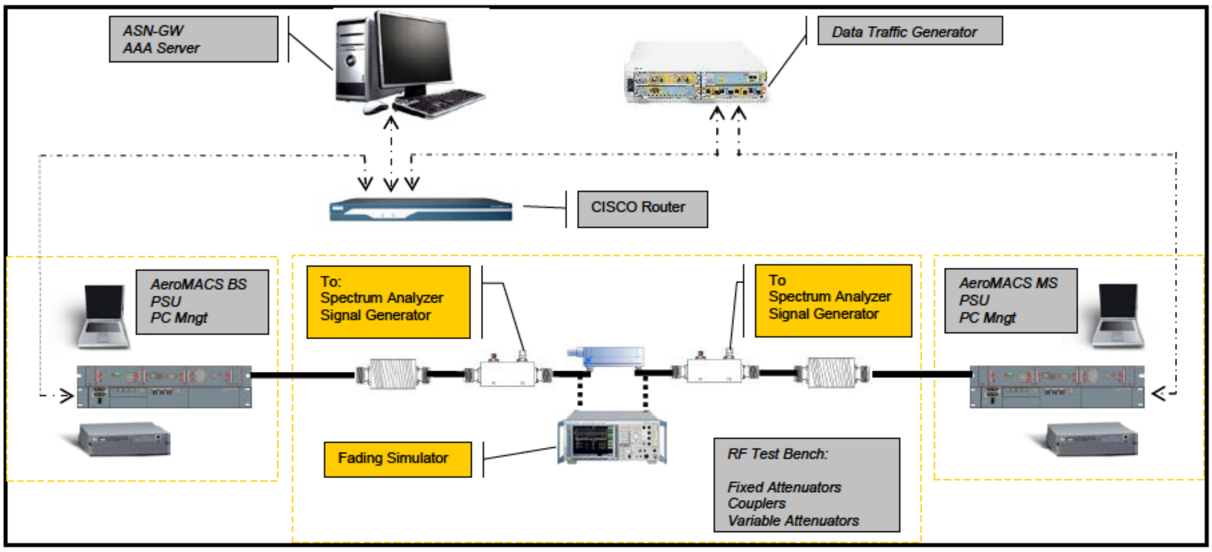


Figure 3-2 : Lab_test_bed_02 (SELEX)

3.5.2.2 Phase 2 verification activities

The verification activities to be conducted during phase 2 lab testing (task T011) are summarized below. The details can be found in [1] and these objectives are further derived in test cases in Section 7 by both involved manufacturers.

General VO Id	Title	Purpose
AeroMACS_VO_Interop_03 (Selex)	Network Entry	Verify that AeroMACS MS and BS perform all relevant actions at Network Entry that affects the air interface
AeroMACS_VO_Interop_05 (Thales)	SF establishment, change and deletion	Verify the completion of the control messages transmission to successfully complete the creation, change and deletion of a service flow to the MS.
AeroMACS_VO_Interop_06 (Selex, Thales)	MS channel quality report	Verify the Fast Feedback Channel Allocation of the BS in order to get information on the currently SNR the MS has.
AeroMACS_VO_Interop_07 (Selex)	Dynamic BW allocation	Verification of correct allocation of MAC resources
AeroMACS_VO_Interop_10 (Selex)	Uplink Power Control	Check that a data transfer continues properly when there is a fading in the UL channel. Verify that MS-BS interface supports the closed loop power control.
AeroMACS_VO_Interop_11 (Selex)	Security functions	Verify that the security functions on the air interface are interoperable between AeroMACS MS and BS. Verify the fragmentation and correct reassembling of the packets and the data integrity (FCS)
AeroMACS_VO_RF_04 (Selex, Thales)	Channel selectivity	Verify the receiver Adjacent and non-adjacent channel selectivity
AeroMACS_VO_RF_05 (Thales)	FCC transmission mask	Verify the BS/MS transmission mask
AeroMACS_VO_RF_08 (Thales)	Transmit power requirements	Verify AeroMACS Transmit power requirements
AeroMACS_VO_RF_11 (Thales)	MS transmit synchronization	Verify the transmitted center frequency of the MS
AeroMACS_VO_RFReal_01 (Selex)	Spectrum operations	Verify that AeroMACS BS/MS operates in the extended MLS band between 5091 and 5150 MHz with a 5MHz spacing between channels.

Table 2: Phase 2 lab verification objectives summary

3.5.2.3 Interoperability testing

IOT tests consist of a limited interoperability testing of air interface with following verification objectives. They are performed with same testbed as described in § 3.5.2.2. where the mobile stations are exchanged between manufacturers.

General VO Id	Title	Purpose
AeroMACS_VO_Limited Interop_A	Scanning and synchronization	When switched on, MS starts off with the scanning of the spectrum. Verify that the correct expected broadcast messages are exchanged, the preamble is correctly decoded by the MS.
AeroMACS_VO_Limited Interop_B	Initial Ranging	Verify that, after successful DL Synchronization, MS and BS exchanges the proper RNG-REQ/RNG-RSP messages, completing the Initial Ranging
AeroMACS_VO_Limited Interop_C	Basic Capabilities Negotiation	Verify the correct exchange of Service Basic Capability informations.
AeroMACS_VO_Limited Interop_D	Admission control	Security associations and key exchange that concern only to the "air interface" as part of the MS Authentication and Authorization procedures.
AeroMACS_VO_Limited Interop_E	Registration	Verify that BS and MS successfully conclude the registration procedure

3.5.3 Airport testing

3.5.3.1 General scope

Airport tests are split between two different projects:

P 9.16 : test scenario operated by SELEX & AIRBUS, focused on the airborne segment (see. 9.16 dedicated documentation),

P 15.02.07: airport test scenario operated by THALES & DSNA, focused on ground segment.

The P15.02.07 airport test scenario will be based on 2 THALES's GS and 3 THALES's MS deployed at the Toulouse airport by DSNA.

As depicted in following picture, the 2 GS are installed on an appropriate building in the Airport. Appropriate means appropriate in terms of propagation (sufficient height to improve the coverage, reduce the masks) and installation capacities (antennas and equipment on the roof, power supply, limited impact on airport normal activities etc…).

Two MS are installed on vehicles which are moving in different airport areas at different speeds and collect measurements regarding different propagation conditions. One MS is located on a fix place.

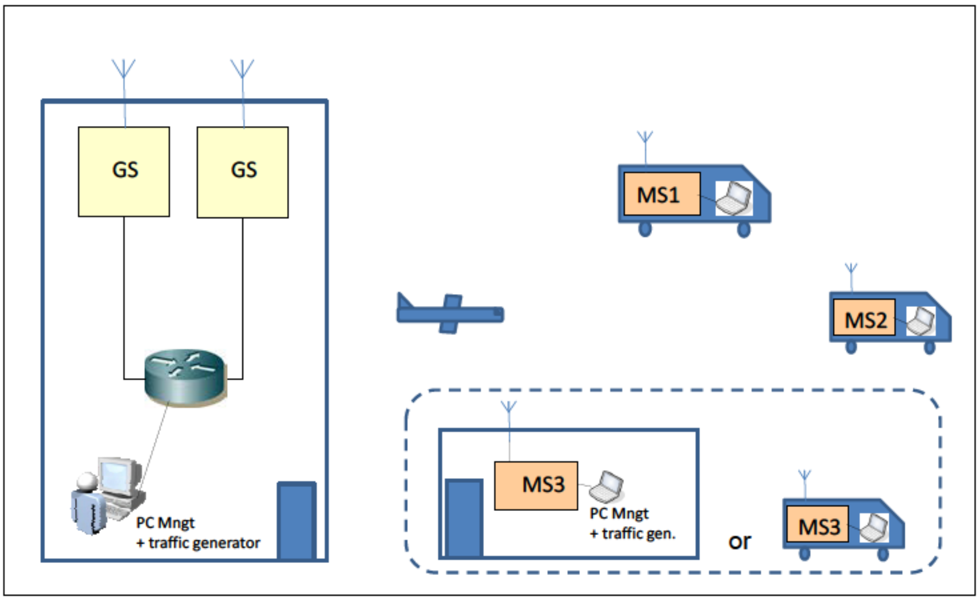


Figure 3-3 : Thales-DSNA airport ground test configuration

Following frequencies where requested for the P15.02.07. airport tests:

Channel ID	Centre Freq. (Mhz)	Thales BS 1	Thales BS 2
1	5093.5	X	
2* (temporally used)	5098.5		X
3	5103.5		X

Table 3: Airport dedicated frequencies for testing

In the picture below, the first deployment project is mentioned.

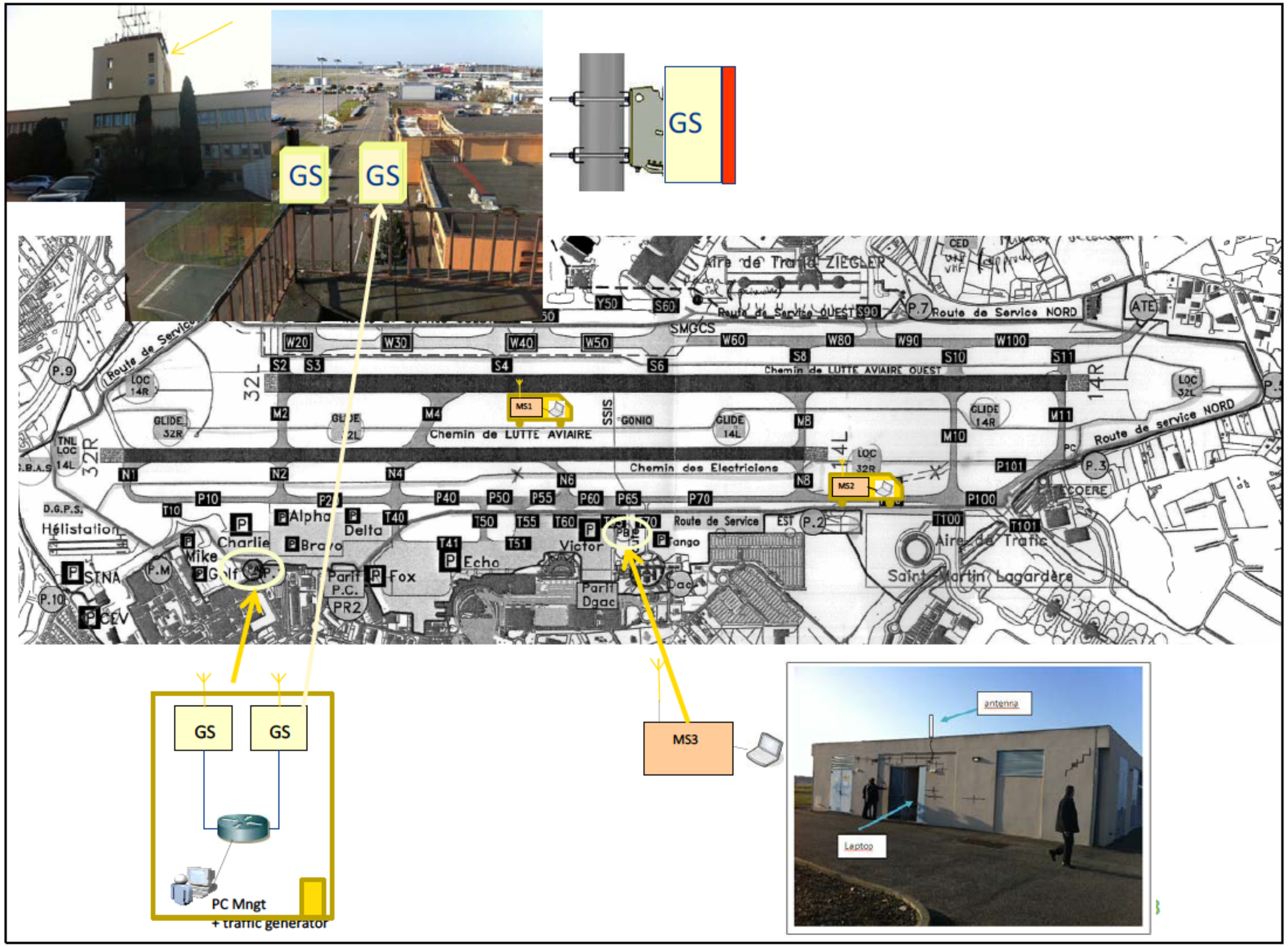


Figure 3-4 : Airport installation

3.5.3.2 GS integration and preliminary verification

The Ground Stations are installed on the former control tower represented on picture below (PA position, lat. 43.623078, long. 1.380049).

Figure 3-5: General view of the former control tower

The two BS are installed on the roof. The working position with the IT devices (PCs, PoE injectors, switch) are installed on the top room of the control power. The connection to the GS is achieved via Ethernet cables.

Figure 3-6: GS location

Each GS is oriented to make the best coverage of the airport with an optimized overlapping zone. From the GS on the roof, an Ethernet cable will come from the GS to the control tower upper room where IT devices will be installed as represented on following picture. All necessary means to accommodate the IT devices and the people are to be provisioned by DSNA (e.g. table, chairs and 230 V AC power supply).

Figure 3-7: Roof situation on the left – Working position on the right

As described in the picture below, the Thales ground station is equipped with a pole mounting kit. DSNA will provide a proper pole to install the base station on the selected location (former control tower roof).

Figure 3-8: Ground station mechanical interface

The orientation of the GS should result in following best server zone:

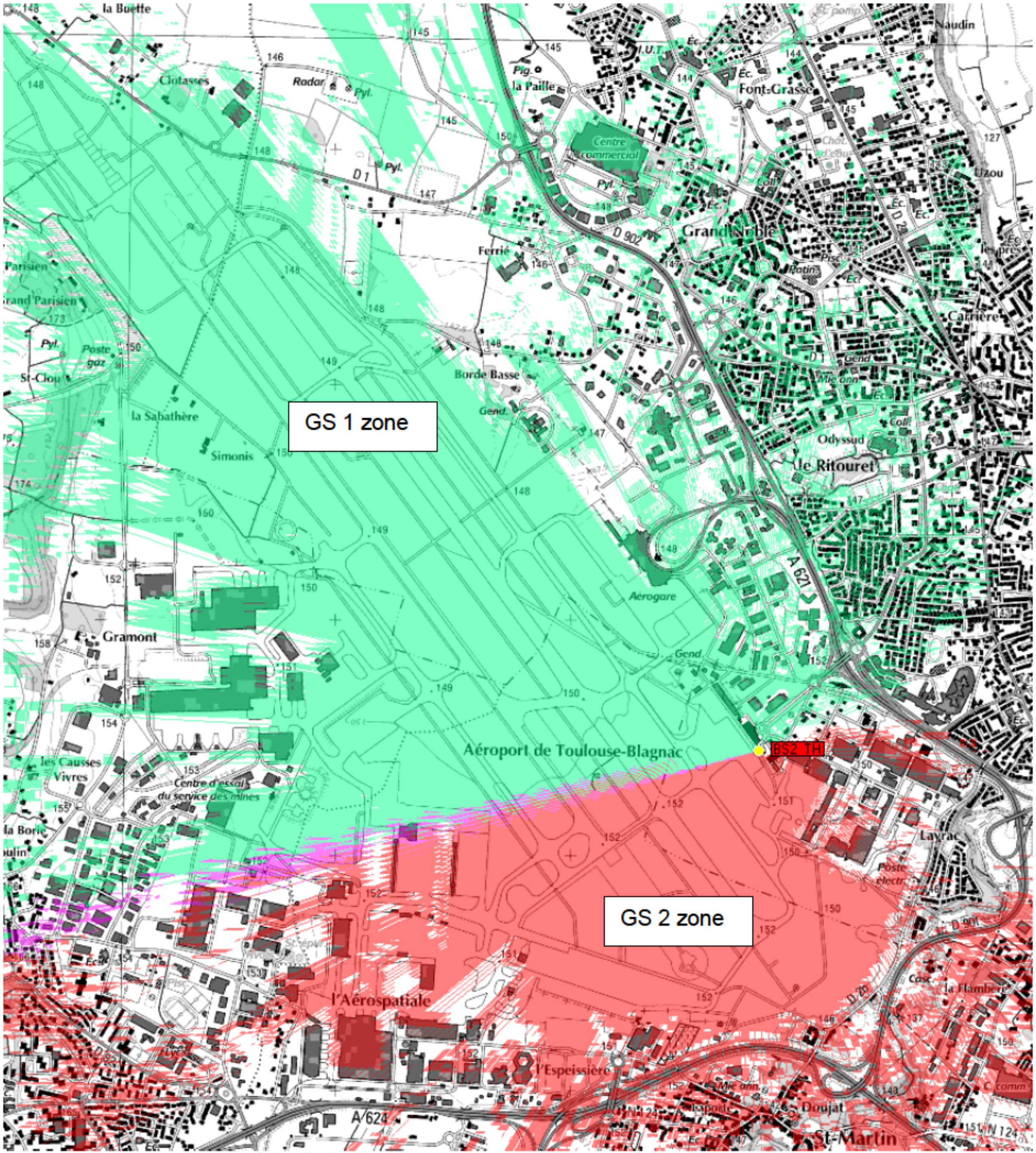


Figure 3-9: Calculated coverage of the two GS (best server zone)

The orientation of the GS should result in following overlapping zone:

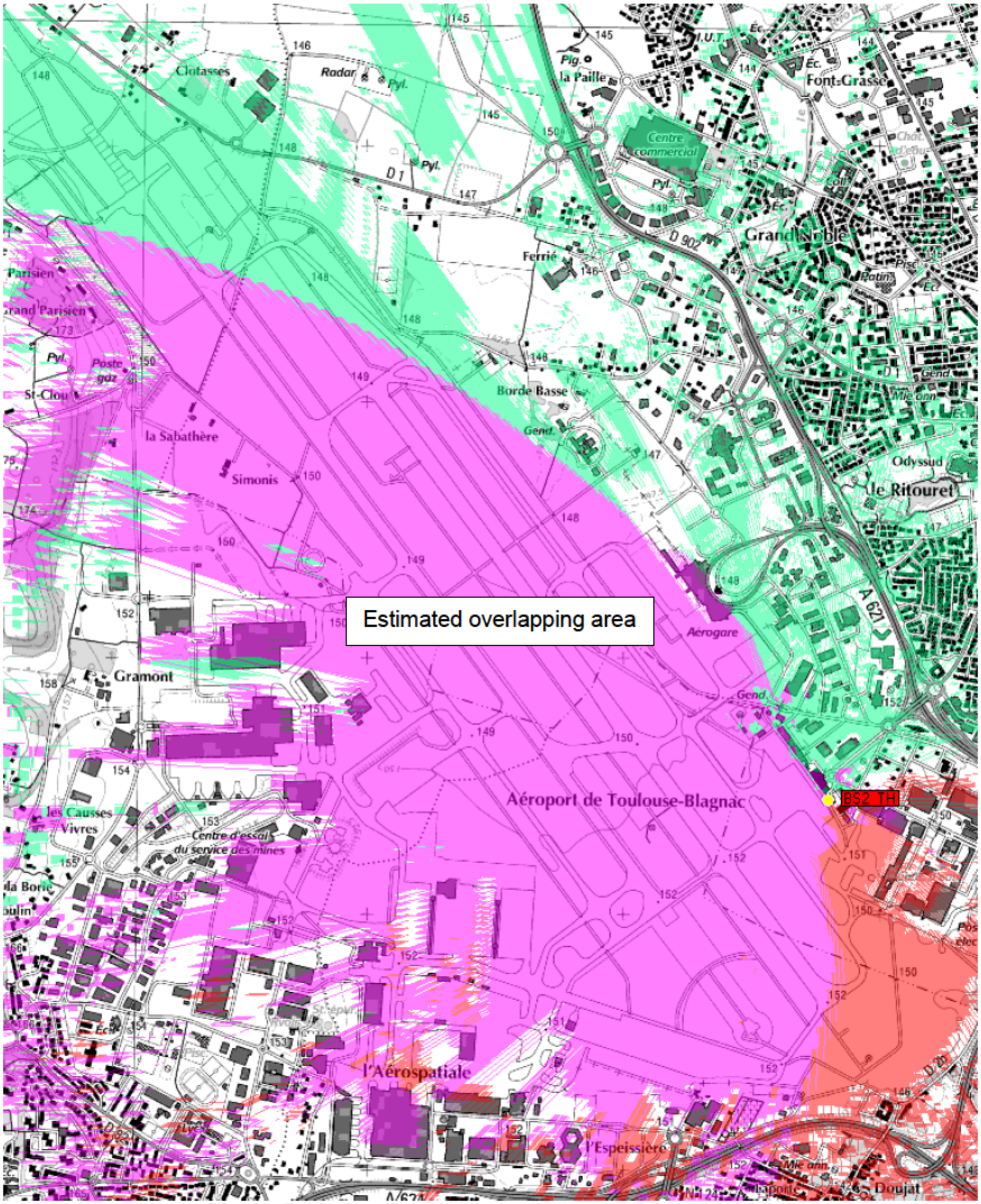


Figure 3-10: Overlapping zone between GS1 and GS2

3.5.3.3 Fix MS integration

The fixed MS is located on a DSNA building near position PB on above map.

Figure 3-11: fix MS location

The MS and the antenna are setup on the roof and an Ethernet cable is coming down to the working position as depicted in following picture.

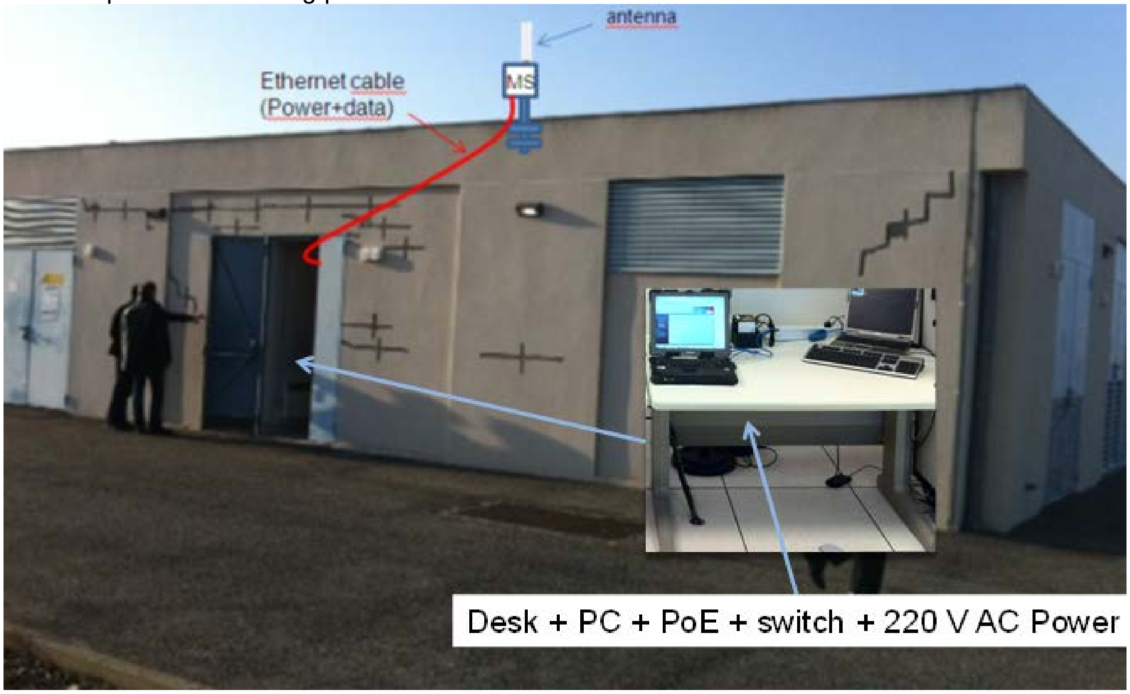


Figure 3-12: MS fix location

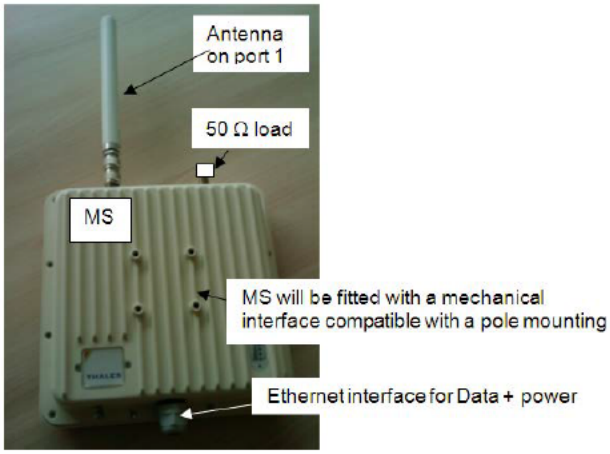


Figure 3-13: MS setup

3.5.3.4 Mobile MS integration

Two MS will also be installed in DSNA vehicles. In the picture below the setup is represented. The MS antenna is installed on the vehicle roof as well as a GPS antenna to record the vehicle position with the PC.

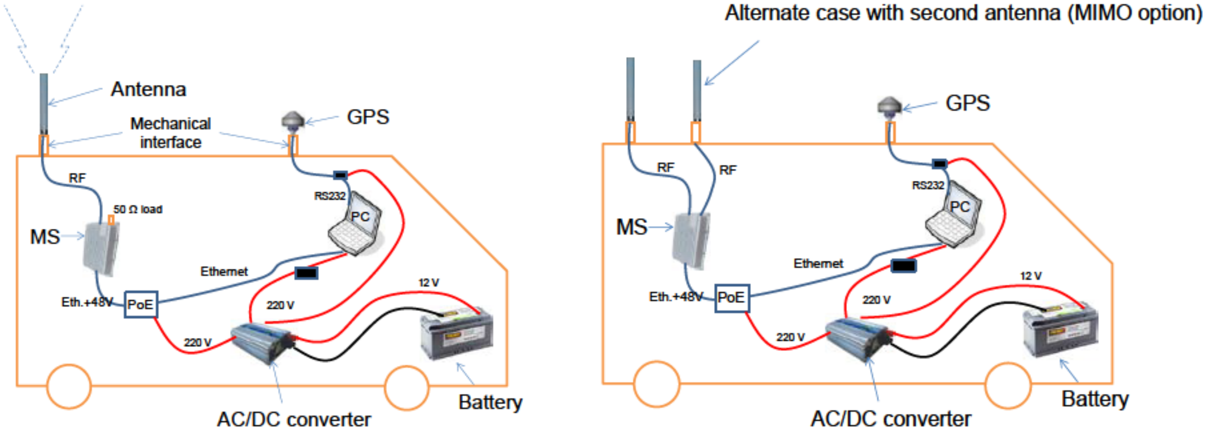


Figure 3-14: Setup of MS in the vehicles

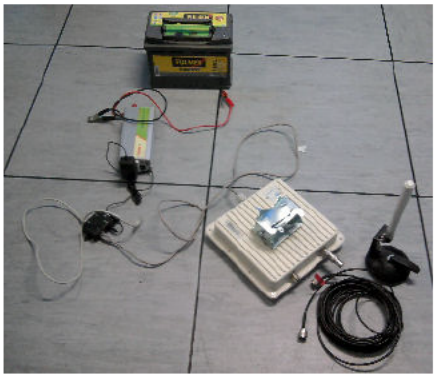


Figure 3-15: Items integrated in the vehicles

3.5.3.5 Scenarios and associated verification activities

The verification objectives (VO) devoted to the Toulouse Airport P15.02.07 test campaign are summarized in following tables. They can be found in D05.2 document [1].

General VO Id	Title	Purpose
AeroMACS_VO_Interop_02	Link adaptation	Assess the different modulation schemes and the throughput hence supported.
AeroMACS_VO_Interop_04	Quality of Service	Verify that the MS-BS interface supports nrtPS, rtPS and BE QoS classes.
AeroMACS_VO_Interop_06	MS channel quality report	Verify the Fast Feedback Channel Allocation of the BS in order to get information on the currently SNR the MS has.
AeroMACS_VO_RF_01	Cell Coverage	Verify the cell coverage
AeroMACS_VO_RF_04	Channel selectivity	Verify the receiver Adjacent and non-adjacent channel selectivity (in max speed)
AeroMACS_VO_RF_08	Transmit power requirements	Verify AeroMACS Transmit power requirements
AeroMACS_VO_RF_09	MS scanning performance	Verify that MS can perform the frequency and channel scanning within the required durations.
AeroMACS_VO_RF_10	MS ranging performance	Verify the successful completion of the ranging process
AeroMACS_VO_RFReal_02	Real deployment	Characterize the coverage (signal strength) in real testing environment.
AeroMACS_VO_RFReal_03	Modulations performances	Characterize the performances of the AeroMACS modulations in real

		environment (uplink and downlink data latency, round-trip time, real throughput available, jitter…).
AeroMACS_VO_RFReal_04	NLOS performances	Evaluate the impacts of obstructions (such as buildings…) on the coverage.
AeroMACS_VO_RFReal_07	Multi-channel utilization	Validate the possibility to communicate simultaneously on several channels without interference or impact on performances from one channel to the other (Alternate and adjacent Channel)
AeroMACS_VO_RFReal_08	Mobility performances	Evaluate the impact of mobility on the communications.

Table 4: VO summary

The scenarios are built regarding the different categories of objective:

- Cell coverage / MS channel quality report:
    - Objective: verify the maximum distance in the airport where the datalink is synchronized and get information on the SNR of the MS and on the received level with spectrum analyzer.
    - Means: one mobile MS and one BS are used at a time, two people from Thales and one from DSNA (qualified driver), one spectrum analyzer in the car
    - Method: The vehicle is driven to different points on the Airport where it is stopped to perform the measurements.
        - The “route de service’ in green in following picture is used in order to cover the whole airport (e.g.: near points T50, P3, P5, ATE, P7, S50, S30, P9) while maintaining LOS conditions
        - Measured at each point: Vehicle position through GPS, radio statistics (RSSI, CINR, modulation...) through interrogation of the MS and GS, and data transmission performances (max throughput, jitter and delay) via iPerf and Ping.
- Modulation performances / Link adaptation:
    - Objective: assess the different modulation schemes and the throughput hence supported, characterize the performances of the modulations in real environment
    - Means: one mobile MS and one BS are used at a time, two people from Thales and one from DSNA (qualified driver)
    - Method: The vehicle is driven to a point on the Airport where it is stopped to perform the measurement.
        - The “route de service’ is used, the stop point is selected with a good coverage so as to be able to test all the modulation and coding schemes.
        - Measured at each point: Vehicle position through GPS, radio statistics (RSSI, CINR, modulation...) through interrogation of the MS and GS, and data transmission performances (max throughput, jitter and delay) via iPerf and Ping.

- Real deployment / NLOS performances
  - Objective: Evaluate the impact of buildings, hangars on the strength of the signal
  - Means: one mobile MS and one BS are used at a time, two people from Thales and one from DSNA (qualified driver)
  - Method: Method is similar to the one described for cell coverage, but in this case stop points are spots where communications are established in near-LOS or Non-LOS conditions. As far as possible (depending on authorization), the different kind of zones of the Airport are visited: ramp Area, parking Area, Tower Area, Access roads to air navigation installations for maintenance operations (note: Taxiway used during the mobility tests).
- Mobility performances / Channel selectivity:
  - Objective: Evaluate the impact of mobility on the data communications and channel selectivity.
  - Means: one mobile MS and one BS are used at a time, two people from Thales and one from DSNA (qualified driver). Then one MS and two BS at max speed to check selectivity.
  - Method:
    - 0 km/h: first general performance before mobility is recorded.
    - At 50 km/h: uses of taxiway or runway (depending upon authorization), parameters are recorded while driving at a constant speed of 50 km/h, MS being preliminary registered to the servicing BS.
    - At 90 km/h: use of runway or taxiway (depending upon authorization and vehicle capacity)
- Multi-channel utilization:
  - Objective: Evaluate the impact of two BS with overlapping coverage and using alternate or adjacent channels.
  - Means: one to three MS and two BS are used at a time, two to three people from Thales and two from DSNA (qualified drivers)
  - Method: The vehicle is driven on different points in the overlapped area (“route of service” is used).
    - The 2 GS channels are either separated from 5 MHz (adjacent channels) or 10 MHz (alternate channels), MS is registered to the GS offering the best signal strength at the point.
    - Measured at each point: Vehicle position through GPS, radio statistics (RSSI, CINR, modulation...) through interrogation of the MS and GS, and data transmission performances (max throughput, jitter, delay) via iPerf and Ping
- Quality of service:
  - Objective: Verify that the MS-BS interface supports nrtPS, rtPS and BE QoS classes.

  - Means: one MS (fix location) and one GS, two people from Thales
  - Method: The different SF are programmed on the GS and allocated to the MS. Through iPerf, communications are generated between GS and MS with controlled data rates. Then it is verified that data traffic exceeding the Maximum Sustained Traffic Rate QoS value related to a SF is dropped or delayed.

- Transmit power requirements:
  - Objective: Verify AeroMACS Transmit power requirements
  - Means: one MS (fix location) and one GS, two people from Thales, one spectrum analyser with additional antenna.
  - Method: through iPerf, communications are generated between GS and MS. The mean EIRP is measured during the transmission via the spectrum analyser.

- MS scanning and ranging performance:
  - Objective: Verify that MS can perform the frequency and channel scanning within the required durations and successful completion of the ranging process
  - Means: one MS (fix location) and one GS, two people from Thales.
  - Method: through iPerf, communications are generated between GS and MS. A list of frequencies is programmed on the MS between 5091 and 5150 MHz and the connection time is measured and connection processed including ranging is observed:
    - One frequency is programmed 5093,5 MHz
    - Two frequencies are programmed: 5093,5 MHz & 5103.5 MHz
    - A scan band with frequency step of 250 kHz: 5093,5 – 5147,5 MHz / step 250 kHz.

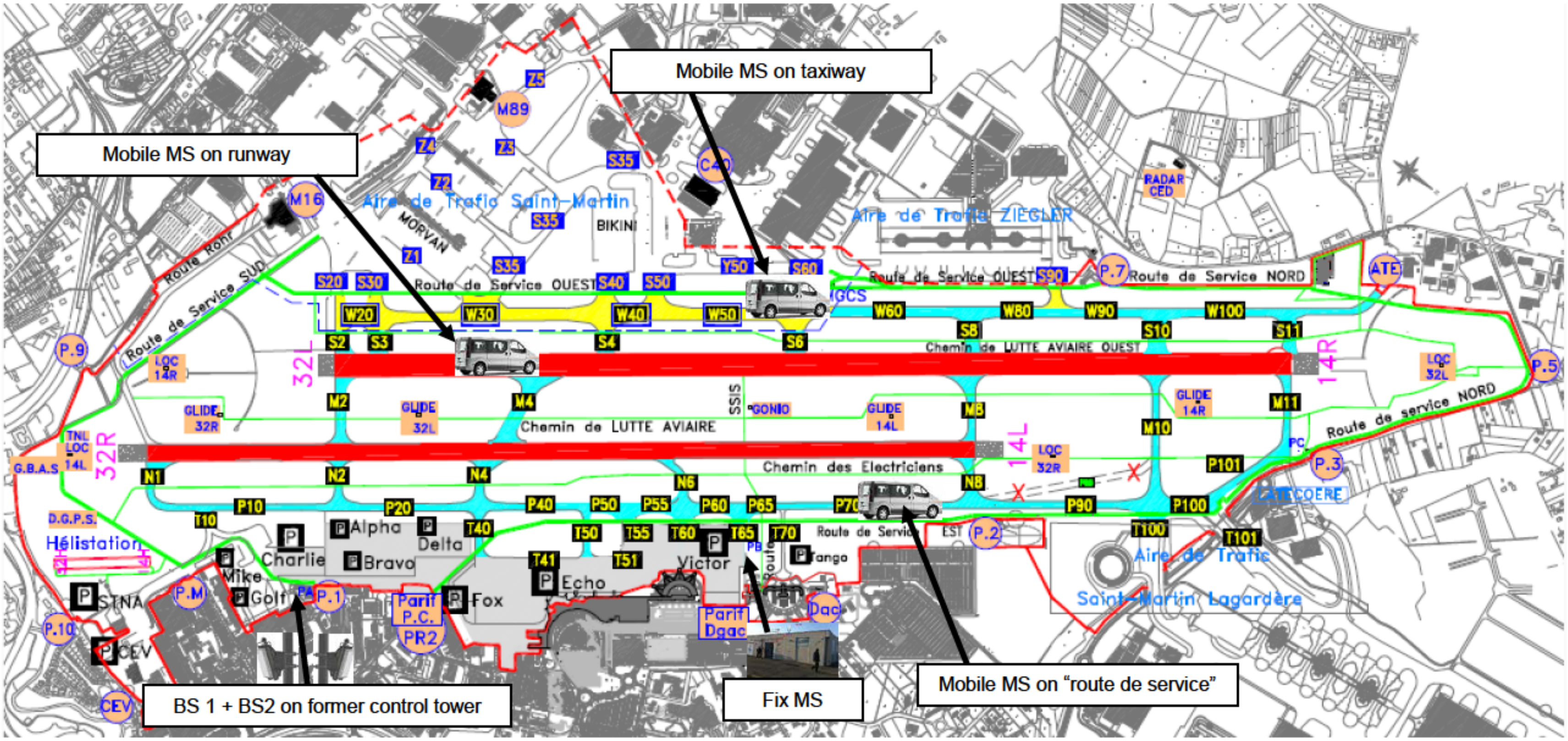


Figure 3-16: Test location in Toulouse Airport

🟩 Route de service (P5 is the farthest point), used for cell coverage

🟥 Runways (32L – 14R and 32R – 14L), used for mobility at 90 km/h

🟨🟦 Whisky Taxiway (W20 – W100), used for mobility up to 50 km/h

3.6 Acceptance criteria

The 15.02.07 project is a technological project where the verification approach consists in assessing and collecting evidences on the performances of the proposed AeroMACS technology against the on-going standardization.

In terms of acceptance, for each test case, a paragraph (cf. § 7.x.y.3) called “verification exercise results” analyses if the tests results are in compliance with the AeroMACS standardization (cf. § 7.x.y.3.2). Any unexpected behaviour is mentioned and its impact is further assessed (cf. § 7.x.y.3.3). Finally, based on the test results, recommendations are drawn (cf. § 7.x.y.4).

Chapter 5 summarizes and draws the whole picture about the tests results (whether each Verification test achieves the corresponding verification objective expectations or not) while chapter 6 summarizes the recommendations.

Based on these test results, an availability note will be issued by each vendor to state if tested devices are ready for system/platform integration.

4 Verification Activities

4.1 Verification Exercises List

The phase 2 verification exercises (test cases) are derived in Section 7 from the Verification Objectives' list defined in D05.2 [1].

Each company (SELEX or THALES) describes the test cases related to the verification objectives it owns. Tests cases are described depending on the tests means involved and can covers several verification objectives. They describe into details the various tests to be executed in each company test environments. Each test case will contain one test objective, a brief description, a reference to the test bench used (as identified in 3.5.2 for lab tests and in 3.5.3 for Airport tests), and the detailed test procedure.

4.1.1 Thales lab and airport test cases identification

This Chapter contains the summary of laboratory test cases to be done by THALES in phase 2. All defined lab test cases have been reported in the following table and are detailed in Section 7. For each test case all the VO's addressed by that particular test are shown in the table. The complete list of VOs is reported in D05.2 document (ref. [1]).

The test case number is identified TLAB2_XXX or TAIR_XXX, where:

- TLAB2: means Thales LABoratory test – phase 2
- TAIR: means Thales AIRport test
- XXX: is the test identification number

Test Case nr.	Test Case Name	Lab. Environment	VO's addressed
TLAB2_010	Service flows control	Lab_test_bed_01	AeroMACS_VO_Interop_05 B/C
TLAB2_020	channel selectivity and transmit power measurements	Lab_test_bed_01	AeroMACS_VO_RF_04 B/C AeroMACS_VO_RF_05 A/B AeroMACS_VO_RF_08 E
TLAB2_030	MS channel quality report and MS transmit synchronisation	Lab_test_bed_01	AeroMACS_VO_Interop_06 A/B AeroMACS_VO_RF_11 A
TLAB2_040	IOT test between Thales GS and Selex MS	Lab_test_bed_01 with Selex MS	AeroMACS_VO_Limited Interop A/B/C/D/E

Table 5: identification of Phase 2 Thales lab test cases

Test Case nr.	Test Case Name	Environment	VO's addressed
TAIR_010	Installation fix and vehicle, and main performances verification on the field (modulations, data rate, QOS, MS channel quality report, transmit power, MS scanning & ranging performances)	Toulouse 2 BS + 1 MS fix 2 BS + 1 MS car 2 Thales ING DSNA for installation 1 DSNA driver 1 spectrum analyzer	AeroMACS_VO_Interop_02 C AeroMACS_VO_Interop_04 B AeroMACS_VO_Interop_06 C/D AeroMACS_VO_RF_08 B AeroMACS_VO_RF_09 A/B/C AeroMACS_VO_RF_10 A
TAIR_020	Cell coverage in LOS, Modulation performances, link adaptation and MS channel quality reporting	Toulouse 1 BS + 1 MS car 2nd BS + 1 MS car 1 spectrum analyzer 2 Thales ING 1 DSNA driver	AeroMACS_VO_RF_01 A/D AeroMACS_VO_Interop_06 C/D AeroMACS_VO_Interop_02 C/D/E AeroMACS_VO_RFReal_02 A/B/C/D AeroMACS_VO_RFReal_03 A/B/C/D/E/F/G/H/I
TAIR_030	Real deployment and NLOS performances	Toulouse 1 BS + 1 MS car 2 Thales ING 1 DSNA driver 1 spectrum analyzer	AeroMACS_VO_RFReal_04 B AeroMACS_VO_RFReal_02 A/B/C/D
TAIR_040	Mobility tests	Toulouse 1 BS + 1 MS car 2 Thales ING 1 DSNA driver 1 spectrum analyzer	AeroMACS_VO_RFReal_08 B AeroMACS_VO_RF_04 D
TAIR_050	Multi-channel tests	Toulouse 1 BS+ 2 MS car + 1fixed MS 2 Thales ING 2 DSNA drivers 1 spectrum analyzer	AeroMACS_VO_RFReal_07 A/B/C/D

Table 6: Identification of Thales/DSNA Toulouse airport test cases

4.1.2 Selex lab test cases identification

This Chapter contains the summary of laboratory test cases to be done by SELEX in phase 2. All defined lab test cases have been reported in the following table and are detailed in Section 7. For each Test Case all the VO's addressed by that particular test are shown in the table. The complete list of VOs is reported in D05.2 document (ref. [1]).

Lab Test Case nr.	**Test Case Name**	**Lab. Environment**	**VO's addressed**
P2_LAB1_1	Connection Re-establishment	Lab_test_bed_02	AeroMACS_VO_Interop_03_B
P2_LAB1_2	Power Control	Lab_test_bed_02	AeroMACS_VO_Interop_06_A/B AeroMACS_VO_Interop_10_C/D
P2_LAB1_3	Quality of Service	Lab_test_bed_02	AeroMACS_VO_Interop_07_B/C
P2_LAB1_4	Security	Lab_test_bed_02	AeroMACS_VO_Interop_11_C/D/F
P2_LAB1_5	Radio Performance	Lab_test_bed_02	AeroMACS_VO_RF_04_A AeroMACS_VO_RFReal_01_B
P2_LAB_6	IOT between Selex Ground System and Thales MS	Lab_test_bed_02	AeroMACS_VO_Limited Interop A/B/C/D/E

Table 7: identification of Phase 2 Selex lab test cases

4.2 Verification activities master schedule

The steps of the verification plan are summarized on the diagram below.

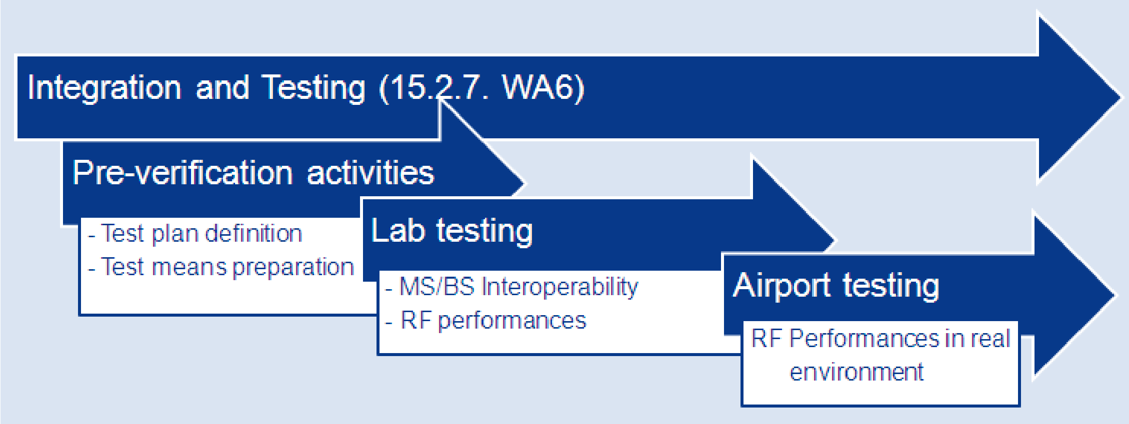
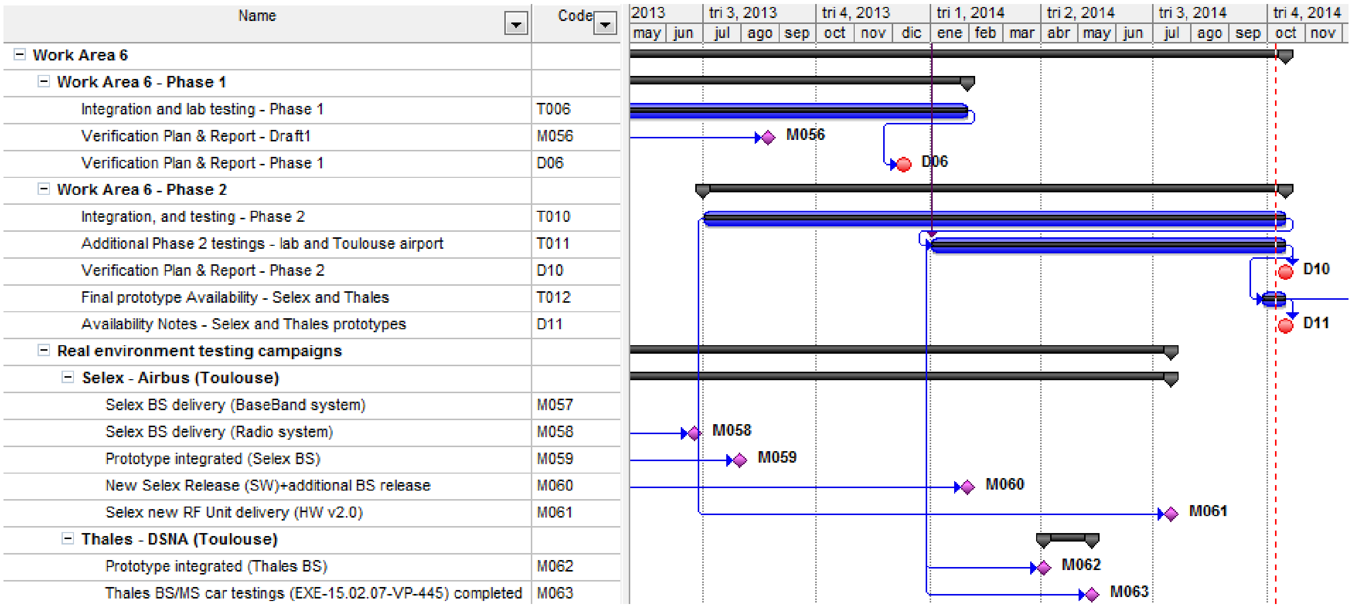


Figure 4-1 : 15.02.07 Verification Activities

The latest Integration and Testing phase 2 schedule is given in following picture:



Name	Code
Work Area 6	
Work Area 6 - Phase 1	
Integration and lab testing - Phase 1	T006
Verification Plan & Report - Draft1	M056
Verification Plan & Report - Phase 1	D06
Work Area 6 - Phase 2	
Integration, and testing - Phase 2	T010
Additional Phase 2 testings - lab and Toulouse airport	T011
Verification Plan & Report - Phase 2	D10
Final prototype Availability - Selex and Thales	T012
Availability Notes - Selex and Thales prototypes	D11
Real environment testing campaigns	
Selex - Airbus (Toulouse)	
Selex BS delivery (BaseBand system)	M057
Selex BS delivery (Radio system)	M058
Prototype integrated (Selex BS)	M059
New Selex Release (SW)+additional BS release	M060
Selex new RF Unit delivery (HW v2.0)	M061
Thales - DSNA (Toulouse)	
Prototype integrated (Thales BS)	M062
Thales BS/MS car testings (EXE-15.02.07-VP-445) completed	M063

Figure 4-2 : Integration and Testing Phase 2 schedule

5 Verification Exercises Results

5.1 Summary of Verification Exercises Results

The results of the different Verification test cases analysed in Section 7 are summarized in following tables:

- OK: Verification test achieves the verification objective expectations
- NOK (Non OK): Verification test does not achieve the verification objective expectations
- POK (Partially OK): Verification test achieves partially the verification objective expectations
- NT (Not Tested): Verification test not performed.

Test Case nr.	Test Case Name	VO's addressed	Result
TLAB2_010	Service flows control	AeroMACS_VO_Interop_05 B/C	OK
TLAB2_020	channel selectivity and transmit power measurements	AeroMACS_VO_RF_04 B/C AeroMACS_VO_RF_05 A/B AeroMACS_VO_RF_08 E	OK
TLAB2_030	MS channel quality report and MS transmit synchronisation	AeroMACS_VO_Interop_06 A/B AeroMACS_VO_RF_11 A	OK
TLAB2_040	IOT between Thales GS and Selex MS	AeroMACS_VO_Limited_ Interop A/B/C/D/E	pOK

Table 8: Summary of Thales lab tests results for phase 2

Lab Test Case nr.	Test Case Name	VO's addressed	Result
P2_LAB1_1	Connection Re-establishment	AeroMACS_VO_Interop_03_ B	OK
P2_LAB1_2	Power Control	AeroMACS_VO_Interop_06_A/B AeroMACS_VO_Interop_10_ C/D	OK
P2_LAB1_3	Quality of Service	AeroMACS_VO_Interop_07_ B/C	OK
P2_LAB1_4	Security	AeroMACS_VO_Interop_11_C/D/F	OK
P2_LAB1_5	Radio Performance	AeroMACS_VO_RF_04_A AeroMACS_VO_RFReal_01_B	OK
P2_LAB_6	IOT between Selex Ground System and Thales MS	AeroMACS_VO_Limited Interop A/B/C/D/E	pOK

Table 9: Summary of Selex Lab. tests results for phase 2

Test Case nr.	Test Case Name	VO's addressed	Result
TAIR_010	Installation and main performances verification (modulations, data rate, QOS, MS channel quality report, transmit power, MS scanning & ranging performances)	AeroMACS_VO_Interop_02 C AeroMACS_VO_Interop_04 B AeroMACS_VO_Interop_06 C/D AeroMACS_VO_RF_08 B AeroMACS_VO_RF_09 A/B/C AeroMACS_VO_RF_10 A	OK
TAIR_020	Cell coverage in LOS, Modulation performances, link adaptation, and MS channel quality reporting	AeroMACS_VO_RF_01 A/D AeroMACS_VO_Interop_06 C/D AeroMACS_VO_Interop_02 C/D/E AeroMACS_VO_RFReal_03 A/B/C/D/E/F/G/H/I AeroMACS_VO_RFReal_02 A/B/C/D	OK
TAIR_030	Real deployment and NLOS performances	AeroMACS_VO_RFReal_04 B AeroMACS_VO_RFReal_02 A/B/C/D	OK
TAIR_050	Mobility tests	AeroMACS_VO_RFReal_08 B AeroMACS_VO_RF_04 D	OK
TAIR_060	Multi-channel tests	AeroMACS_VO_RFReal_07 A/B/C/D	OK

Table 10: Summary of Thales/DSNA Airport tests results

5.2 Analysis of Verification Exercises Results

The detailed analysis of the verification Exercises can be found in each verification exercise report in Section 7.

Indeed, each verification exercise has a dedicated paragraph: "7.x.y.3.2 Analysis of Verification Exercise Results".

Each test case was performed successfully regarding the related verification objectives except IOT between vendors' devices[1]:

- TLAB2_040: IOT between Thales BS and Selex MS performed on THALES Lab_test_bed_01 was only partially successful. Only Scanning was completed successfully, with proper identification of the BS Preamble by MS side. Synchronization was not successfully completed, as the Selex MS indicated a FCH decoding failed. The reasons of this interoperability issue should be investigated in a further IOT activity beyond P15.02.07.
- P2_LAB_6: IOT between Selex BS and Thales MS performed on SELEX ES Lab_test_bed_02 was partially successful: authentication was not successful finalizing with an Authentication Failure. Further investigation beyond P15.02.07 is recommended in the security field.

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[1] Section 7.1.6 and 7.2.4 include the verification report of the above IOT tests. Appendix A includes a summary of the IOT tests, that was provided to the SJU as a separate document, and is included in this appendix.

6 Conclusions and recommendations

The main objective of the integration & testing work area of P15.02.07 is to assess the performances of AeroMACS prototypes.

The phase 1 lab measurements (see ref. [3]) gave a good characterization of the prototypes with positive test results. This gave a good confidence before the field testing.

The phase 2 testing, the results of which are reported in the present document, allowed gathering additional measurements in lab and real environment of the Airport surface datalink and thus complement significantly the assessment of the AeroMACS technology in ground segment context with some important information as cell coverage, LOS / nLOS / NLOS propagation behaviour, mobility effect....

Interoperability between Thales and Selex ES prototypes was tested in both senses (Selex Mobile Station versus Thales Ground System and vice versa), but, despite numerous efforts from P15.02.07 teams, it has not been completely achieved. The details of the Interoperability tests performed are provided in 7.1.6 and 7.2.4. The test campaigns executed suggest further investigations being required in the field of Interoperability, and also confirm the need to identify unambiguously the WiMAX network protocols and messages formatting involved in the Authentication/Encryption process.

Planning ad-hoc activities with the purpose to complete IOT and to cover the network and security (e.g certificates) layers in the near future (SESAR2020/VLD could be suitable opportunities) in coordination with the relevant standardization authorities is thus recommended.

As a conclusion, both lab and Airport testing allowed collecting positive evidences on the suitability of the prototypes to assess the AeroMACS technology regarding the on-going standardization, to prefigure future realizations, and representative airport deployments, which are highly recommended to complete P15.02.07 achievements at the upper layer, namely network layer.

7 Verification Exercises Reports

7.1 Selex lab verification exercises

7.1.1 Verification Exercise # P2_LAB1_1 Connection Re-Establishment

7.1.1.1 Verification Exercise Scope

The purpose of this Test Case is verifying that the MS after a signal loss (in Network Re-entry) is able to re-establish the DL Synchronization.

7.1.1.2 Conduct of Verification Exercise

7.1.1.2.1 Verification Exercise Preparation

The test bed described in Figure 3-2 was arranged.

Equipment:

ASN-GW is an Aricent Wing ASN-GW.

MS, BS and ASN-GW were linked together according to test bed configuration with proper attenuation and switched on.

Fading Simulator and Data Traffic Generators shown in Figure 3-2 were not used in this test.

7.1.1.2.2 Verification Exercise execution

Step nr.	Action	Action description (if needed)	PCO (Point of Control and Observation)	Result
1.	Switch on MS			OK
2.	Verify that MS begins scanning for BS		Mngt PC connected to MS	OK
3.	Switch on BS			OK
4.	Configure BS to one channel (e.g. 5091 MHz)			OK
5	Reboot BS			OK
6.	Verify that MS connects successfully		Mngt PCs connected to MS and BS	OK

7.	Increase attenuation until the MS loses the connection with BS		Variable attenuator and Mngt PCs connected to MS and BS	OK
8.	Verify that the MS is able to re-establish the DL Synchronization.		Mngt PCs connected to MS and BS	OK

7.1.1.2.3 Deviation from the planned activities

None.

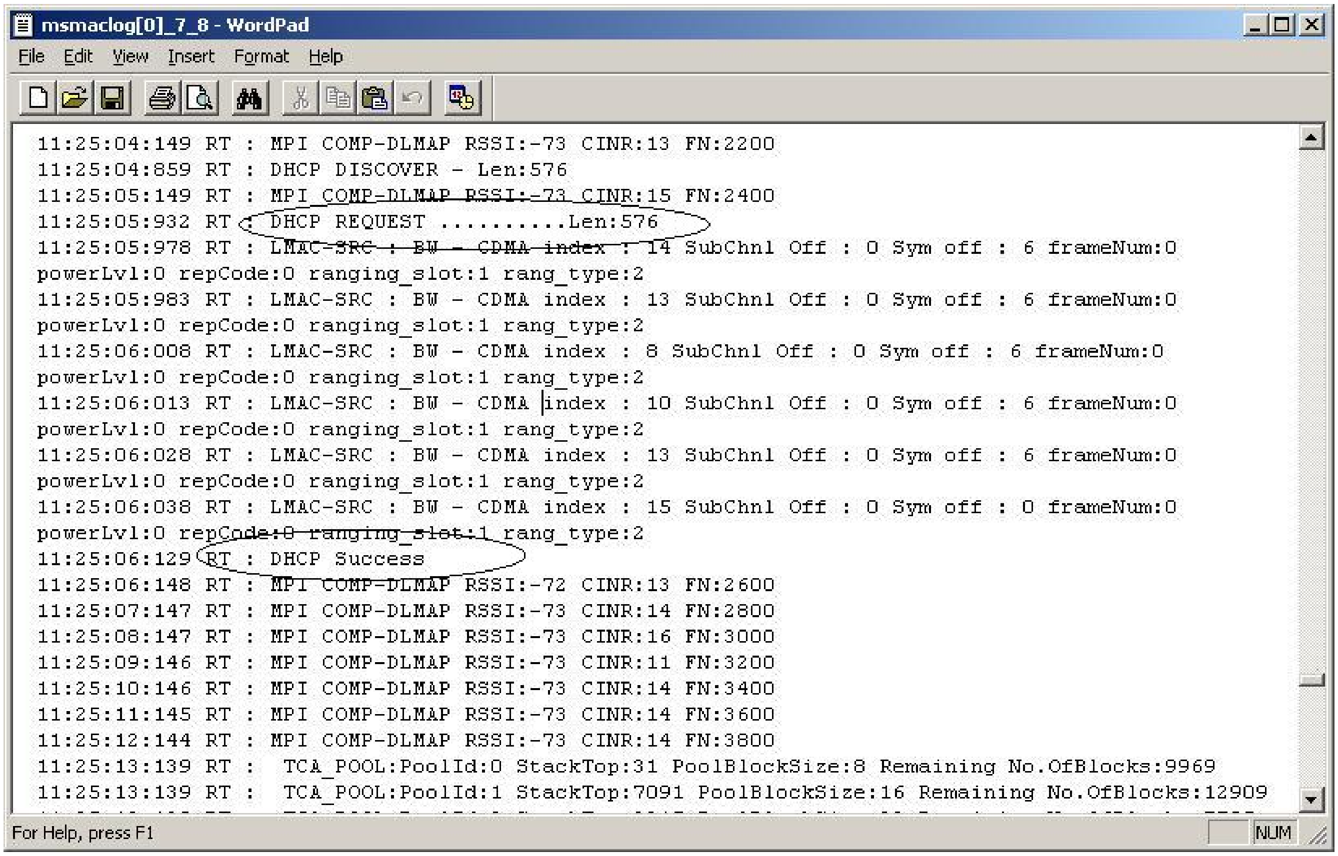
7.1.1.3 Verification exercise Results

7.1.1.3.1 Summary of Verification exercise Results

ID	Result	Description	When observed?	Expected result	Obtained result	VO
1	Resynchronization	Verify that the MS after a signal loss (in Network Re-entry) is able to re-establish the DL Synchronization.	Step 8	Resynchronization	OK	AeroMACS_VO_Interop_03_B

7.1.1.3.2 Analysis of Verification Exercise Results

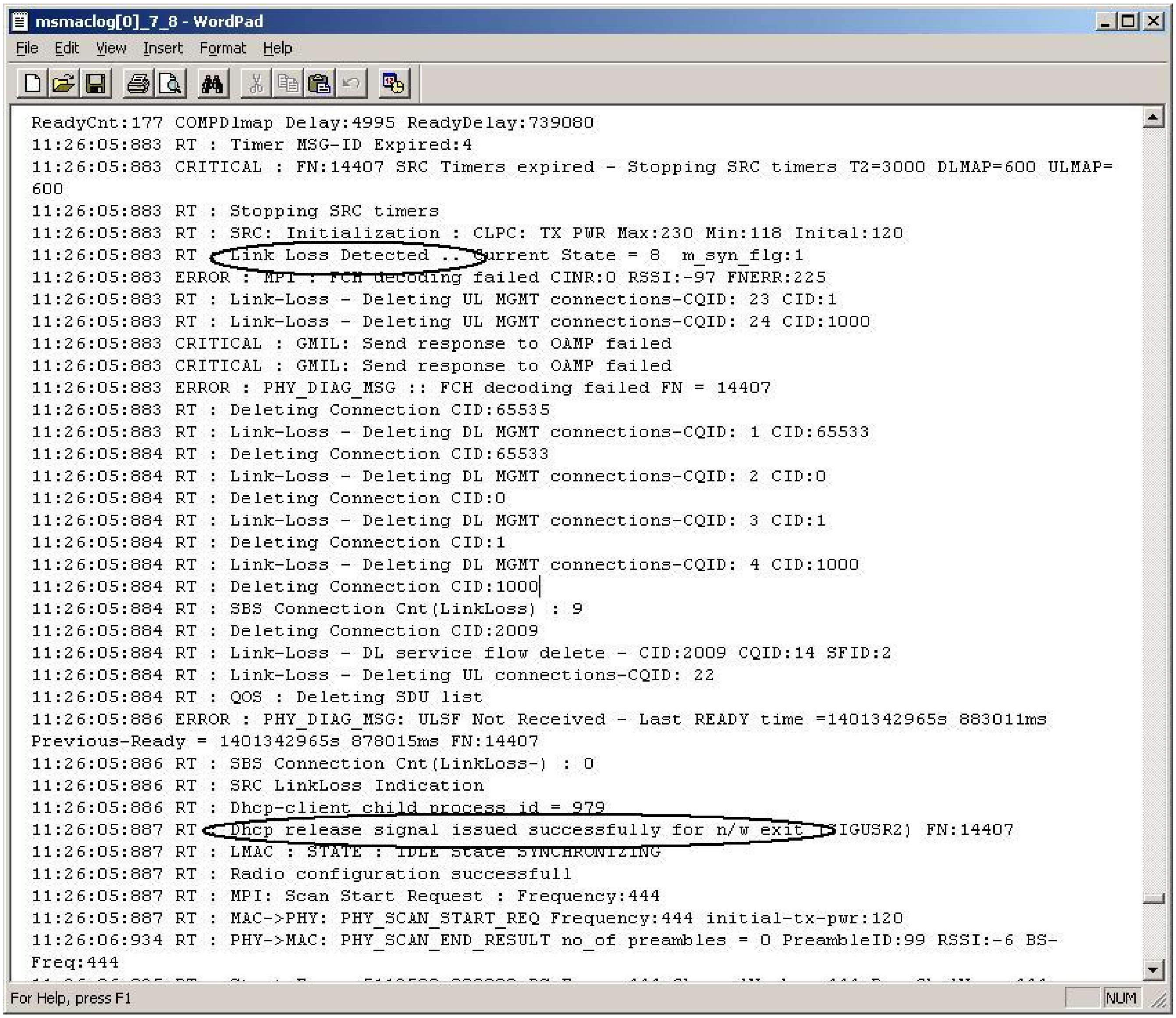
As a test preamble, the various phases of the normal Initial Network Entry was executed by BS and MS (test step no. 6). Figure 7-1 shows the last step (MS DHCP Registration),



```
11:25:04:149 RT : MPI COMP-DLMAP RSSI:-73 CINR:13 FN:2200
11:25:04:859 RT : DHCP DISCOVER - Len:576
11:25:05:149 RT : MPI COMP-DLMAP RSSI:-73 CINR:15 FN:2400
11:25:05:932 RT : DHCP REQUEST ..........Len:576
11:25:05:978 RT : LMAC-SRC : BW - CDMA index : 14 SubChnl Off : 0 Sym off : 6 frameNum:0
powerLvl:0 repCode:0 ranging_slot:1 rang_type:2
11:25:05:983 RT : LMAC-SRC : BW - CDMA index : 13 SubChnl Off : 0 Sym off : 6 frameNum:0
powerLvl:0 repCode:0 ranging_slot:1 rang_type:2
11:25:06:008 RT : LMAC-SRC : BW - CDMA index : 8 SubChnl Off : 0 Sym off : 6 frameNum:0
powerLvl:0 repCode:0 ranging_slot:1 rang_type:2
11:25:06:013 RT : LMAC-SRC : BW - CDMA index : 10 SubChnl Off : 0 Sym off : 6 frameNum:0
powerLvl:0 repCode:0 ranging_slot:1 rang_type:2
11:25:06:028 RT : LMAC-SRC : BW - CDMA index : 13 SubChnl Off : 0 Sym off : 6 frameNum:0
powerLvl:0 repCode:0 ranging_slot:1 rang_type:2
11:25:06:038 RT : LMAC-SRC : BW - CDMA index : 15 SubChnl Off : 0 Sym off : 0 frameNum:0
powerLvl:0 repCode:0 ranging_slot:1 rang_type:2
11:25:06:129 RT : DHCP Success
11:25:06:148 RT : MPI COMP-DLMAP RSSI:-72 CINR:13 FN:2600
11:25:07:147 RT : MPI COMP-DLMAP RSSI:-73 CINR:14 FN:2800
11:25:08:147 RT : MPI COMP-DLMAP RSSI:-73 CINR:16 FN:3000
11:25:09:146 RT : MPI COMP-DLMAP RSSI:-73 CINR:11 FN:3200
11:25:10:146 RT : MPI COMP-DLMAP RSSI:-73 CINR:14 FN:3400
11:25:11:145 RT : MPI COMP-DLMAP RSSI:-73 CINR:14 FN:3600
11:25:12:144 RT : MPI COMP-DLMAP RSSI:-73 CINR:14 FN:3800
11:25:13:139 RT :  TCA_POOL:PoolId:0 StackTop:31 PoolBlockSize:8 Remaining No.OfBlocks:9969
11:25:13:139 RT :  TCA_POOL:PoolId:1 StackTop:7091 PoolBlockSize:16 Remaining No.OfBlocks:12909
```

Figure 7-1: MS Log - Initial Net Entry: MS Registration

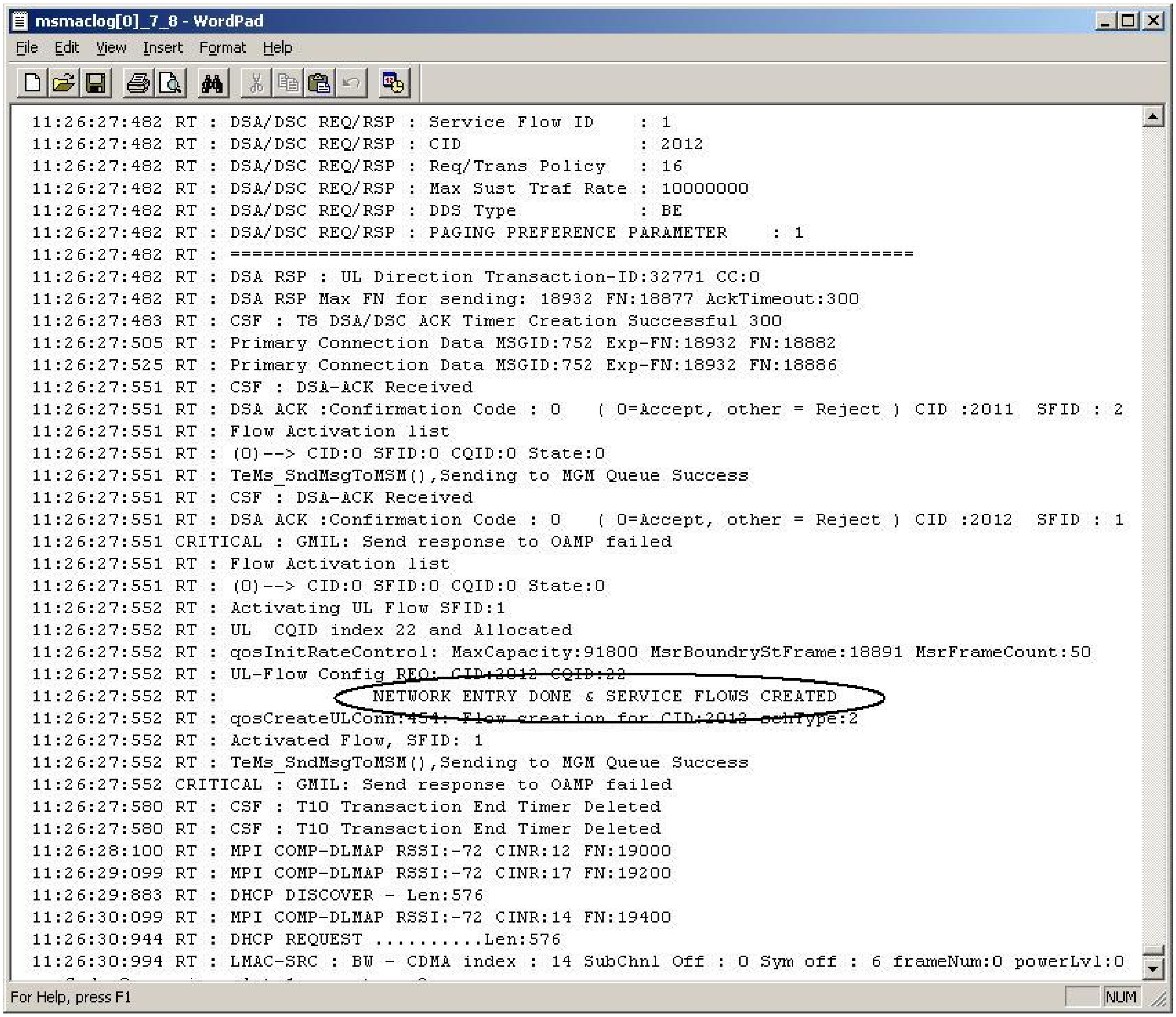
After the address assignment to the MS, the attenuation between MS and BS was gradually increased; this caused a Link Loss, with a subsequent Network Exit by the MS side (see Figure 7-2).



```
ReadyCnt:177 COMPDlmap Delay:4995 ReadyDelay:739080
11:26:05:883 RT : Timer MSG-ID Expired:4
11:26:05:883 CRITICAL : FN:14407 SRC Timers expired - Stopping SRC timers T2=3000 DLMAP=600 ULMAP=
600
11:26:05:883 RT : Stopping SRC timers
11:26:05:883 RT : SRC: Initialization : CLPC: TX PWR Max:230 Min:118 Inital:120
11:26:05:883 RT : Link Loss Detected .. Current State = 8  m_syn_flg:1
11:26:05:883 ERROR : MPI : FCH decoding failed CINR:0 RSSI:-97 FNERR:225
11:26:05:883 RT : Link-Loss - Deleting UL MGMT connections-CQID: 23 CID:1
11:26:05:883 RT : Link-Loss - Deleting UL MGMT connections-CQID: 24 CID:1000
11:26:05:883 CRITICAL : GMIL: Send response to OAMP failed
11:26:05:883 CRITICAL : GMIL: Send response to OAMP failed
11:26:05:883 ERROR : PHY_DIAG_MSG :: FCH decoding failed FN = 14407
11:26:05:883 RT : Deleting Connection CID:65535
11:26:05:883 RT : Link-Loss - Deleting DL MGMT connections-CQID: 1 CID:65533
11:26:05:884 RT : Deleting Connection CID:65533
11:26:05:884 RT : Link-Loss - Deleting DL MGMT connections-CQID: 2 CID:0
11:26:05:884 RT : Deleting Connection CID:0
11:26:05:884 RT : Link-Loss - Deleting DL MGMT connections-CQID: 3 CID:1
11:26:05:884 RT : Deleting Connection CID:1
11:26:05:884 RT : Link-Loss - Deleting DL MGMT connections-CQID: 4 CID:1000
11:26:05:884 RT : Deleting Connection CID:1000
11:26:05:884 RT : SBS Connection Cnt(LinkLoss) : 9
11:26:05:884 RT : Deleting Connection CID:2009
11:26:05:884 RT : Link-Loss - DL service flow delete - CID:2009 CQID:14 SFID:2
11:26:05:884 RT : Link-Loss - Deleting UL connections-CQID: 22
11:26:05:884 RT : QOS : Deleting SDU list
11:26:05:886 ERROR : PHY_DIAG_MSG: ULSF Not Received - Last READY time =1401342965s 883011ms
Previous-Ready = 1401342965s 878015ms FN:14407
11:26:05:886 RT : SBS Connection Cnt(LinkLoss-) : 0
11:26:05:886 RT : SRC LinkLoss Indication
11:26:05:886 RT : Dhcp-client child process id = 979
11:26:05:887 RT : Dhcp release signal issued successfully for n/w exit (SIGUSR2) FN:14407
11:26:05:887 RT : LMAC : STATE : IDLE State SYNCHRONIZING
11:26:05:887 RT : Radio configuration successfull
11:26:05:887 RT : MPI: Scan Start Request : Frequency:444
11:26:05:887 RT : MAC->PHY: PHY_SCAN_START_REQ Frequency:444 initial-tx-pwr:120
11:26:06:934 RT : PHY->MAC: PHY_SCAN_END_RESULT no_of preambles = 0 PreambleID:99 RSSI:-6 BS-
Freq:444
```

Figure 7-2: Forced Link Loss and Network Exit

Subsequently, the attenuation between MS and BS was gradually decreased, until the MS correctly repeated the Network Entry (Figure 7-3).



```
11:26:27:482 RT : DSA/DSC REQ/RSP : Service Flow ID    : 1
11:26:27:482 RT : DSA/DSC REQ/RSP : CID                : 2012
11:26:27:482 RT : DSA/DSC REQ/RSP : Req/Trans Policy   : 16
11:26:27:482 RT : DSA/DSC REQ/RSP : Max Sust Traf Rate : 10000000
11:26:27:482 RT : DSA/DSC REQ/RSP : DDS Type           : BE
11:26:27:482 RT : DSA/DSC REQ/RSP : PAGING PREFERENCE PARAMETER    : 1
11:26:27:482 RT : ==============================================================
11:26:27:482 RT : DSA RSP : UL Direction Transaction-ID:32771 CC:0
11:26:27:482 RT : DSA RSP Max FN for sending: 18932 FN:18877 AckTimeout:300
11:26:27:483 RT : CSF : T8 DSA/DSC ACK Timer Creation Successful 300
11:26:27:505 RT : Primary Connection Data MSGID:752 Exp-FN:18932 FN:18882
11:26:27:525 RT : Primary Connection Data MSGID:752 Exp-FN:18932 FN:18886
11:26:27:551 RT : CSF : DSA-ACK Received
11:26:27:551 RT : DSA ACK :Confirmation Code : 0   ( 0=Accept, other = Reject ) CID :2011  SFID : 2
11:26:27:551 RT : Flow Activation list
11:26:27:551 RT : (0)--> CID:0 SFID:0 CQID:0 State:0
11:26:27:551 RT : TeMs_SndMsgToMSM(),Sending to MGM Queue Success
11:26:27:551 RT : CSF : DSA-ACK Received
11:26:27:551 RT : DSA ACK :Confirmation Code : 0   ( 0=Accept, other = Reject ) CID :2012  SFID : 1
11:26:27:551 CRITICAL : GMIL: Send response to OAMP failed
11:26:27:551 RT : Flow Activation list
11:26:27:551 RT : (0)--> CID:0 SFID:0 CQID:0 State:0
11:26:27:552 RT : Activating UL Flow SFID:1
11:26:27:552 RT : UL  CQID index 22 and Allocated
11:26:27:552 RT : qosInitRateControl: MaxCapacity:91800 MsrBoundryStFrame:18891 MsrFrameCount:50
11:26:27:552 RT : UL-Flow Config REQ: CID:2012 CQID:22
11:26:27:552 RT :             NETWORK ENTRY DONE & SERVICE FLOWS CREATED
11:26:27:552 RT : qosCreateULConn:454: Flow creation for CID:2012 schType:2
11:26:27:552 RT : Activated Flow, SFID: 1
11:26:27:552 RT : TeMs_SndMsgToMSM(),Sending to MGM Queue Success
11:26:27:552 CRITICAL : GMIL: Send response to OAMP failed
11:26:27:580 RT : CSF : T10 Transaction End Timer Deleted
11:26:27:580 RT : CSF : T10 Transaction End Timer Deleted
11:26:28:100 RT : MPI COMP-DLMAP RSSI:-72 CINR:12 FN:19000
11:26:29:099 RT : MPI COMP-DLMAP RSSI:-72 CINR:17 FN:19200
11:26:29:883 RT : DHCP DISCOVER - Len:576
11:26:30:099 RT : MPI COMP-DLMAP RSSI:-72 CINR:14 FN:19400
11:26:30:944 RT : DHCP REQUEST ..........Len:576
11:26:30:994 RT : LMAC-SRC : BW - CDMA index : 14 SubChnl Off : 0 Sym off : 6 frameNum:0 powerLvl:0
```

Figure 7-3: Network Re-entry

7.1.1.3.3 Unexpected behaviors/results

None.

7.1.1.4 Conclusions and recommendations

The testing allowed checking successfully the correct Network Re-entry of the MS after a signal loss.

7.1.2 Verification Exercise # P2_LAB1_2 Power Control

7.1.2.1 Verification Exercise Scope

The purpose of this Test Case is verifying the correct use of CQI channels during the Closed Loop Power Control Execution, also verifying the CL PC performance.

7.1.2.2 Conduct of Verification Exercise

7.1.2.2.1 Verification Exercise Preparation

The test bed described in Figure 3-2 was arranged.

7.1.2.2.2 Verification Exercise execution

Step nr.	Action	Action description (if needed)	PCO (Point of Control and Observation)	Result
1.	Switch on MS			OK
2.	Switch on BS	BS switched on with CQICH enabled		OK
3.	Enable CL PC			OK
4.	Verify that MS connects successfully		Mngt PC connected to MS	OK
5	Verify that the Channel Quality Information channels are properly allocated in the CQICH region and used by the MS to transmit channel quality measures to the BS		Mngt PC connected to MS and BS	OK
6.	Verify that the channel quality measurements are sent to the BS with the chosen periodicity and verify any other option that might be		Mngt PC connected to MS and BS	OK

	applied			
7.	Verify that closed loop parameters remain within specified tolerances		Mngt PC connected to MS and BS	OK
8.	Verify that closed loop PC satisfactorily counteracts channel gain variations up to 30 dB/s		Mngt PC connected to MS and BS	OK

7.1.2.2.3 Deviation from the planned activities

None.

7.1.2.3 Verification exercise Results

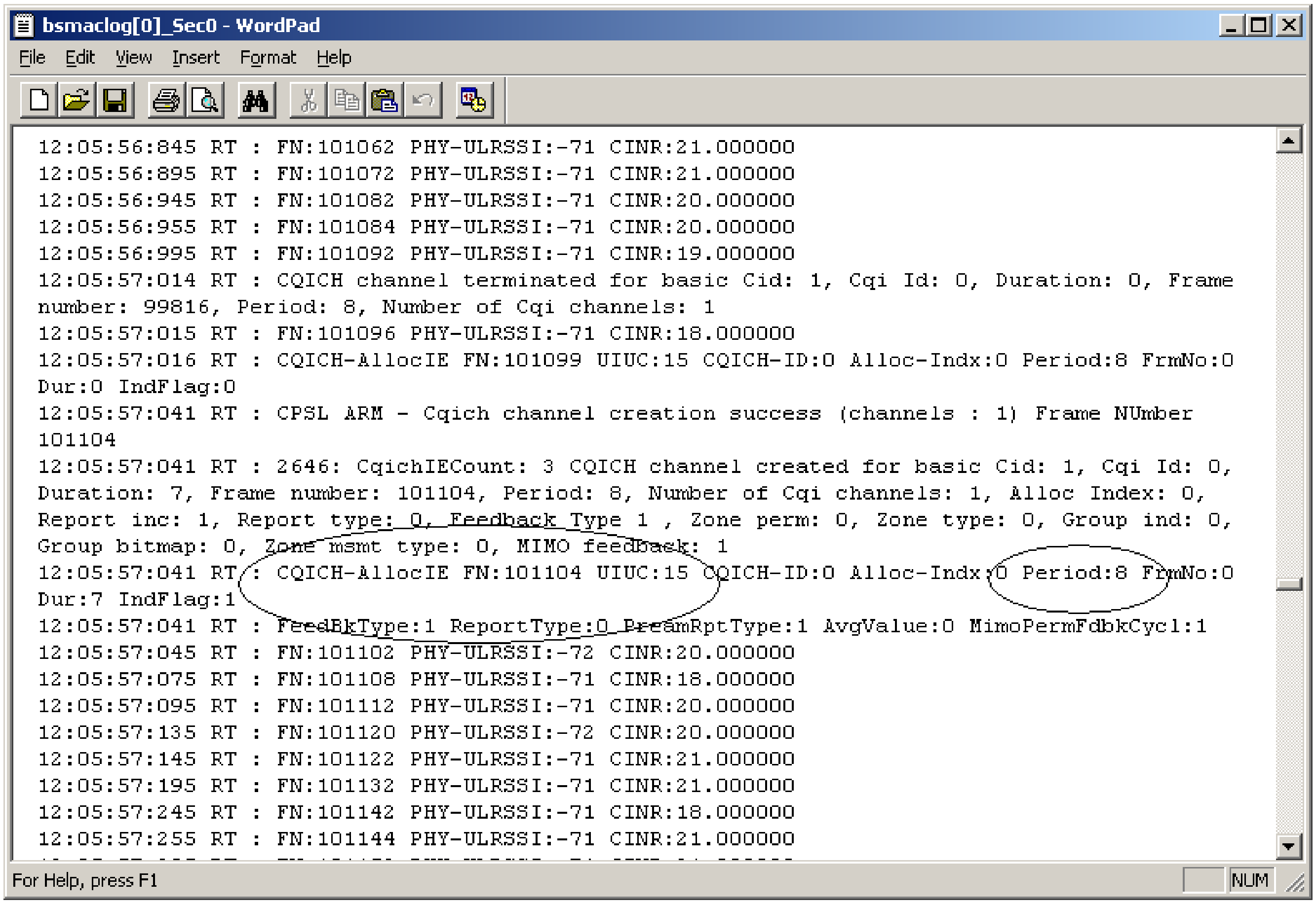
7.1.2.3.1 Summary of Verification exercise Results

ID	Result	Description	When observed?	Expected result	Obtained result	VO
1	CQI channels allocation & application	Verify that the Channel Quality Information channels are properly allocated in the CQICH region and used by the MS to transmit channel quality measures to the BS	Step 5	CQI channels allocation & application	OK	AeroMACS_VO_Interop_06_A
2.	CQI periodicity	Verify that the channel quality measurements are sent to the BS with the chosen periodicity and verify any other option that might be applied	Step 6	CQI periodicity	OK	AeroMACS_VO_Interop_06_B
3.	CL power control parameters	Verify that all closed loop parameters (power levels, power steps, power range ...) are all	Step 7	CL power control parameters	OK	AeroMACS_VO_Interop_10_C

		applied within the specified tolerances				
4.	CL power control performance	Verify that the closed loop power control satisfactorily sustains a data transfer without causing any oscillation or instability in the system, facing channel gain variations of up to 30 dB/s	Step 8	CL power control performance	OK	AeroMACS_VO_Interop_10_D

7.1.2.3.2 Analysis of Verification Exercise Results

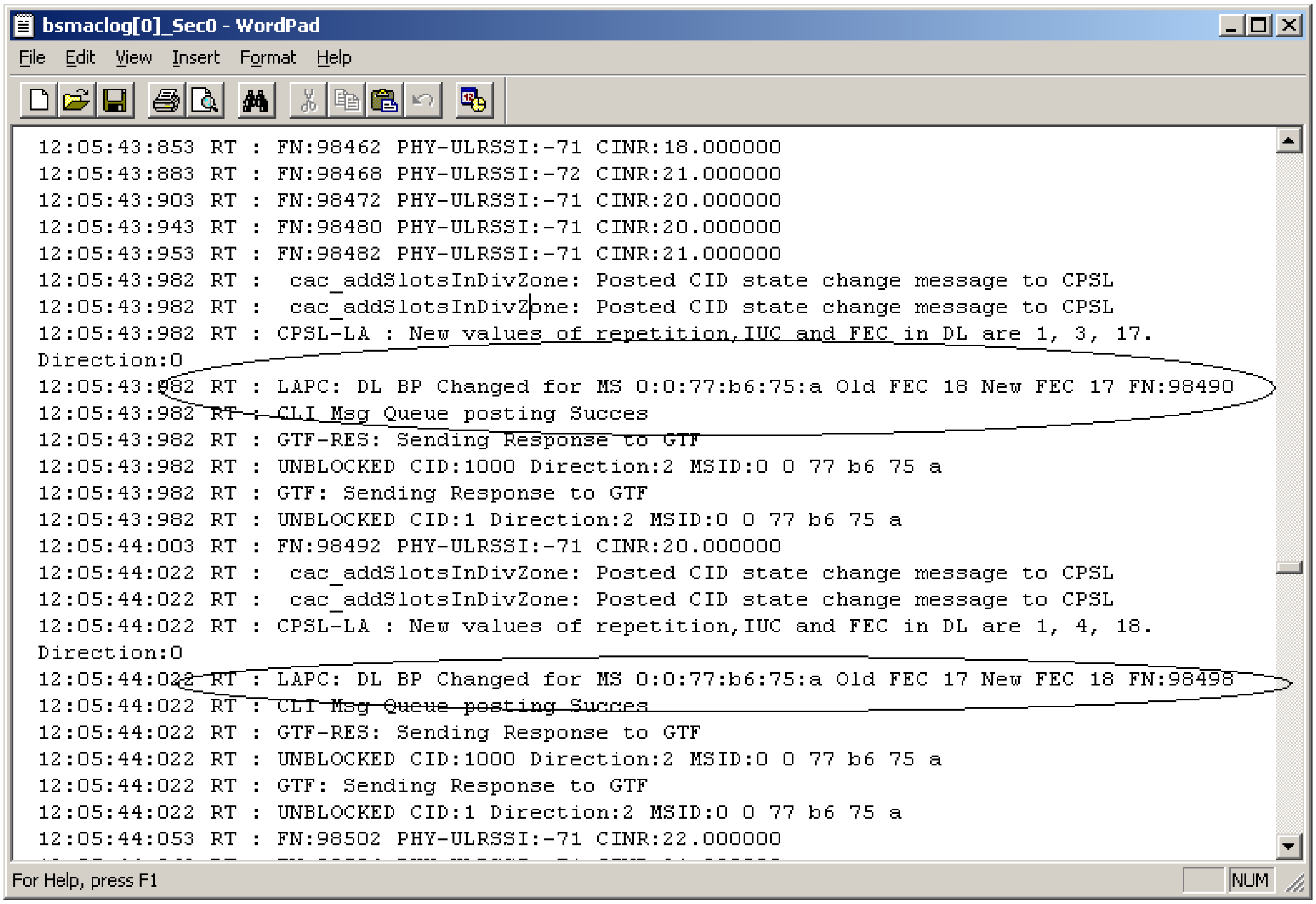
MS and BS were switched on, and the Network Entry was completed. The CQICH procedure and Closed Loop Power Control had been previously enabled on the BS, which allocated a CQICH sub-channel to the MS using a CQICH IE (CQICH Allocation IE), in order to allow the MS to send periodic CINR reports. The CQICH Allocation, together with the periodicity expressed in frames (8 in this case) is evidenced in the BS Log file shown in Figure 7-4.



```
12:05:56:845 RT : FN:101062 PHY-ULRSSI:-71 CINR:21.000000
12:05:56:895 RT : FN:101072 PHY-ULRSSI:-71 CINR:21.000000
12:05:56:945 RT : FN:101082 PHY-ULRSSI:-71 CINR:20.000000
12:05:56:955 RT : FN:101084 PHY-ULRSSI:-71 CINR:20.000000
12:05:56:995 RT : FN:101092 PHY-ULRSSI:-71 CINR:19.000000
12:05:57:014 RT : CQICH channel terminated for basic Cid: 1, Cqi Id: 0, Duration: 0, Frame
number: 99816, Period: 8, Number of Cqi channels: 1
12:05:57:015 RT : FN:101096 PHY-ULRSSI:-71 CINR:18.000000
12:05:57:016 RT : CQICH-AllocIE FN:101099 UIUC:15 CQICH-ID:0 Alloc-Indx:0 Period:8 FrmNo:0
Dur:0 IndFlag:0
12:05:57:041 RT : CPSL ARM - Cqich channel creation success (channels : 1) Frame NUmber
101104
12:05:57:041 RT : 2646: CqichIECount: 3 CQICH channel created for basic Cid: 1, Cqi Id: 0,
Duration: 7, Frame number: 101104, Period: 8, Number of Cqi channels: 1, Alloc Index: 0,
Report inc: 1, Report type: 0, Feedback Type 1 , Zone perm: 0, Zone type: 0, Group ind: 0,
Group bitmap: 0, Zone msmt type: 0, MIMO feedback: 1
12:05:57:041 RT : CQICH-AllocIE FN:101104 UIUC:15 CQICH-ID:0 Alloc-Indx:0 Period:8 FrmNo:0
Dur:7 IndFlag:1
12:05:57:041 RT : FeedBkType:1 ReportType:0 PreamRptType:1 AvgValue:0 MimoPermFdbkCycl:1
12:05:57:045 RT : FN:101102 PHY-ULRSSI:-72 CINR:20.000000
12:05:57:075 RT : FN:101108 PHY-ULRSSI:-71 CINR:18.000000
12:05:57:095 RT : FN:101112 PHY-ULRSSI:-71 CINR:20.000000
12:05:57:135 RT : FN:101120 PHY-ULRSSI:-72 CINR:20.000000
12:05:57:145 RT : FN:101122 PHY-ULRSSI:-71 CINR:21.000000
12:05:57:195 RT : FN:101132 PHY-ULRSSI:-71 CINR:21.000000
12:05:57:245 RT : FN:101142 PHY-ULRSSI:-71 CINR:18.000000
12:05:57:255 RT : FN:101144 PHY-ULRSSI:-71 CINR:21.000000
```

Figure 7-4: BS Log - CQICH Allocation

After that, it was observed that the MS started to send periodically its measurements in the allocated CQICH channels. In Figure 7-5 it is possible to appreciate that the measurements periodicity is 8 frames as expected.



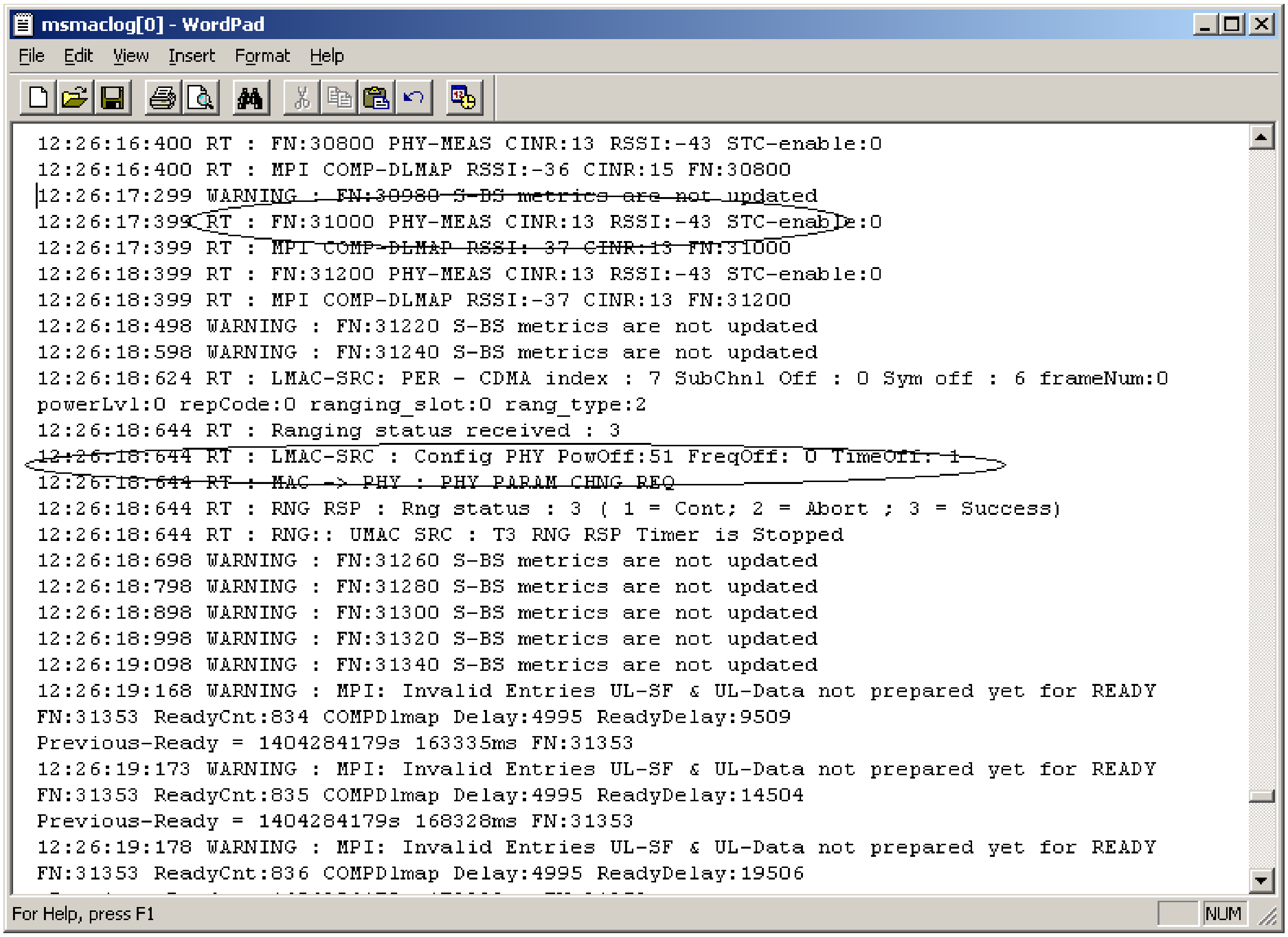
```
12:05:43:853 RT : FN:98462 PHY-ULRSSI:-71 CINR:18.000000
12:05:43:883 RT : FN:98468 PHY-ULRSSI:-72 CINR:21.000000
12:05:43:903 RT : FN:98472 PHY-ULRSSI:-71 CINR:20.000000
12:05:43:943 RT : FN:98480 PHY-ULRSSI:-71 CINR:20.000000
12:05:43:953 RT : FN:98482 PHY-ULRSSI:-71 CINR:21.000000
12:05:43:982 RT :  cac_addSlotsInDivZone: Posted CID state change message to CPSL
12:05:43:982 RT :  cac_addSlotsInDivZone: Posted CID state change message to CPSL
12:05:43:982 RT : CPSL-LA : New values of repetition,IUC and FEC in DL are 1, 3, 17.
Direction:0
12:05:43:982 RT : LAPC: DL BP Changed for MS 0:0:77:b6:75:a Old FEC 18 New FEC 17 FN:98490
12:05:43:982 RT : CLI Msg Queue posting Succes
12:05:43:982 RT : GTF-RES: Sending Response to GTF
12:05:43:982 RT : UNBLOCKED CID:1000 Direction:2 MSID:0 0 77 b6 75 a
12:05:43:982 RT : GTF: Sending Response to GTF
12:05:43:982 RT : UNBLOCKED CID:1 Direction:2 MSID:0 0 77 b6 75 a
12:05:44:003 RT : FN:98492 PHY-ULRSSI:-71 CINR:20.000000
12:05:44:022 RT :  cac_addSlotsInDivZone: Posted CID state change message to CPSL
12:05:44:022 RT :  cac_addSlotsInDivZone: Posted CID state change message to CPSL
12:05:44:022 RT : CPSL-LA : New values of repetition,IUC and FEC in DL are 1, 4, 18.
Direction:0
12:05:44:022 RT : LAPC: DL BP Changed for MS 0:0:77:b6:75:a Old FEC 17 New FEC 18 FN:98498
12:05:44:022 RT : CLI Msg Queue posting Succes
12:05:44:022 RT : GTF-RES: Sending Response to GTF
12:05:44:022 RT : UNBLOCKED CID:1000 Direction:2 MSID:0 0 77 b6 75 a
12:05:44:022 RT : GTF: Sending Response to GTF
12:05:44:022 RT : UNBLOCKED CID:1 Direction:2 MSID:0 0 77 b6 75 a
12:05:44:053 RT : FN:98502 PHY-ULRSSI:-71 CINR:22.000000
```

Figure 7-5: CQICH measurements

Finally the Closed Loop Power Control was also successfully verified. In particular, it was verified that the Algorithm was able to face a sudden attenuation of 30 dB/s during a data transfer, without any connection loss.

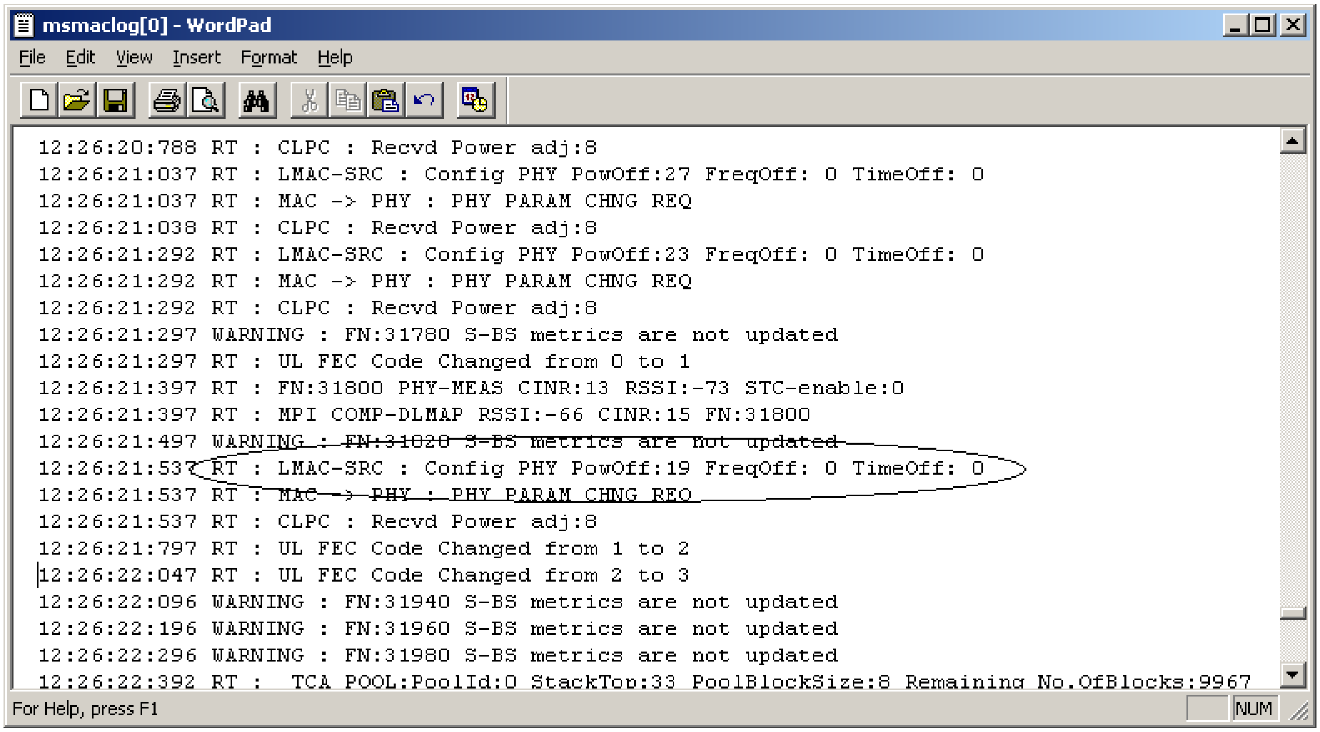
The variable attenuation was manually increased by 30 dBs in about 1 second, and it was verified that the MS did not lose the connection with MS. From the MS log in Figure 7-6 it is possible to appreciate the initial situation, in which RSSI= -43 dBm, and as a consequence the MS is applying a certain TX power offset, evidenced in the picture.
After the sudden attenuation by 30 dBs, the BS started commanding power adjustments to the MS, until the TX power offset became 32 dBs higher than the initial one (see “PHY PowOff” in Figure 7-7).

Subsequently, the initial attenuation was restored, and the proper working of the MS-BS connection was observed.



```
12:26:16:400 RT : FN:30800 PHY-MEAS CINR:13 RSSI:-43 STC-enable:0
12:26:16:400 RT : MPI COMP-DLMAP RSSI:-36 CINR:15 FN:30800
12:26:17:299 WARNING : FN:30980 S-BS metrics are not updated
12:26:17:399 RT : FN:31000 PHY-MEAS CINR:13 RSSI:-43 STC-enable:0
12:26:17:399 RT : MPI COMP-DLMAP RSSI:-37 CINR:13 FN:31000
12:26:18:399 RT : FN:31200 PHY-MEAS CINR:13 RSSI:-43 STC-enable:0
12:26:18:399 RT : MPI COMP-DLMAP RSSI:-37 CINR:13 FN:31200
12:26:18:498 WARNING : FN:31220 S-BS metrics are not updated
12:26:18:598 WARNING : FN:31240 S-BS metrics are not updated
12:26:18:624 RT : LMAC-SRC: PER - CDMA index : 7 SubChnl Off : 0 Sym off : 6 frameNum:0
powerLvl:0 repCode:0 ranging_slot:0 rang_type:2
12:26:18:644 RT : Ranging status received : 3
12:26:18:644 RT : LMAC-SRC : Config PHY PowOff:51 FreqOff: 0 TimeOff: 1
12:26:18:644 RT : MAC -> PHY : PHY PARAM CHNG REQ
12:26:18:644 RT : RNG RSP : Rng status : 3 ( 1 = Cont; 2 = Abort ; 3 = Success)
12:26:18:644 RT : RNG:: UMAC SRC : T3 RNG RSP Timer is Stopped
12:26:18:698 WARNING : FN:31260 S-BS metrics are not updated
12:26:18:798 WARNING : FN:31280 S-BS metrics are not updated
12:26:18:898 WARNING : FN:31300 S-BS metrics are not updated
12:26:18:998 WARNING : FN:31320 S-BS metrics are not updated
12:26:19:098 WARNING : FN:31340 S-BS metrics are not updated
12:26:19:168 WARNING : MPI: Invalid Entries UL-SF & UL-Data not prepared yet for READY
FN:31353 ReadyCnt:834 COMPDlmap Delay:4995 ReadyDelay:9509
Previous-Ready = 1404284179s 163335ms FN:31353
12:26:19:173 WARNING : MPI: Invalid Entries UL-SF & UL-Data not prepared yet for READY
FN:31353 ReadyCnt:835 COMPDlmap Delay:4995 ReadyDelay:14504
Previous-Ready = 1404284179s 168328ms FN:31353
12:26:19:178 WARNING : MPI: Invalid Entries UL-SF & UL-Data not prepared yet for READY
FN:31353 ReadyCnt:836 COMPDlmap Delay:4995 ReadyDelay:19506
```

Figure 7-6: CL PC - initial situation



```
12:26:20:788 RT : CLPC : Recvd Power adj:8
12:26:21:037 RT : LMAC-SRC : Config PHY PowOff:27 FreqOff: 0 TimeOff: 0
12:26:21:037 RT : MAC -> PHY : PHY PARAM CHNG REQ
12:26:21:038 RT : CLPC : Recvd Power adj:8
12:26:21:292 RT : LMAC-SRC : Config PHY PowOff:23 FreqOff: 0 TimeOff: 0
12:26:21:292 RT : MAC -> PHY : PHY PARAM CHNG REQ
12:26:21:292 RT : CLPC : Recvd Power adj:8
12:26:21:297 WARNING : FN:31780 S-BS metrics are not updated
12:26:21:297 RT : UL FEC Code Changed from 0 to 1
12:26:21:397 RT : FN:31800 PHY-MEAS CINR:13 RSSI:-73 STC-enable:0
12:26:21:397 RT : MPI COMP-DLMAP RSSI:-66 CINR:15 FN:31800
12:26:21:497 WARNING : FN:31820 S-BS metrics are not updated
12:26:21:537 RT : LMAC-SRC : Config PHY PowOff:19 FreqOff: 0 TimeOff: 0
12:26:21:537 RT : MAC -> PHY : PHY PARAM CHNG REQ
12:26:21:537 RT : CLPC : Recvd Power adj:8
12:26:21:797 RT : UL FEC Code Changed from 1 to 2
12:26:22:047 RT : UL FEC Code Changed from 2 to 3
12:26:22:096 WARNING : FN:31940 S-BS metrics are not updated
12:26:22:196 WARNING : FN:31960 S-BS metrics are not updated
12:26:22:296 WARNING : FN:31980 S-BS metrics are not updated
12:26:22:392 RT :  TCA POOL:PoolId:0 StackTop:33 PoolBlockSize:8 Remaining No.OfBlocks:9967
```

Figure 7-7: CL PC - Final situation

7.1.2.3.3 Unexpected behaviors/results

None.

7.1.2.4 Conclusions and recommendations

The testing allowed checking successfully the correct use of CQI channels during the Closed Loop Power Control Execution.

7.1.3 Verification Exercise # P2_LAB1_3 Quality of Service

7.1.3.1 Verification Exercise Scope

The purpose of this Test Case is to verify that all QoS related requirements are satisfied (SF creation and deletion, traffic parameters, bandwidth management) for different Scheduling Types and for different traffic priorities, in both directions.

7.1.3.2 Conduct of Verification Exercise

7.1.3.2.1 Verification Exercise Preparation

The test bed described in Figure 3-2 was arranged, except the Spectrum Analyser/Signal Generator and Fading Simulator, which were not needed in this test.

7.1.3.2.2 Verification Exercise execution

Step nr.	Action	Action description (if needed)	PCO (Point of Control and Observation)	Result
1.	Switch on BS			OK
2.	Set 1 SF (SF1) with the scheduling type (QoS class) to be used as 1 among BE/nrtPS/rtPS		Mngt PC connected to ASN-GW/AAA	OK
3.	Switch on MS			OK
4.	Start an IP Flow with a configuration compatible with the SF Classification for DL (then for UL) traffic	Using IPERF	IPERF @ PC connected to ASN-GW x DL (MS x UL)	OK
5.	Verify that the IP packets are transferred on the air interface	Using IPERF	IPERF @ PC connected to MS x DL (ASN-GW x UL)	OK
6.	Verify that data exceeding the MSTR is dropped or delayed	Using IPERF	IPERF @ PC connected to MS x DL (ASN-GW x UL)	OK
7.	Set 1 additional SF (SF2) with the same configuration of the SF of step 3 except for MSTR		Mngt PC connected to ASN-GW/AAA	OK
8.	Restart MS			OK
9.	Start two IP Flow one compatible with SF1 configuration and the other with SF2. SF1 throughput < SF2 throughput SF1 throughput + SF2 throughput > Channel capacity	Using IPERF	IPERF @ PC connected to ASN-GW x DL (MS x UL)	OK

10.	Check fairness between flows	Using IPERF	IPERF @ PC connected to MS x DL (ASN-GW x UL)	OK
11.	Increase the Traffic Priority of SF2 (SF2 higher priority than SF1)		Mngt PC connected to ASN-GW/AAA	OK
12.	Restart MS			OK
13.	Start two IP Flow one compatible with SF1 configuration and the other with SF2. SF1 throughput > SF2 throughput SF1 throughput + SF2 throughput > Channel capacity	Using IPERF	IPERF @ PC connected to ASN-GW x DL (MS x UL)	OK
14.	Check unfairness between flows (SF1 throughput > SF2 throughput)	Using IPERF	IPERF @ PC connected to MS x DL (ASN-GW x UL)	OK
15.	Switch off MS			OK
16.	Pass to another scheduling type (QoS class) and repeat steps from 2 to 18 until all types have been tested			OK

7.1.3.2.3 Deviation from the planned activities

None.

7.1.3.3 Verification exercise Results

7.1.3.3.1 Summary of Verification exercise Results

ID	Result	Description	When observed?	Expected result	Obtained result	VO
1.	Priority	Verify the behaviour of two SFs with the same configuration except traffic priorities	Step 14 Step 16	Behaviour of two SFs with the same configuration except traffic priorities	OK	AeroMACS_VO_Interop_04_A
2.	MSTR	Verify that the Maximum Sustained Traffic Rate value for a SF is respected	Step 6	Maximum Sustained Traffic Rate value for a SF is respected	OK	AeroMACS_VO_Interop_04_B
3.	DSA	Verify that the correct DSA procedure is implemented	Step 5 Step 6	The correct DSA procedure is implemented	OK	AeroMACS_VO_Interop_05_A
4.	BW allocation	Verification of correct allocation of the MAC resources	Step 5 Step 6 Step	Correct allocation of the MAC resources	OK	AeroMACS_VO_Interop_07_A AeroMACS_VO_Interop_07_B AeroMACS_VO_Interop_07_C AeroMACS_VO_Interop_07_D

			10 Step 14 Step 16			

7.1.3.3.2 Analysis of Verification Exercise Results

As usual, MS and BS were switched on, and the Network Entry was completed. The attenuation was set at a value such to allow BS and MS to establish a 16-QAM ½ connection.
Since the BS imposed a DL:UL ratio equal to 35:12, the maximum data throughput available in DL (channel capacity) is estimated being about 3.7 Mbps (excluding FCH+DLMAP+ULMAP overheads in DL)

Under these conditions, two Service Flows with Scheduling Type Best Effort and same priority but different MSTRs were set up at the BS (see Table 11).

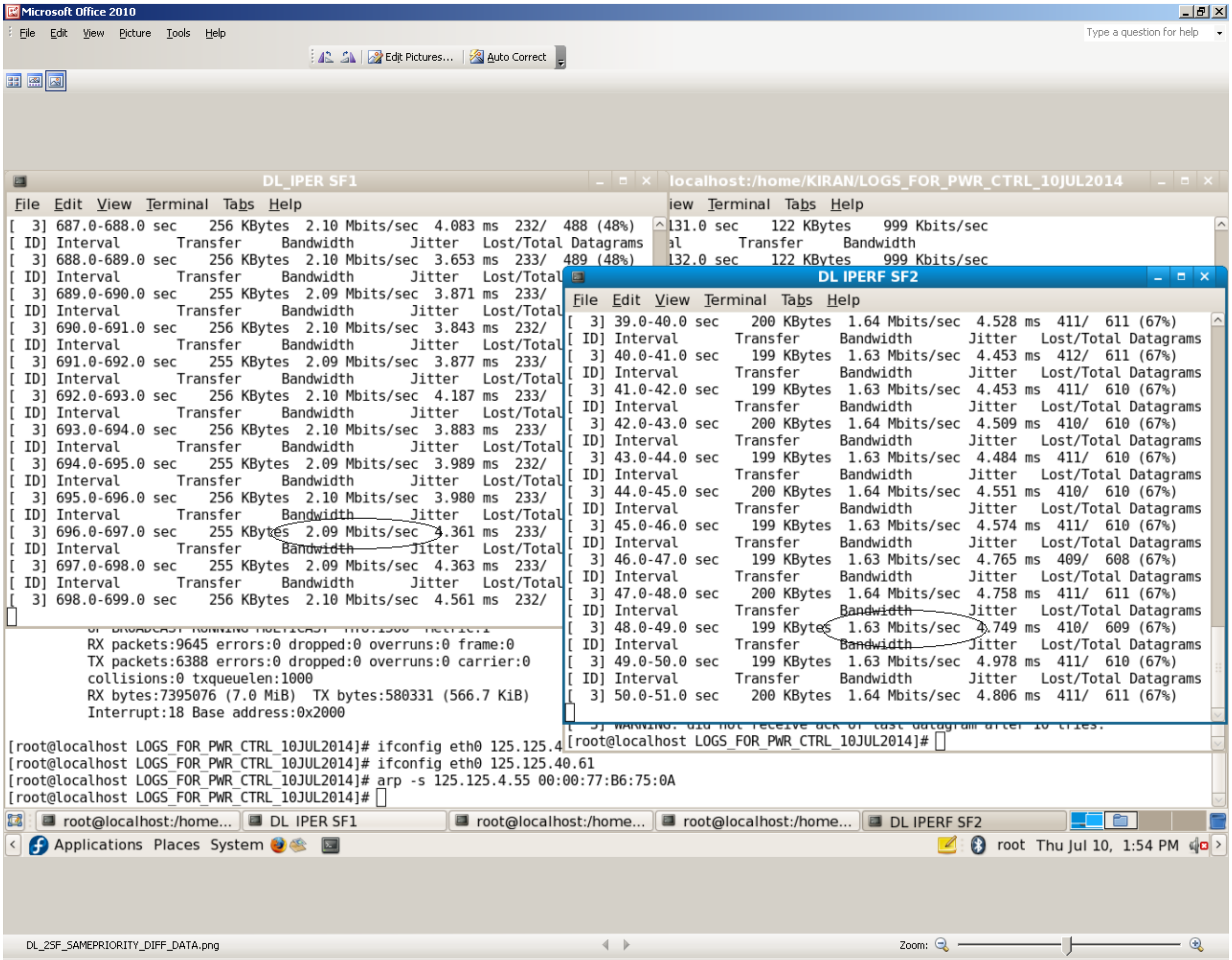
Service Flow	**Scheduling Type**	**DL MSTR**	**UL MSTR**
SF1	BE	4 Mbps	600 Kbps
SF2	BE	3 Mbps	400 Kbps

Table 11: Service Flows characteristics

Then, two IP Flows were subsequently started with IPERF, compatibly with the SFs classification rules for DL and with the following throughputs:

- IP flow on SF1: 4.5 Mbps
- IP flow on SF2: 5 Mbps.

The needed bandwidth was assigned by the BS to the MS thanks to the BW-REQ/BW-RSP mechanism, and the data transfer started. In Figure 7-8 it may be observed certain fairness between the exchanged data flows. The difference between them is compatible with the difference between MSTR1 and MSTR2 values.



```
[  3] 687.0-688.0 sec    256 KBytes  2.10 Mbits/sec  4.083 ms  232/  488 (48%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 688.0-689.0 sec    256 KBytes  2.10 Mbits/sec  3.653 ms  233/  489 (48%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total
[  3] 689.0-690.0 sec    255 KBytes  2.09 Mbits/sec  3.871 ms  233/
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total
[  3] 690.0-691.0 sec    256 KBytes  2.10 Mbits/sec  3.843 ms  232/
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total
[  3] 691.0-692.0 sec    255 KBytes  2.09 Mbits/sec  3.877 ms  233/
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total
[  3] 692.0-693.0 sec    256 KBytes  2.10 Mbits/sec  4.187 ms  233/
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total
[  3] 693.0-694.0 sec    256 KBytes  2.10 Mbits/sec  3.883 ms  233/
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total
[  3] 694.0-695.0 sec    255 KBytes  2.09 Mbits/sec  3.989 ms  232/
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total
[  3] 695.0-696.0 sec    256 KBytes  2.10 Mbits/sec  3.980 ms  233/
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total
[  3] 696.0-697.0 sec    255 KBytes  2.09 Mbits/sec  4.361 ms  233/
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total
[  3] 697.0-698.0 sec    255 KBytes  2.09 Mbits/sec  4.363 ms  233/
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total
[  3] 698.0-699.0 sec    256 KBytes  2.10 Mbits/sec  4.561 ms  232/
```

```
131.0 sec    122 KBytes    999 Kbits/sec
al        Transfer     Bandwidth
132.0 sec    122 KBytes    999 Kbits/sec
```

```
[  3] 39.0-40.0 sec    200 KBytes  1.64 Mbits/sec  4.528 ms  411/  611 (67%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 40.0-41.0 sec    199 KBytes  1.63 Mbits/sec  4.453 ms  412/  611 (67%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 41.0-42.0 sec    199 KBytes  1.63 Mbits/sec  4.453 ms  411/  610 (67%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 42.0-43.0 sec    200 KBytes  1.64 Mbits/sec  4.509 ms  410/  610 (67%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 43.0-44.0 sec    199 KBytes  1.63 Mbits/sec  4.484 ms  411/  610 (67%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 44.0-45.0 sec    200 KBytes  1.64 Mbits/sec  4.551 ms  410/  610 (67%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 45.0-46.0 sec    199 KBytes  1.63 Mbits/sec  4.574 ms  411/  610 (67%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 46.0-47.0 sec    199 KBytes  1.63 Mbits/sec  4.765 ms  409/  608 (67%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 47.0-48.0 sec    200 KBytes  1.64 Mbits/sec  4.758 ms  411/  611 (67%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 48.0-49.0 sec    199 KBytes  1.63 Mbits/sec  4.749 ms  410/  609 (67%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 49.0-50.0 sec    199 KBytes  1.63 Mbits/sec  4.978 ms  411/  610 (67%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 50.0-51.0 sec    200 KBytes  1.64 Mbits/sec  4.806 ms  411/  611 (67%)
```

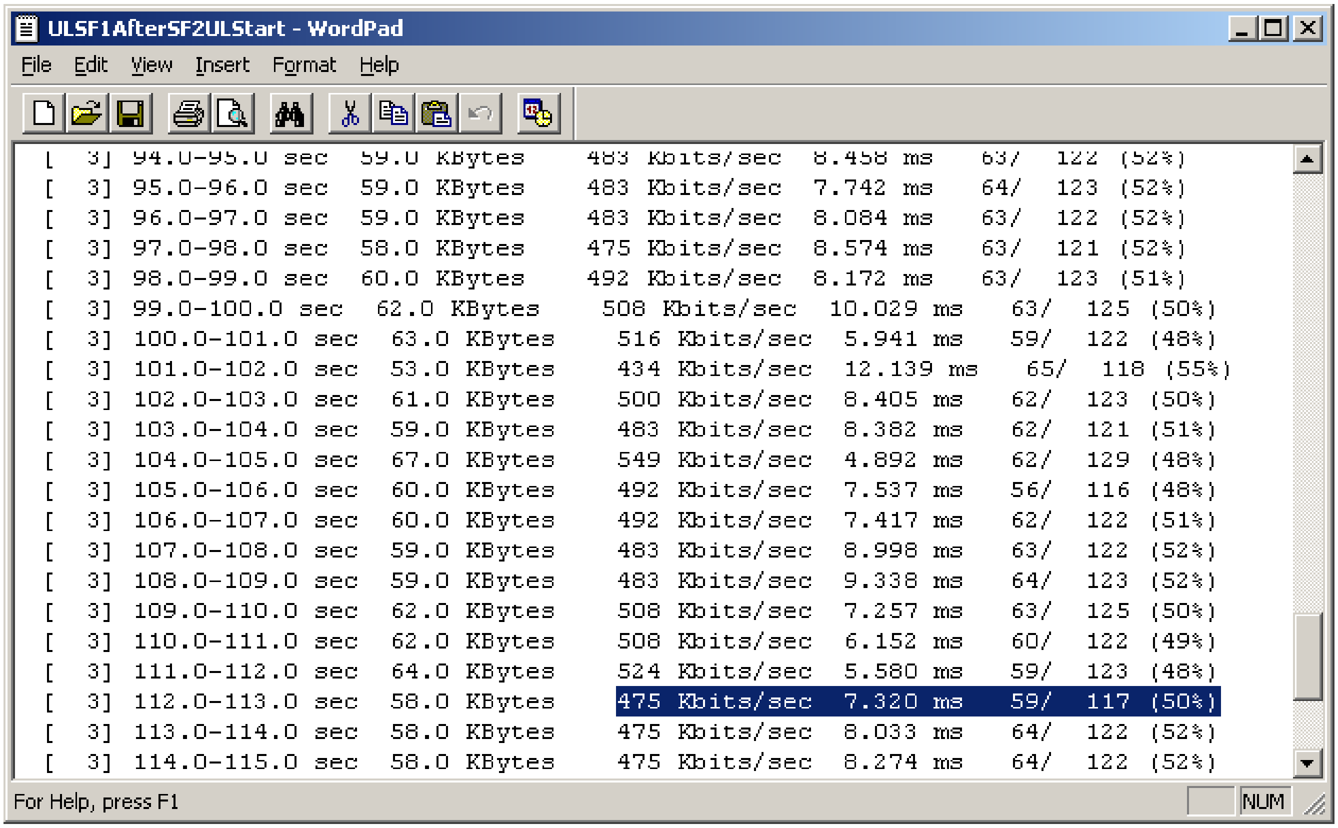
```
[root@localhost LOGS_FOR_PWR_CTRL_10JUL2014]#
```

```
          RX packets:9645 errors:0 dropped:0 overruns:0 frame:0
          TX packets:6388 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:7395076 (7.0 MiB)  TX bytes:580331 (566.7 KiB)
          Interrupt:18 Base address:0x2000

[root@localhost LOGS_FOR_PWR_CTRL_10JUL2014]# ifconfig eth0 125.125.4
[root@localhost LOGS_FOR_PWR_CTRL_10JUL2014]# ifconfig eth0 125.125.40.61
[root@localhost LOGS_FOR_PWR_CTRL_10JUL2014]# arp -s 125.125.4.55 00:00:77:B6:75:0A
[root@localhost LOGS_FOR_PWR_CTRL_10JUL2014]#
```

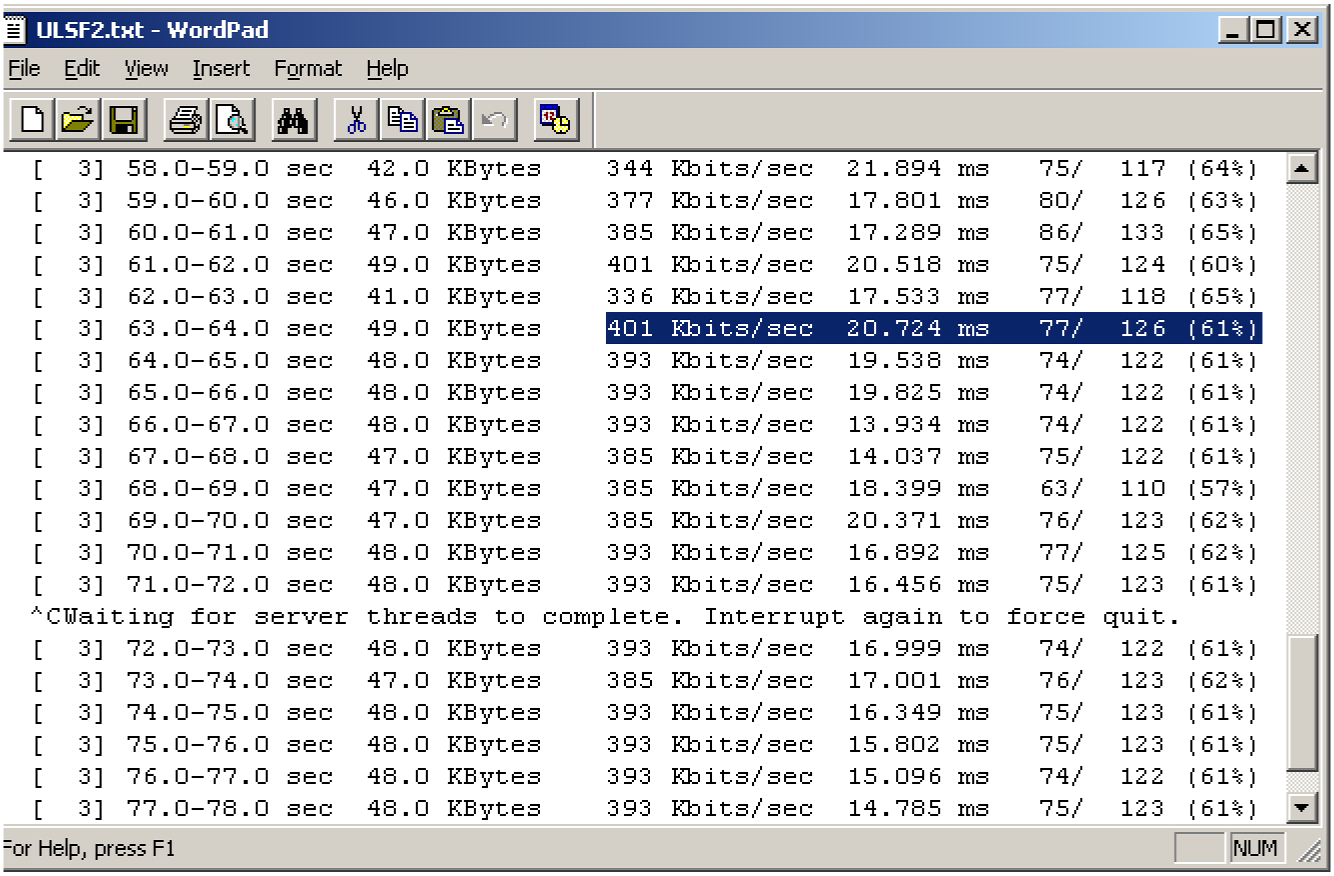
Figure 7-8: IPERF Log - 2 SFs with the same priority but different MSTR

Then the test was repeated for the UL, using the same Service Flows set before. This time the IP Flows were both set to 1 Mbps. However, this time the channel capacity was about 880 Kbps, as the active MCS was QPSK ¾.
As it is possible to see from the IPERF logs in Figure 7-9 and Figure 7-10, the total throughput was compliant with the channel capacity. Again, the difference between the throughputs is compatible with the difference between UL MSTR1 and MSTR2 values.



```
[  3] 94.0-95.0 sec  59.0 KBytes   483 Kbits/sec  8.458 ms   63/  122 (52%)
[  3] 95.0-96.0 sec  59.0 KBytes   483 Kbits/sec  7.742 ms   64/  123 (52%)
[  3] 96.0-97.0 sec  59.0 KBytes   483 Kbits/sec  8.084 ms   63/  122 (52%)
[  3] 97.0-98.0 sec  58.0 KBytes   475 Kbits/sec  8.574 ms   63/  121 (52%)
[  3] 98.0-99.0 sec  60.0 KBytes   492 Kbits/sec  8.172 ms   63/  123 (51%)
[  3] 99.0-100.0 sec  62.0 KBytes   508 Kbits/sec  10.029 ms   63/  125 (50%)
[  3] 100.0-101.0 sec  63.0 KBytes   516 Kbits/sec  5.941 ms   59/  122 (48%)
[  3] 101.0-102.0 sec  53.0 KBytes   434 Kbits/sec  12.139 ms   65/  118 (55%)
[  3] 102.0-103.0 sec  61.0 KBytes   500 Kbits/sec  8.405 ms   62/  123 (50%)
[  3] 103.0-104.0 sec  59.0 KBytes   483 Kbits/sec  8.382 ms   62/  121 (51%)
[  3] 104.0-105.0 sec  67.0 KBytes   549 Kbits/sec  4.892 ms   62/  129 (48%)
[  3] 105.0-106.0 sec  60.0 KBytes   492 Kbits/sec  7.537 ms   56/  116 (48%)
[  3] 106.0-107.0 sec  60.0 KBytes   492 Kbits/sec  7.417 ms   62/  122 (51%)
[  3] 107.0-108.0 sec  59.0 KBytes   483 Kbits/sec  8.998 ms   63/  122 (52%)
[  3] 108.0-109.0 sec  59.0 KBytes   483 Kbits/sec  9.338 ms   64/  123 (52%)
[  3] 109.0-110.0 sec  62.0 KBytes   508 Kbits/sec  7.257 ms   63/  125 (50%)
[  3] 110.0-111.0 sec  62.0 KBytes   508 Kbits/sec  6.152 ms   60/  122 (49%)
[  3] 111.0-112.0 sec  64.0 KBytes   524 Kbits/sec  5.580 ms   59/  123 (48%)
[  3] 112.0-113.0 sec  58.0 KBytes   475 Kbits/sec  7.320 ms   59/  117 (50%)
[  3] 113.0-114.0 sec  58.0 KBytes   475 Kbits/sec  8.033 ms   64/  122 (52%)
[  3] 114.0-115.0 sec  58.0 KBytes   475 Kbits/sec  8.274 ms   64/  122 (52%)
```

Figure 7-9: UL - throughput on SF1

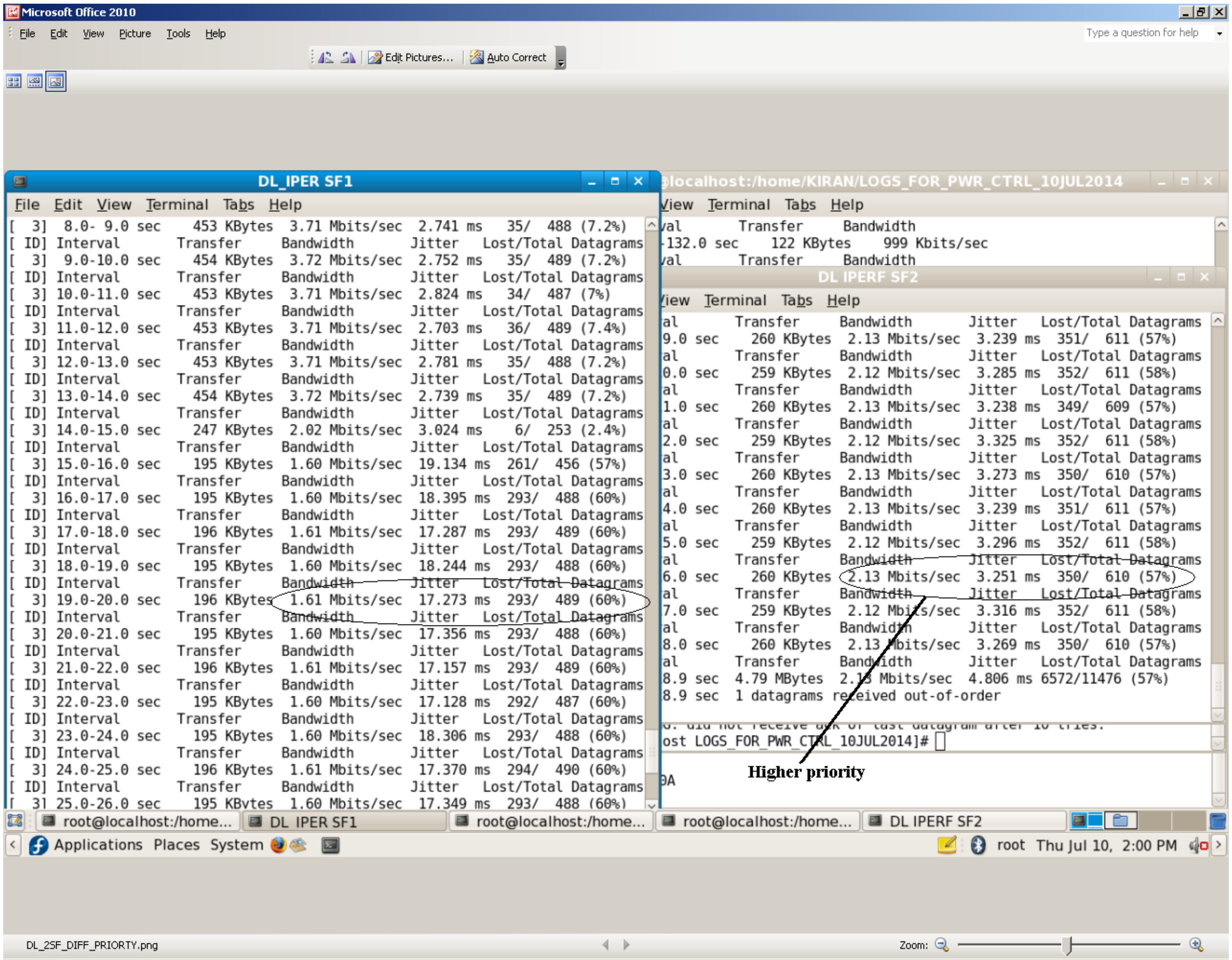


```
[  3] 58.0-59.0 sec  42.0 KBytes    344 Kbits/sec  21.894 ms   75/   117 (64%)
[  3] 59.0-60.0 sec  46.0 KBytes    377 Kbits/sec  17.801 ms   80/   126 (63%)
[  3] 60.0-61.0 sec  47.0 KBytes    385 Kbits/sec  17.289 ms   86/   133 (65%)
[  3] 61.0-62.0 sec  49.0 KBytes    401 Kbits/sec  20.518 ms   75/   124 (60%)
[  3] 62.0-63.0 sec  41.0 KBytes    336 Kbits/sec  17.533 ms   77/   118 (65%)
[  3] 63.0-64.0 sec  49.0 KBytes    401 Kbits/sec  20.724 ms   77/   126 (61%)
[  3] 64.0-65.0 sec  48.0 KBytes    393 Kbits/sec  19.538 ms   74/   122 (61%)
[  3] 65.0-66.0 sec  48.0 KBytes    393 Kbits/sec  19.825 ms   74/   122 (61%)
[  3] 66.0-67.0 sec  48.0 KBytes    393 Kbits/sec  13.934 ms   74/   122 (61%)
[  3] 67.0-68.0 sec  47.0 KBytes    385 Kbits/sec  14.037 ms   75/   122 (61%)
[  3] 68.0-69.0 sec  47.0 KBytes    385 Kbits/sec  18.399 ms   63/   110 (57%)
[  3] 69.0-70.0 sec  47.0 KBytes    385 Kbits/sec  20.371 ms   76/   123 (62%)
[  3] 70.0-71.0 sec  48.0 KBytes    393 Kbits/sec  16.892 ms   77/   125 (62%)
[  3] 71.0-72.0 sec  48.0 KBytes    393 Kbits/sec  16.456 ms   75/   123 (61%)
^CWaiting for server threads to complete. Interrupt again to force quit.
[  3] 72.0-73.0 sec  48.0 KBytes    393 Kbits/sec  16.999 ms   74/   122 (61%)
[  3] 73.0-74.0 sec  47.0 KBytes    385 Kbits/sec  17.001 ms   76/   123 (62%)
[  3] 74.0-75.0 sec  48.0 KBytes    393 Kbits/sec  16.349 ms   75/   123 (61%)
[  3] 75.0-76.0 sec  48.0 KBytes    393 Kbits/sec  15.802 ms   75/   123 (61%)
[  3] 76.0-77.0 sec  48.0 KBytes    393 Kbits/sec  15.096 ms   74/   122 (61%)
[  3] 77.0-78.0 sec  48.0 KBytes    393 Kbits/sec  14.785 ms   75/   123 (61%)
```

Figure 7-10: UL - throughput on SF2

Subsequently, the Traffic Priority of Service Flow #2 was increased with respect to SF1, and the MS was restarted; the same tests done before in DL and UL were repeated. This time, a reversal of results was observed, both in DL and UL: in fact this time, thanks to the SF2 higher priority, its throughput got higher, to the detriment of SF1 throughput (and despite of the lower MSTR2 threshold). Figure 7-11 shows the DL case.

The tests were repeated with different Scheduling Types (rtps, e-rtps, nrtps), giving similar results.



```
[  3]  8.0- 9.0 sec    453 KBytes  3.71 Mbits/sec  2.741 ms   35/  488 (7.2%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3]  9.0-10.0 sec    454 KBytes  3.72 Mbits/sec  2.752 ms   35/  489 (7.2%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 10.0-11.0 sec    453 KBytes  3.71 Mbits/sec  2.824 ms   34/  487 (7%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 11.0-12.0 sec    453 KBytes  3.71 Mbits/sec  2.703 ms   36/  489 (7.4%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 12.0-13.0 sec    453 KBytes  3.71 Mbits/sec  2.781 ms   35/  488 (7.2%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 13.0-14.0 sec    454 KBytes  3.72 Mbits/sec  2.739 ms   35/  489 (7.2%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 14.0-15.0 sec    247 KBytes  2.02 Mbits/sec  3.024 ms    6/  253 (2.4%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 15.0-16.0 sec    195 KBytes  1.60 Mbits/sec  19.134 ms  261/  456 (57%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 16.0-17.0 sec    195 KBytes  1.60 Mbits/sec  18.395 ms  293/  488 (60%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 17.0-18.0 sec    196 KBytes  1.61 Mbits/sec  17.287 ms  293/  489 (60%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 18.0-19.0 sec    195 KBytes  1.60 Mbits/sec  18.244 ms  293/  488 (60%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 19.0-20.0 sec    196 KBytes  1.61 Mbits/sec  17.273 ms  293/  489 (60%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 20.0-21.0 sec    195 KBytes  1.60 Mbits/sec  17.356 ms  293/  488 (60%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 21.0-22.0 sec    196 KBytes  1.61 Mbits/sec  17.157 ms  293/  489 (60%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 22.0-23.0 sec    195 KBytes  1.60 Mbits/sec  17.128 ms  292/  487 (60%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 23.0-24.0 sec    195 KBytes  1.60 Mbits/sec  18.306 ms  293/  488 (60%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 24.0-25.0 sec    196 KBytes  1.61 Mbits/sec  17.370 ms  294/  490 (60%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagrams
[  3] 25.0-26.0 sec    195 KBytes  1.60 Mbits/sec  17.349 ms  293/  488 (60%)
```

```
val       Transfer     Bandwidth
-132.0 sec    122 KBytes    999 Kbits/sec
val       Transfer     Bandwidth
```

```
al        Transfer     Bandwidth       Jitter   Lost/Total Datagrams
9.0 sec    260 KBytes  2.13 Mbits/sec  3.239 ms  351/  611 (57%)
al        Transfer     Bandwidth       Jitter   Lost/Total Datagrams
0.0 sec    259 KBytes  2.12 Mbits/sec  3.285 ms  352/  611 (58%)
al        Transfer     Bandwidth       Jitter   Lost/Total Datagrams
1.0 sec    260 KBytes  2.13 Mbits/sec  3.238 ms  349/  609 (57%)
al        Transfer     Bandwidth       Jitter   Lost/Total Datagrams
2.0 sec    259 KBytes  2.12 Mbits/sec  3.325 ms  352/  611 (58%)
al        Transfer     Bandwidth       Jitter   Lost/Total Datagrams
3.0 sec    260 KBytes  2.13 Mbits/sec  3.273 ms  350/  610 (57%)
al        Transfer     Bandwidth       Jitter   Lost/Total Datagrams
4.0 sec    260 KBytes  2.13 Mbits/sec  3.239 ms  351/  611 (57%)
al        Transfer     Bandwidth       Jitter   Lost/Total Datagrams
5.0 sec    259 KBytes  2.12 Mbits/sec  3.296 ms  352/  611 (58%)
al        Transfer     Bandwidth       Jitter   Lost/Total Datagrams
6.0 sec    260 KBytes  2.13 Mbits/sec  3.251 ms  350/  610 (57%)
al        Transfer     Bandwidth       Jitter   Lost/Total Datagrams
7.0 sec    259 KBytes  2.12 Mbits/sec  3.316 ms  352/  611 (58%)
al        Transfer     Bandwidth       Jitter   Lost/Total Datagrams
8.0 sec    260 KBytes  2.13 Mbits/sec  3.269 ms  350/  610 (57%)
al        Transfer     Bandwidth       Jitter   Lost/Total Datagrams
8.9 sec  4.79 MBytes  2.13 Mbits/sec  4.806 ms 6572/11476 (57%)
8.9 sec  1 datagrams received out-of-order
```

```
ost LOGS_FOR_PWR_CTRL_10JUL2014]# 
```

```
0A
```

Figure 7-11: SF2 with higher priority

7.1.3.3.3 Unexpected behaviors/results

None

7.1.3.4 Conclusions and recommendations

The testing allowed verifying that all QoS related requirements are satisfied for different Scheduling Types and for different traffic priorities, in both directions.

7.1.4 Verification Exercise # P2_LAB1_4 Security

7.1.4.1 Verification Exercise Scope

Scope of this test is to verify that after Authentication, Data are properly encrypted, according to the required Private Key Management Protocol.

7.1.4.2 Conduct of Verification Exercise

7.1.4.2.1 Verification Exercise Preparation

The test bed described in Figure 3-2 was used, except the Spectrum Analyser/Signal Generator and Fading Simulator, which were not needed in this test.

7.1.4.2.2 Verification Exercise execution

Step nr.	Action	Action description	PCO (Point of Control and Observation)	Result
1.	Switch on MS			OK
2.	Switch on BS and ASN-GW/AAA			OK
3.	Establish a communication and verify that the EAP based authentication method is supported:	With Authentication enabled, valid credentials inserted	R6 i/f with wireshark	OK
4.	Verify that the used PKM protocol is PKMv2	Authentication has been previously enabled	Internal log	OK
5.	Verify that all the Encrypted Data Traffic is correctly sent and received without errors due to the application of the Encryption procedure		Internal log	OK
6.	Verify re-authentication	Forced re-authentication on the	R6 i/f with wireshark	OK

		ASN-GW/AAA		

7.1.4.2.3 Deviation from the planned activities

None.

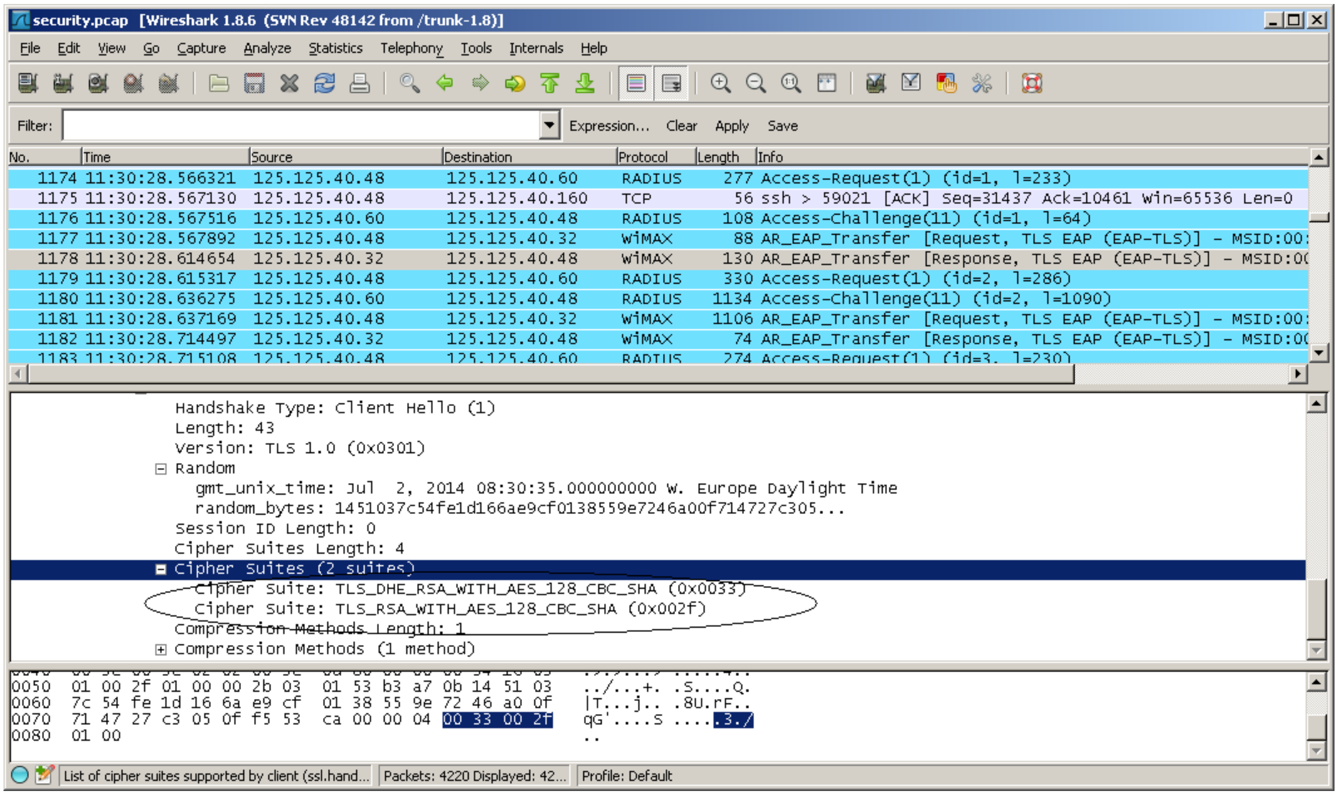
7.1.4.3 Verification exercise Results

7.1.4.3.1 Summary of Verification exercise Results

ID	Result	Description	When observed ?	Expected result	Obtained result	VO
1.	Authentication	Verify that authentication and key exchange steps are present	Step 3	Network entry with authentication	OK	AeroMACS_VO_Interop_11_B
2.	Re-Authentication	Verify the re-authentication procedure	Step 6	Re-Authentication procedure	OK	AeroMACS_VO_Interop_11_C
3.	PKM	Verify that the Privacy Key Management Protocols used is PKMv2	Step 4	PKMv2	OK	AeroMACS_VO_Interop_11_D
4.	Data Msg	Data Msgs have the payload encrypted	Step 5	Encrypted data payload	OK	AeroMACS_VO_Interop_11_F

7.1.4.3.2 Analysis of Verification Exercise Results

The ASN-GW was configured in order to require Authentication to the MS entering the Network; BS and MS were switched on, and the MS started the Net Entry procedure, that was completed successfully. Concerning the Authentication procedure, Wireshark log in Figure 7-12 shows the “Client Hello” message sent by the BS (125.125.40.32, on behalf of the MS) to the ASN-GW (125.125.40.48) starting the Handshake for Authentication, In particular the picture shows the Cipher Suites supported by the MS. The ASN-GW will then select one of the supported suites in a subsequent “Server Hello” message, containing also the BS Certificate (see Figure 7-13). So it is possible to see that the MS and BS negotiate the AES128 Encryption method for data plane.

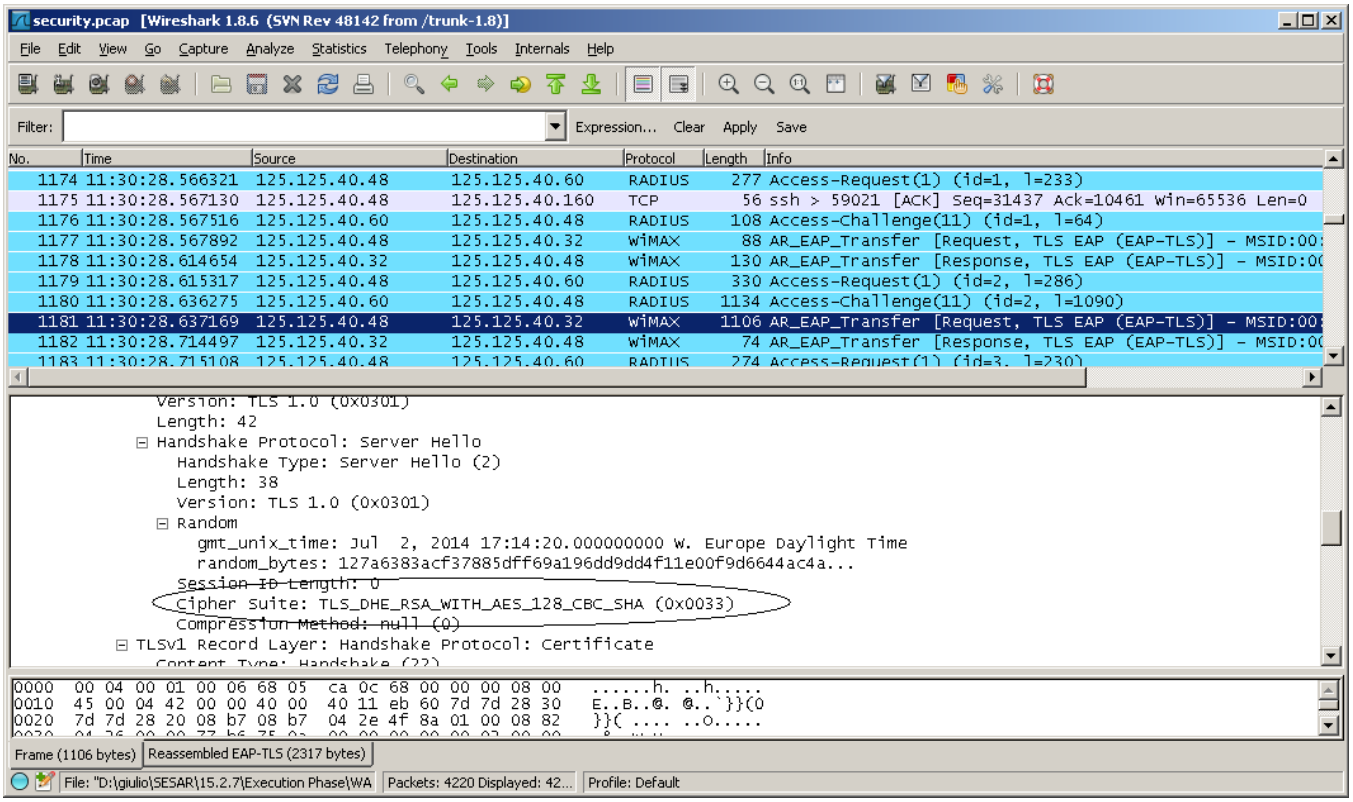


```
No.   Time            Source          Destination      Protocol  Length Info
 1174 11:30:28.566321 125.125.40.48   125.125.40.60    RADIUS     277 Access-Request(1) (id=1, l=233)
 1175 11:30:28.567130 125.125.40.48   125.125.40.160   TCP         56 ssh > 59021 [ACK] Seq=31437 Ack=10461 Win=65536 Len=0
 1176 11:30:28.567516 125.125.40.60   125.125.40.48    RADIUS     108 Access-Challenge(11) (id=1, l=64)
 1177 11:30:28.567892 125.125.40.48   125.125.40.32    WiMAX       88 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:00:
 1178 11:30:28.614654 125.125.40.32   125.125.40.48    WiMAX      130 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:0(
 1179 11:30:28.615317 125.125.40.48   125.125.40.60    RADIUS     330 Access-Request(1) (id=2, l=286)
 1180 11:30:28.636275 125.125.40.60   125.125.40.48    RADIUS    1134 Access-Challenge(11) (id=2, l=1090)
 1181 11:30:28.637169 125.125.40.48   125.125.40.32    WiMAX     1106 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:00:
 1182 11:30:28.714497 125.125.40.32   125.125.40.48    WiMAX       74 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:0(
 1183 11:30:28.715108 125.125.40.48   125.125.40.60    RADIUS     274 Access-Request(1) (id=3, l=230)
```

```
      Handshake Type: Client Hello (1)
      Length: 43
      Version: TLS 1.0 (0x0301)
    ⊟ Random
        gmt_unix_time: Jul  2, 2014 08:30:35.000000000 W. Europe Daylight Time
        random_bytes: 1451037c54fe1d166ae9cf0138559e7246a00f714727c305...
      Session ID Length: 0
      Cipher Suites Length: 4
    ⊟ Cipher Suites (2 suites)
        Cipher Suite: TLS_DHE_RSA_WITH_AES_128_CBC_SHA (0x0033)
        Cipher Suite: TLS_RSA_WITH_AES_128_CBC_SHA (0x002f)
      Compression Methods Length: 1
    ⊞ Compression Methods (1 method)
```

```
0050  01 00 2f 01 00 00 2b 03  01 53 b3 a7 0b 14 51 03   ../...+. .S....Q.
0060  7c 54 fe 1d 16 6a e9 cf  01 38 55 9e 72 46 a0 0f   |T...j.. .8U.rF..
0070  71 47 27 c3 05 0f f5 53  ca 00 00 04 00 33 00 2f   qG'....S .....3./
0080  01 00                                              ..
```

Figure 7-12: Cipher Suites supported by MS



```
No.  Time             Source          Destination      Protocol Length Info
1174 11:30:28.566321  125.125.40.48   125.125.40.60    RADIUS    277 Access-Request(1) (id=1, l=233)
1175 11:30:28.567130  125.125.40.48   125.125.40.160   TCP        56 ssh > 59021 [ACK] Seq=31437 Ack=10461 Win=65536 Len=0
1176 11:30:28.567516  125.125.40.60   125.125.40.48    RADIUS    108 Access-Challenge(11) (id=1, l=64)
1177 11:30:28.567892  125.125.40.48   125.125.40.32    WiMAX      88 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:00:
1178 11:30:28.614654  125.125.40.32   125.125.40.48    WiMAX     130 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:0(
1179 11:30:28.615317  125.125.40.48   125.125.40.60    RADIUS    330 Access-Request(1) (id=2, l=286)
1180 11:30:28.636275  125.125.40.60   125.125.40.48    RADIUS   1134 Access-Challenge(11) (id=2, l=1090)
1181 11:30:28.637169  125.125.40.48   125.125.40.32    WiMAX    1106 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:00:
1182 11:30:28.714497  125.125.40.32   125.125.40.48    WiMAX      74 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:0(
1183 11:30:28.715108  125.125.40.48   125.125.40.60    RADIUS    274 Access-Request(1) (id=3, l=230)
```

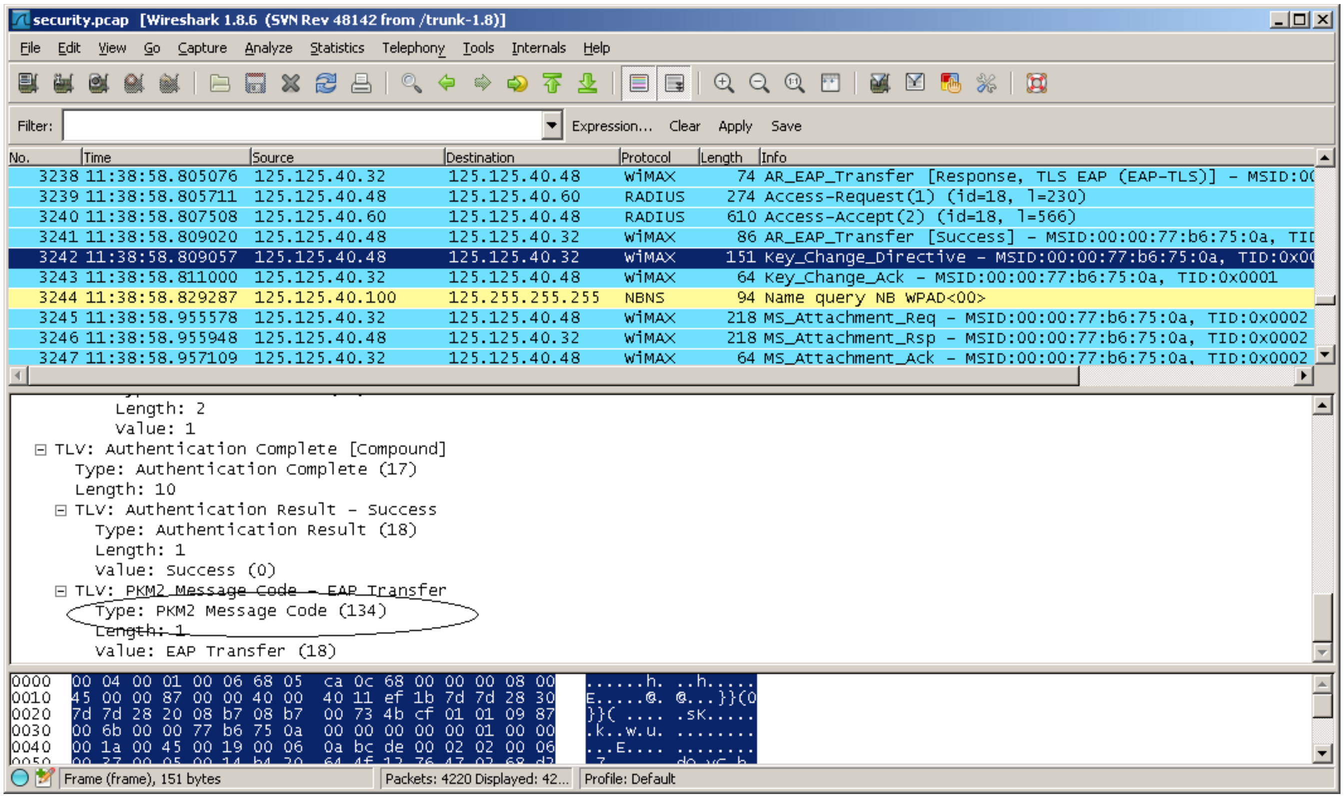
```
        Version: TLS 1.0 (0x0301)
        Length: 42
      ⊟ Handshake Protocol: Server Hello
          Handshake Type: Server Hello (2)
          Length: 38
          Version: TLS 1.0 (0x0301)
        ⊟ Random
            gmt_unix_time: Jul  2, 2014 17:14:20.000000000 W. Europe Daylight Time
            random_bytes: 127a6383acf37885dff69a196dd9dd4f11e00f9d6644ac4a...
          Session ID Length: 0
          Cipher Suite: TLS_DHE_RSA_WITH_AES_128_CBC_SHA (0x0033)
          Compression Method: null (0)
    ⊟ TLSv1 Record Layer: Handshake Protocol: Certificate
        Content Type: Handshake (22)
```

```
0000  00 04 00 01 00 06 68 05  ca 0c 68 00 00 00 08 00   ......h. ..h.....
0010  45 00 04 42 00 00 40 00  40 11 eb 60 7d 7d 28 30   E..B..@. @..`}}(0
0020  7d 7d 28 20 08 b7 08 b7  04 2e 4f 8a 01 00 08 82   }}( .... ..O.....
```

Figure 7-13: "Server Hello" from ASN-GW

After the successful MS authentication, the subsequent phase of Registration started. It is possible to observe in Figure 7-14 that the PKMv2 is used. From this point on, all of the Data exchanged between BS and MS were cyphered, and the proper reception at the addressee was observed.

After the expiration of the AK Lifetime timer, the proper Re-Authentication was observed.

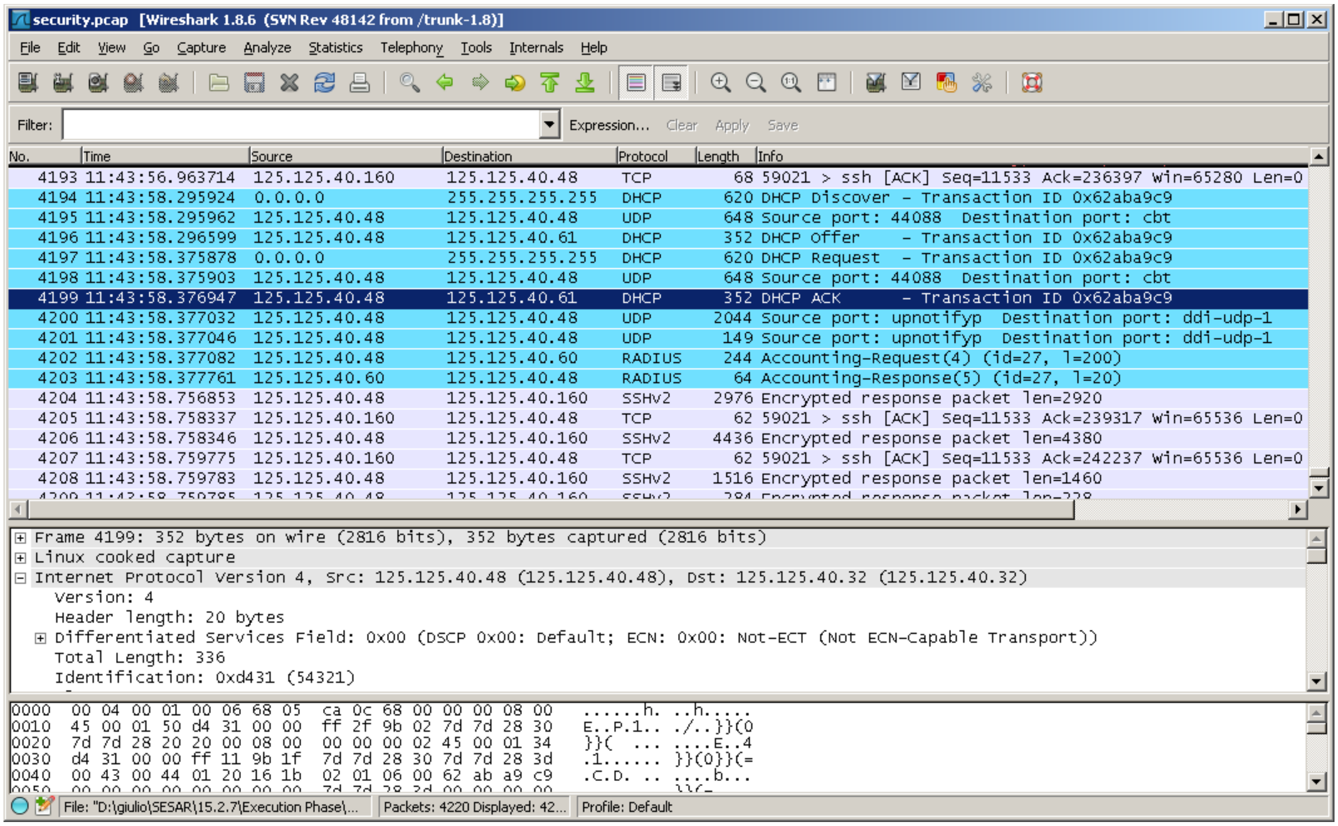


```
No.  Time            Source          Destination      Protocol Length Info
3238 11:38:58.805076 125.125.40.32   125.125.40.48    WiMAX      74 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:0(
3239 11:38:58.805711 125.125.40.48   125.125.40.60    RADIUS    274 Access-Request(1) (id=18, l=230)
3240 11:38:58.807508 125.125.40.60   125.125.40.48    RADIUS    610 Access-Accept(2) (id=18, l=566)
3241 11:38:58.809020 125.125.40.48   125.125.40.32    WiMAX      86 AR_EAP_Transfer [Success] - MSID:00:00:77:b6:75:0a, TID
3242 11:38:58.809057 125.125.40.48   125.125.40.32    WiMAX     151 Key_Change_Directive - MSID:00:00:77:b6:75:0a, TID:0x0(
3243 11:38:58.811000 125.125.40.32   125.125.40.48    WiMAX      64 Key_Change_Ack - MSID:00:00:77:b6:75:0a, TID:0x0001
3244 11:38:58.829287 125.125.40.100  125.255.255.255  NBNS       94 Name query NB WPAD<00>
3245 11:38:58.955578 125.125.40.32   125.125.40.48    WiMAX     218 MS_Attachment_Req - MSID:00:00:77:b6:75:0a, TID:0x0002
3246 11:38:58.955948 125.125.40.48   125.125.40.32    WiMAX     218 MS_Attachment_Rsp - MSID:00:00:77:b6:75:0a, TID:0x0002
3247 11:38:58.957109 125.125.40.32   125.125.40.48    WiMAX      64 MS_Attachment_Ack - MSID:00:00:77:b6:75:0a, TID:0x0002
```

```
          Length: 2
          Value: 1
  ⊟ TLV: Authentication Complete [Compound]
      Type: Authentication Complete (17)
      Length: 10
    ⊟ TLV: Authentication Result - Success
        Type: Authentication Result (18)
        Length: 1
        Value: Success (0)
    ⊟ TLV: PKM2 Message Code - EAP Transfer
        Type: PKM2 Message Code (134)
        Length: 1
        Value: EAP Transfer (18)
```

```
0000  00 04 00 01 00 06 68 05  ca 0c 68 00 00 00 08 00   ......h. ..h.....
0010  45 00 00 87 00 00 40 00  40 11 ef 1b 7d 7d 28 30   E.....@. @...}}(0
0020  7d 7d 28 20 08 b7 08 b7  00 73 4b cf 01 01 09 87   }}( .... .sK.....
0030  00 6b 00 00 77 b6 75 0a  00 00 00 00 00 01 00 00   .k..w.u. ........
0040  00 1a 00 45 00 19 00 06  0a bc de 00 02 02 00 06   ...E.... ........
```

Figure 7-14: Privacy Key Management Protocol



```
No.    Time            Source            Destination       Protocol  Length Info
  4193 11:43:56.963714 125.125.40.160    125.125.40.48     TCP          68 59021 > ssh [ACK] Seq=11533 Ack=236397 Win=65280 Len=0
  4194 11:43:58.295924 0.0.0.0           255.255.255.255   DHCP        620 DHCP Discover - Transaction ID 0x62aba9c9
  4195 11:43:58.295962 125.125.40.48     125.125.40.48     UDP         648 Source port: 44088  Destination port: cbt
  4196 11:43:58.296599 125.125.40.48     125.125.40.61     DHCP        352 DHCP Offer    - Transaction ID 0x62aba9c9
  4197 11:43:58.375878 0.0.0.0           255.255.255.255   DHCP        620 DHCP Request  - Transaction ID 0x62aba9c9
  4198 11:43:58.375903 125.125.40.48     125.125.40.48     UDP         648 Source port: 44088  Destination port: cbt
  4199 11:43:58.376947 125.125.40.48     125.125.40.61     DHCP        352 DHCP ACK      - Transaction ID 0x62aba9c9
  4200 11:43:58.377032 125.125.40.48     125.125.40.48     UDP        2044 Source port: upnotifyp  Destination port: ddi-udp-1
  4201 11:43:58.377046 125.125.40.48     125.125.40.48     UDP         149 Source port: upnotifyp  Destination port: ddi-udp-1
  4202 11:43:58.377082 125.125.40.48     125.125.40.60     RADIUS      244 Accounting-Request(4) (id=27, l=200)
  4203 11:43:58.377761 125.125.40.60     125.125.40.48     RADIUS       64 Accounting-Response(5) (id=27, l=20)
  4204 11:43:58.756853 125.125.40.48     125.125.40.160    SSHv2      2976 Encrypted response packet len=2920
  4205 11:43:58.758337 125.125.40.160    125.125.40.48     TCP          62 59021 > ssh [ACK] Seq=11533 Ack=239317 Win=65536 Len=0
  4206 11:43:58.758346 125.125.40.48     125.125.40.160    SSHv2      4436 Encrypted response packet len=4380
  4207 11:43:58.759775 125.125.40.160    125.125.40.48     TCP          62 59021 > ssh [ACK] Seq=11533 Ack=242237 Win=65536 Len=0
  4208 11:43:58.759783 125.125.40.48     125.125.40.160    SSHv2      1516 Encrypted response packet len=1460

⊞ Frame 4199: 352 bytes on wire (2816 bits), 352 bytes captured (2816 bits)
⊞ Linux cooked capture
⊟ Internet Protocol Version 4, Src: 125.125.40.48 (125.125.40.48), Dst: 125.125.40.32 (125.125.40.32)
    Version: 4
    Header length: 20 bytes
  ⊞ Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00: Not-ECT (Not ECN-Capable Transport))
    Total Length: 336
    Identification: 0xd431 (54321)

0000  00 04 00 01 00 06 68 05  ca 0c 68 00 00 00 08 00   ......h. ..h.....
0010  45 00 01 50 d4 31 00 00  ff 2f 9b 02 7d 7d 28 30   E..P.1.. ./..}}(0
0020  7d 7d 28 20 20 00 08 00  00 00 00 02 45 00 01 34   }}(  ... ....E..4
0030  d4 31 00 00 ff 11 9b 1f  7d 7d 28 30 7d 7d 28 3d   .1...... }}(0}}(=
0040  00 43 00 44 01 20 16 1b  02 01 06 00 62 ab a9 c9   .C.D. .. ....b...
```

Figure 7-15: First cyphered messages after Authentication: DHCP

7.1.4.4 Conclusions and recommendations

It was verified that, after Authentication, Data are properly encrypted, according to the required Private Key Management Protocol.

7.1.5 Verification Exercise # P2_LAB1_5 Radio Characteristic Requirements

7.1.5.1 Verification Exercise Scope

Scope of this Test is to estimate the tolerated co-channel OFDMA signal and the capability to recover and operate correctly when the co-channel is removed.

7.1.5.2 Conduct of Verification Exercise

7.1.5.2.1 Verification Exercise Preparation

The test bed described in Figure 3-2 was arranged.

7.1.5.2.2 Verification Exercise execution

Step nr.	Action	Action description (if needed)	PCO (Point of Control and Observation)	Result
1.	Switch on MS			OK
2.	Switch on BS (BS1)	BS switched on with PTX = 30 dBm		OK
3.	Verify the frequency filter for each channel of the BS prototype			OK
4.	Verify that MS connects successfully		Mngt PCs connected to MS and BS	OK
5.	Measure RSSI level received at MS		Mngt PCs connected to MS	OK
6.	Switch on the interfering device at the same frequency as MS/BS, applying the maximum possible attenuation	As BS2 TX power is equal to 30 dBm, an initial attenuation equal to 130 dB was set	Use another BS (BS2)	OK
7.	Gradually reduce the attenuation for BS2, until the MS loses the link with BS1		Variable attenuator	OK
8.	Measure the attenuation that caused the link loss		Variable attenuator	OK
9.	Calculate the cochannel interference that caused the loss			OK
10.	Raise again the attenuation affecting the interfering device		Variable attenuator	OK
11.	Verify that the MS registers again on BS1		Mngt PC connected to BS	OK

7.1.5.2.3 Deviation from the planned activities

None.

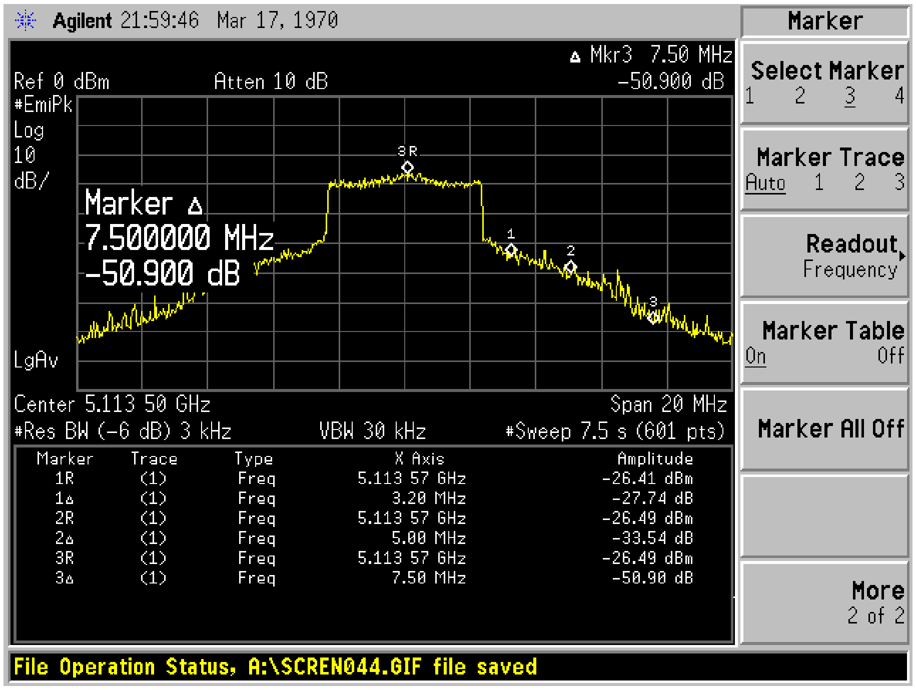
7.1.5.3 Verification exercise Results

7.1.5.3.1 Summary of Verification exercise Results

ID	Result	Description	When observed?	Expected result	Obtained result	VO
1	Frequency filter	Verify the frequency filter for each channel of the BS prototype	Step 3	Measurement of the frequency filter for each channel	OK	**AeroMACS_VO_RFReal_01_B**
2	Co-Channel	Test the tolerated co-channel OFDMA signal	Step 9	Co-channel rejection capability	OK	**AeroMACS_VO_RF_04_A**

7.1.5.3.2 Analysis of Verification Exercise Results

The frequency filter for each channel of the BS prototype was verified. Figure 7-16 shows an example for the 5113.5 MHz channel.



```
Agilent 21:59:46  Mar 17, 1970
                                             △ Mkr3  7.50 MHz
Ref 0 dBm          Atten 10 dB                    -50.900 dB
#EmiPk
Marker △
7.500000 MHz
-50.900 dB
Center 5.113 50 GHz                                 Span 20 MHz
#Res BW (-6 dB) 3 kHz      VBW 30 kHz     #Sweep 7.5 s (601 pts)
 Marker    Trace     Type        X Axis          Amplitude
   1R       (1)      Freq     5.113 57 GHz      -26.41 dBm
   1△       (1)      Freq         3.20 MHz       -27.74 dB
   2R       (1)      Freq     5.113 57 GHz      -26.49 dBm
   2△       (1)      Freq         5.00 MHz       -33.54 dB
   3R       (1)      Freq     5.113 57 GHz      -26.49 dBm
   3△       (1)      Freq         7.50 MHz       -50.90 dB
File Operation Status, A:\SCREN044.GIF file saved
```

Figure 7-16: Frequency filter at 5113.5 MHz

Then, the MS was switched on and executed the complete Net Entry. The received power level received by the MS was measured as -70 dBm. (BS1 TX Power = 30 dBm and total attenuation = 100 dB).

All the steps described in 7.1.5.2.2 were executed, and it was verified that the MS lost the link when the attenuation affecting BS2 transmission was 10 dB lower than the one affecting BS1 transmission. This indicated a co-channel rejection capability estimate equal to 10 dB.

7.1.5.3.3 Unexpected behaviors/results

None

7.1.5.4 Conclusions and recommendations

The testing allowed proper estimation of the tolerated co-channel OFDMA signal and the capability to recover and operate correctly when the co-channel is removed.

7.1.6 Verification Exercise # P2_LAB1_6 Limited IOT Requirements

7.1.6.1 Verification Exercise Scope

The scope of this Exercise is verifying basic interoperability capability between prototypes from Selex ES and Thales. The verification scenario in this section is limited to one BS with a static MS to check that the various steps of the Initial Network Entry are properly executed.

7.1.6.2 Conduct of Verification Exercise

7.1.6.2.1 Verification Exercise Preparation

The Test Bed used in the SELEX ES Labs for the Air Interface Limited Interoperability Tests is the same reported in Figure 3-2, in which the Mobile Station was a Thales Mobile Station. In particular:

- the ASN-GW used was a COTS Aricent Wing 4.2.0 ASN-GW, compatible with WMF NWG 1.2.
- the AAA Server used was FreeRADIUS 2.1.3.1 (see [4] for details).
- Wireshark 1.8.6 was used to monitor the messages exchange between the Thales MS and the ASN-GW/AAA Server

7.1.6.2.2 Verification Exercise execution

Step nr.	Action	Action description (if needed)	PCO (Point of Control and Observation)	Result
1.	Switch on MS			
2.	Switch on BS			
3.	Verify that MS starts off with the scanning of the spectrum. Verify that the correct expected broadcast messages are exchanged, and the preamble is correctly decoded by the MS.		Mngt PCs connected to MS and BS	OK
4.	Verify that, after successful DL Synchronization, MS and BS exchanges the proper RNG-REQ/RNG-RSP messages, completing the Initial		Mngt PCs connected to MS and BS	OK

	Ranging			
5.	Verify the correct exchange of Service Basic Capability informations		Mngt PCs connected to MS and BS	OK
6.	Verify the Security associations and key exchange that concern only to the "air interface" as part of the MS Authentication and Authorization procedures		Mngt PCs connected to MS and BS	NOK
7.	Verify that BS and MS successfully conclude the registration procedure		Mngt PCs connected to MS and BS	NT

7.1.6.2.3 Deviation from the planned activities

It was not possible to complete the last step of the test: step number 7 above as authentication/authorization in step 6 failed.
The reasons for the MS Certificate Authentication failure by the AAA Server were investigated by Selex ES and Thales teams, for more information about the results of this investigation refer to7.1.6.3.3.

7.1.6.3 Verification exercise Results

7.1.6.3.1 Summary of Verification exercise Results

ID	Result	Description	When observed?	Expected result	Obtained result	VO
1	Scanning and synchronization	Verify that scanning and synchronization are correctly performed	Step 3	Synchronization	OK	AeroMACS_VO_Limited Interop_A
2	Initial Ranging	Verify that Initial Ranging is correctly performed	Step 4	Initial ranging executed	OK	AeroMACS_VO_Limited Interop_B
3	Basic Capabilities Negotiation	Verify the correct exchange of SBC information	Step 5	SBC_REQ/SBC_RSP properly exchanged	OK	AeroMACS_VO_Limited Interop_C
4	Admission control	Verify that Authentication and Authorization procedures are correctly executed on MS and BS side	Step 6	Verify that MS is authenticated by the Ground System	NOK	AeroMACS_VO_Limited Interop_D
5	Registration	Verify that BS and MS	Step 7	Verify that BS and MS	NT	AeroMACS_VO_Limited

		successfully conclude the registration procedure		successfully conclude the registration procedure		Interop_E

7.1.6.3.2 Analysis of Verification Exercise Results

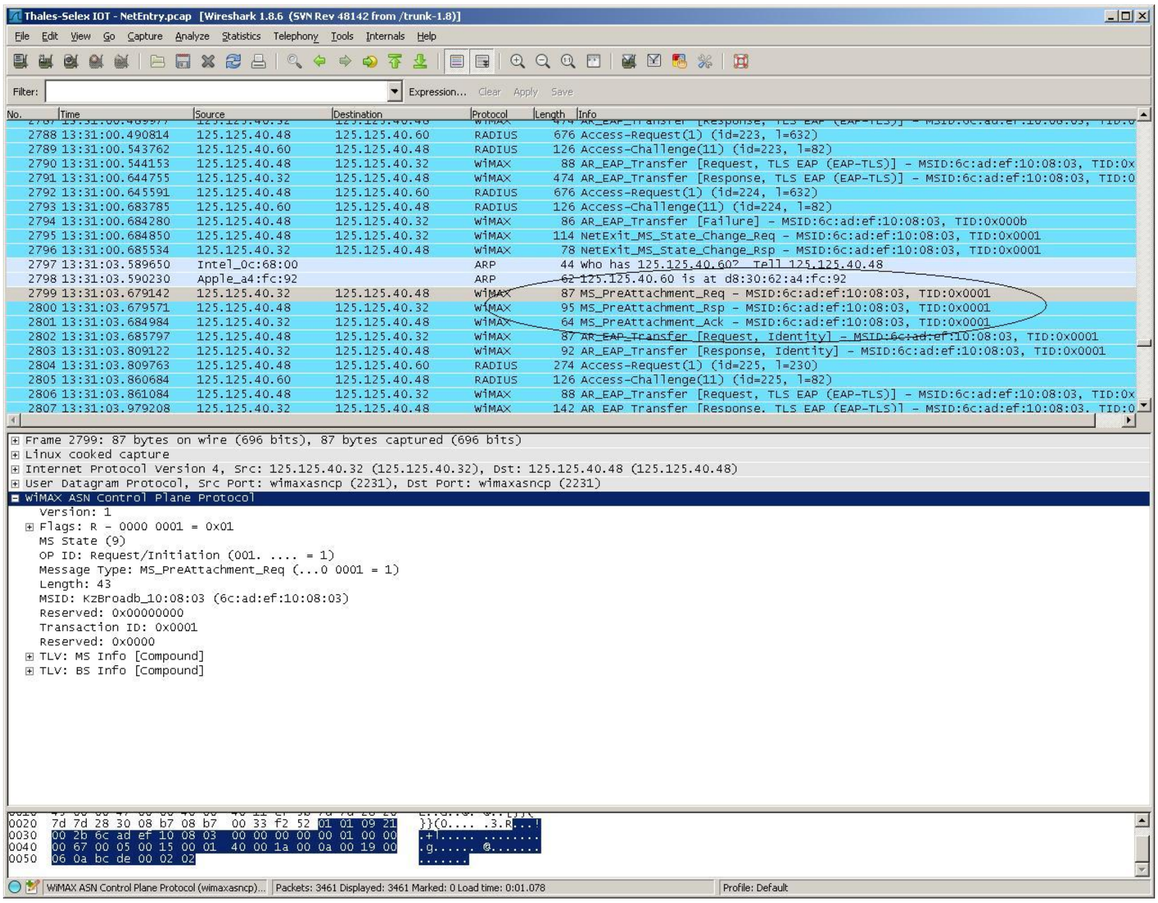
The Thales MS was switched on and started the Spectrum Scanning. Then the Selex BS was switched on, and started transmitting broadcast information.

In order to check the proper execution of the various net Entry phases, the messages exchange between MS and ASN-GW/AAA Server was monitored, using Wireshark.

Figure 7-17 shows the sequence of Pre-attachment messages between MS (IP address = 125.125.40.32) and ASN-GW (IP address = 125.125.40.48).

The first MS_PreAttachment Req message from the MS to the ASN-GW indicates that the MS has successfully executed the Scanning/Synchronization and Initial Ranging Phases (Result IDs 1 and 2), and sent the SBC-REQ to the BS, starting the Basic Capabilities Negotiation.

The subsequent PreAttachment Response and Acknowledgement testify the completion of the Basic Capabilities exchange, during which the MS and BS negotiate the Authorization Policy (PKMv2, EAP_TLS).



```
No.  Time            Source            Destination     Protocol Length Info
2788 13:31:00.490814 125.125.40.48     125.125.40.60   RADIUS    676 Access-Request(1) (id=223, l=632)
2789 13:31:00.543762 125.125.40.60     125.125.40.48   RADIUS    126 Access-Challenge(11) (id=223, l=82)
2790 13:31:00.544153 125.125.40.48     125.125.40.32   WiMAX      88 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
2791 13:31:00.644755 125.125.40.32     125.125.40.48   WiMAX     474 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
2792 13:31:00.645591 125.125.40.48     125.125.40.60   RADIUS    676 Access-Request(1) (id=224, l=632)
2793 13:31:00.683785 125.125.40.60     125.125.40.48   RADIUS    126 Access-Challenge(11) (id=224, l=82)
2794 13:31:00.684280 125.125.40.48     125.125.40.32   WiMAX      86 AR_EAP_Transfer [Failure] - MSID:6c:ad:ef:10:08:03, TID:0x000b
2795 13:31:00.684850 125.125.40.48     125.125.40.32   WiMAX     114 NetExit_MS_State_Change_Req - MSID:6c:ad:ef:10:08:03, TID:0x0001
2796 13:31:00.685534 125.125.40.32     125.125.40.48   WiMAX      78 NetExit_MS_State_Change_Rsp - MSID:6c:ad:ef:10:08:03, TID:0x0001
2797 13:31:03.589650 Intel_0c:68:00                   ARP        44 Who has 125.125.40.60?  Tell 125.125.40.48
2798 13:31:03.590230 Apple_a4:fc:92                   ARP        62 125.125.40.60 is at d8:30:62:a4:fc:92
2799 13:31:03.679142 125.125.40.32     125.125.40.48   WiMAX      87 MS_PreAttachment_Req - MSID:6c:ad:ef:10:08:03, TID:0x0001
2800 13:31:03.679571 125.125.40.48     125.125.40.32   WiMAX      95 MS_PreAttachment_Rsp - MSID:6c:ad:ef:10:08:03, TID:0x0001
2801 13:31:03.684984 125.125.40.32     125.125.40.48   WiMAX      64 MS_PreAttachment_Ack - MSID:6c:ad:ef:10:08:03, TID:0x0001
2802 13:31:03.685797 125.125.40.48     125.125.40.32   WiMAX      87 AR_EAP_Transfer [Request, Identity] - MSID:6c:ad:ef:10:08:03, TID:0x0001
2803 13:31:03.809122 125.125.40.32     125.125.40.48   WiMAX      92 AR_EAP_Transfer [Response, Identity] - MSID:6c:ad:ef:10:08:03, TID:0x0001
2804 13:31:03.809763 125.125.40.48     125.125.40.60   RADIUS    274 Access-Request(1) (id=225, l=230)
2805 13:31:03.860684 125.125.40.60     125.125.40.48   RADIUS    126 Access-Challenge(11) (id=225, l=82)
2806 13:31:03.861084 125.125.40.48     125.125.40.32   WiMAX      88 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
2807 13:31:03.979208 125.125.40.32     125.125.40.48   WiMAX     142 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
```

```
⊞ Frame 2799: 87 bytes on wire (696 bits), 87 bytes captured (696 bits)
⊞ Linux cooked capture
⊞ Internet Protocol Version 4, Src: 125.125.40.32 (125.125.40.32), Dst: 125.125.40.48 (125.125.40.48)
⊞ User Datagram Protocol, Src Port: wimaxasncp (2231), Dst Port: wimaxasncp (2231)
⊟ WiMAX ASN Control Plane Protocol
    Version: 1
  ⊞ Flags: R - 0000 0001 = 0x01
    MS State (9)
    OP ID: Request/Initiation (001. .... = 1)
    Message Type: MS_PreAttachment_Req (...0 0001 = 1)
    Length: 43
    MSID: KzBroadb_10:08:03 (6c:ad:ef:10:08:03)
    Reserved: 0x00000000
    Transaction ID: 0x0001
    Reserved: 0x0000
  ⊞ TLV: MS Info [Compound]
  ⊞ TLV: BS Info [Compound]
```

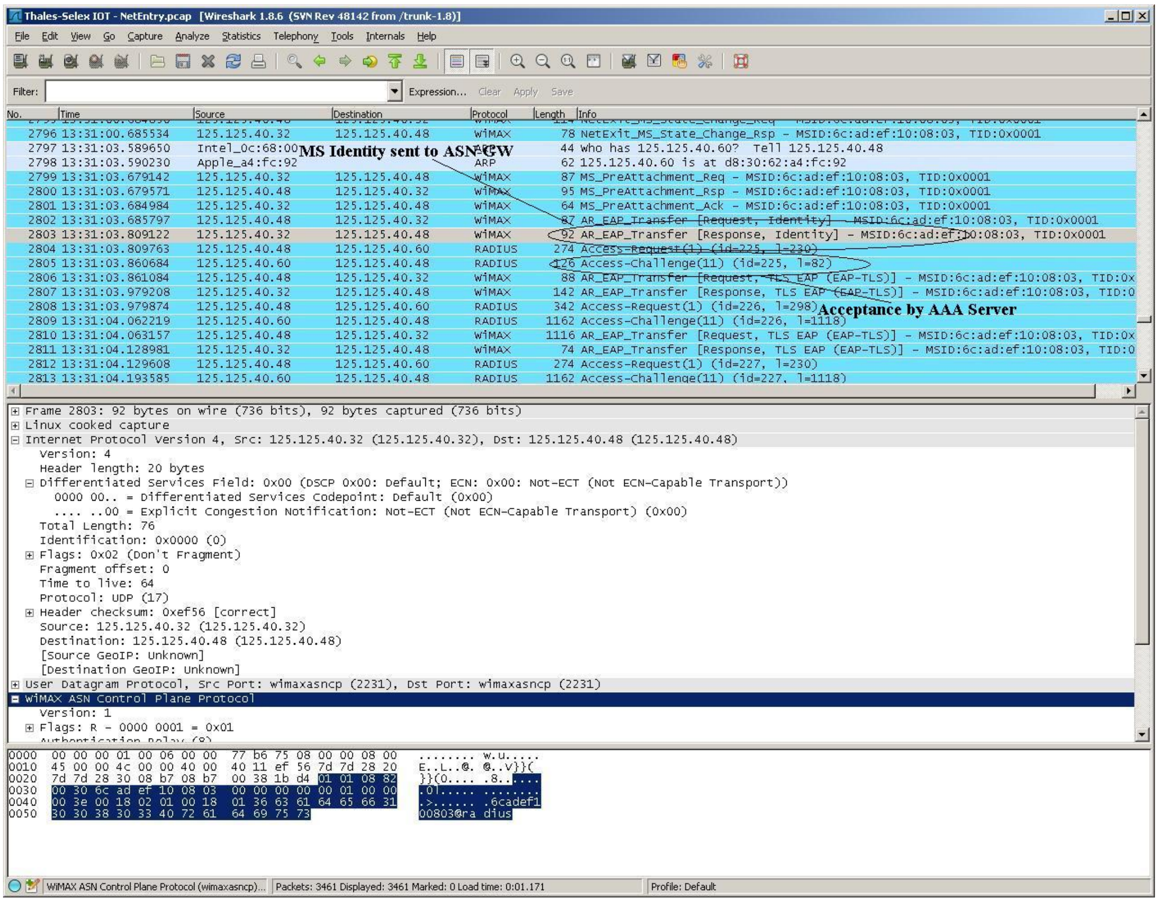
```
0020  7d 7d 28 30 08 b7 08 b7  00 33 f2 52 01 01 09 21   }}(0.... .3.R...!
0030  00 2b 6c ad ef 10 08 03  00 00 00 00 00 01 00 00   .+l..... ........
0040  00 67 00 05 00 15 00 01  40 00 1a 00 0a 00 19 00   .g...... @.......
0050  06 0a bc de 00 02 02                               .......
```

```
WiMAX ASN Control Plane Protocol (wimaxasncp)... | Packets: 3461 Displayed: 3461 Marked: 0 Load time: 0:01.078 | Profile: Default
```

Figure 7-17: Net Entry - Pre-attachment

Subsequently, the Authentication procedure started. The MS sent its Identity (NAI) by means of a PKMv2-REQ message to the BS, which forwarded it to the ASN-GW by means of a AuthRelay_EAP_Transfer_Response message (packet n° 2803 in Figure 7-18).

The Identity was then forwarded to the AAA-Server (IP address = 125.125.40.60) for its acceptance, that happened properly (packet n°2805 in Figure 7-18).



```
No.  Time            Source            Destination     Protocol Length Info
2796 13:31:00.685534 125.125.40.32     125.125.40.48   WiMAX      78 NetExit_MS_State_Change_Rsp - MSID:6c:ad:ef:10:08:03, TID:0x0001
2797 13:31:03.589650 Intel_0c:68:00                    ARP        44 Who has 125.125.40.60?  Tell 125.125.40.48
2798 13:31:03.590230 Apple_a4:fc:92                    ARP        62 125.125.40.60 is at d8:30:62:a4:fc:92
2799 13:31:03.679142 125.125.40.32     125.125.40.48   WiMAX      87 MS_PreAttachment_Req - MSID:6c:ad:ef:10:08:03, TID:0x0001
2800 13:31:03.679571 125.125.40.48     125.125.40.32   WiMAX      95 MS_PreAttachment_Rsp - MSID:6c:ad:ef:10:08:03, TID:0x0001
2801 13:31:03.684984 125.125.40.32     125.125.40.48   WiMAX      64 MS_PreAttachment_Ack - MSID:6c:ad:ef:10:08:03, TID:0x0001
2802 13:31:03.685797 125.125.40.48     125.125.40.32   WiMAX      87 AR_EAP_Transfer [Request, Identity] - MSID:6c:ad:ef:10:08:03, TID:0x0001
2803 13:31:03.809122 125.125.40.32     125.125.40.48   WiMAX      92 AR_EAP_Transfer [Response, Identity] - MSID:6c:ad:ef:10:08:03, TID:0x0001
2804 13:31:03.809763 125.125.40.48     125.125.40.60   RADIUS    274 Access-Request(1) (id=225, l=230)
2805 13:31:03.860684 125.125.40.60     125.125.40.48   RADIUS    126 Access-Challenge(11) (id=225, l=82)
2806 13:31:03.861084 125.125.40.48     125.125.40.32   WiMAX      88 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
2807 13:31:03.979208 125.125.40.32     125.125.40.48   WiMAX     142 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
2808 13:31:03.979874 125.125.40.48     125.125.40.60   RADIUS    342 Access-Request(1) (id=226, l=298)
2809 13:31:04.062219 125.125.40.60     125.125.40.48   RADIUS   1162 Access-Challenge(11) (id=226, l=1118)
2810 13:31:04.063157 125.125.40.48     125.125.40.32   WiMAX    1116 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
2811 13:31:04.128981 125.125.40.32     125.125.40.48   WiMAX      74 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
2812 13:31:04.129608 125.125.40.48     125.125.40.60   RADIUS    274 Access-Request(1) (id=227, l=230)
2813 13:31:04.193585 125.125.40.60     125.125.40.48   RADIUS   1162 Access-Challenge(11) (id=227, l=1118)
```

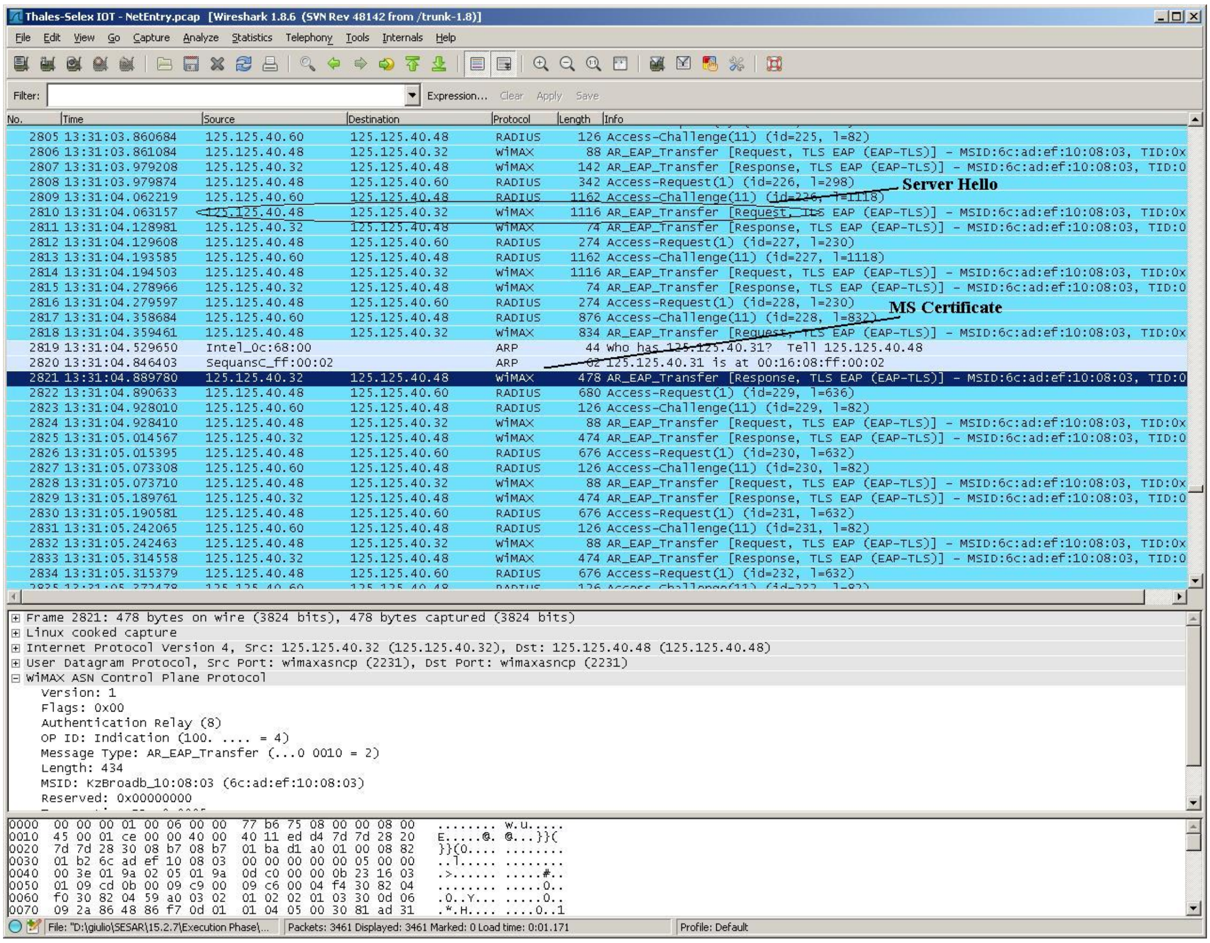
```
⊞ Frame 2803: 92 bytes on wire (736 bits), 92 bytes captured (736 bits)
⊞ Linux cooked capture
⊟ Internet Protocol Version 4, Src: 125.125.40.32 (125.125.40.32), Dst: 125.125.40.48 (125.125.40.48)
    Version: 4
    Header length: 20 bytes
  ⊟ Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00: Not-ECT (Not ECN-Capable Transport))
      0000 00.. = Differentiated Services Codepoint: Default (0x00)
      .... ..00 = Explicit Congestion Notification: Not-ECT (Not ECN-Capable Transport) (0x00)
    Total Length: 76
    Identification: 0x0000 (0)
  ⊞ Flags: 0x02 (Don't Fragment)
    Fragment offset: 0
    Time to live: 64
    Protocol: UDP (17)
  ⊞ Header checksum: 0xef56 [correct]
    Source: 125.125.40.32 (125.125.40.32)
    Destination: 125.125.40.48 (125.125.40.48)
    [Source GeoIP: Unknown]
    [Destination GeoIP: Unknown]
⊞ User Datagram Protocol, Src Port: wimaxasncp (2231), Dst Port: wimaxasncp (2231)
⊟ WiMAX ASN Control Plane Protocol
    Version: 1
  ⊞ Flags: R - 0000 0001 = 0x01
    Authentication Relay (8)
```

```
0000  00 00 00 01 00 06 00 00  77 b6 75 08 00 00 08 00   ........ w.u.....
0010  45 00 00 4c 00 00 40 00  40 11 ef 56 7d 7d 28 20   E..L..@. @..V}}( 
0020  7d 7d 28 30 08 b7 08 b7  00 38 1b d4 01 01 08 82   }}(0.... .8......
0030  00 30 6c ad ef 10 08 03  00 00 00 00 00 01 00 00   .0l..... ........
0040  00 3e 00 18 02 01 00 18  01 36 63 61 64 65 66 31   .>...... .6cadef1
0050  30 30 38 30 33 40 72 61  64 69 75 73               00803@ra dius
```

Figure 7-18: Authentication - MS Identity Acceptance

Once the MS Identity was accepted by the AAA Server, the ASN-GW sent a "Server Hello" EAP-TLS Request towards the MS, containing the AAA Server Certificate and asking for the MS Certificate (packet n°2810 in Figure 7-19).

The MS sent an EAP_Response containing its Certificate (packet n°2821 in Figure 7-19).



```
No.   Time            Source             Destination      Protocol  Length Info
 2805 13:31:03.860684 125.125.40.60      125.125.40.48    RADIUS     126 Access-Challenge(11) (id=225, l=82)
 2806 13:31:03.861084 125.125.40.48      125.125.40.32    WiMAX       88 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
 2807 13:31:03.979208 125.125.40.32      125.125.40.48    WiMAX      142 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
 2808 13:31:03.979874 125.125.40.48      125.125.40.60    RADIUS     342 Access-Request(1) (id=226, l=298)
 2809 13:31:04.062219 125.125.40.60      125.125.40.48    RADIUS    1162 Access-Challenge(11) (id=226, l=1118)
 2810 13:31:04.063157 125.125.40.48      125.125.40.32    WiMAX     1116 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
 2811 13:31:04.128981 125.125.40.32      125.125.40.48    WiMAX       74 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
 2812 13:31:04.129608 125.125.40.48      125.125.40.60    RADIUS     274 Access-Request(1) (id=227, l=230)
 2813 13:31:04.193585 125.125.40.60      125.125.40.48    RADIUS    1162 Access-Challenge(11) (id=227, l=1118)
 2814 13:31:04.194503 125.125.40.48      125.125.40.32    WiMAX     1116 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
 2815 13:31:04.278966 125.125.40.32      125.125.40.48    WiMAX       74 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
 2816 13:31:04.279597 125.125.40.48      125.125.40.60    RADIUS     274 Access-Request(1) (id=228, l=230)
 2817 13:31:04.358684 125.125.40.60      125.125.40.48    RADIUS     876 Access-Challenge(11) (id=228, l=832)
 2818 13:31:04.359461 125.125.40.48      125.125.40.32    WiMAX      834 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
 2819 13:31:04.529650 Intel_0c:68:00                      ARP         44 Who has 125.125.40.31?  Tell 125.125.40.48
 2820 13:31:04.846403 SequansC_ff:00:02                   ARP         62 125.125.40.31 is at 00:16:08:ff:00:02
 2821 13:31:04.889780 125.125.40.32      125.125.40.48    WiMAX      478 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
 2822 13:31:04.890633 125.125.40.48      125.125.40.60    RADIUS     680 Access-Request(1) (id=229, l=636)
 2823 13:31:04.928010 125.125.40.60      125.125.40.48    RADIUS     126 Access-Challenge(11) (id=229, l=82)
 2824 13:31:04.928410 125.125.40.48      125.125.40.32    WiMAX       88 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
 2825 13:31:05.014567 125.125.40.32      125.125.40.48    WiMAX      474 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
 2826 13:31:05.015395 125.125.40.48      125.125.40.60    RADIUS     676 Access-Request(1) (id=230, l=632)
 2827 13:31:05.073308 125.125.40.60      125.125.40.48    RADIUS     126 Access-Challenge(11) (id=230, l=82)
 2828 13:31:05.073710 125.125.40.48      125.125.40.32    WiMAX       88 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
 2829 13:31:05.189761 125.125.40.32      125.125.40.48    WiMAX      474 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
 2830 13:31:05.190581 125.125.40.48      125.125.40.60    RADIUS     676 Access-Request(1) (id=231, l=632)
 2831 13:31:05.242065 125.125.40.60      125.125.40.48    RADIUS     126 Access-Challenge(11) (id=231, l=82)
 2832 13:31:05.242463 125.125.40.48      125.125.40.32    WiMAX       88 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
 2833 13:31:05.314558 125.125.40.32      125.125.40.48    WiMAX      474 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
 2834 13:31:05.315379 125.125.40.48      125.125.40.60    RADIUS     676 Access-Request(1) (id=232, l=632)
```

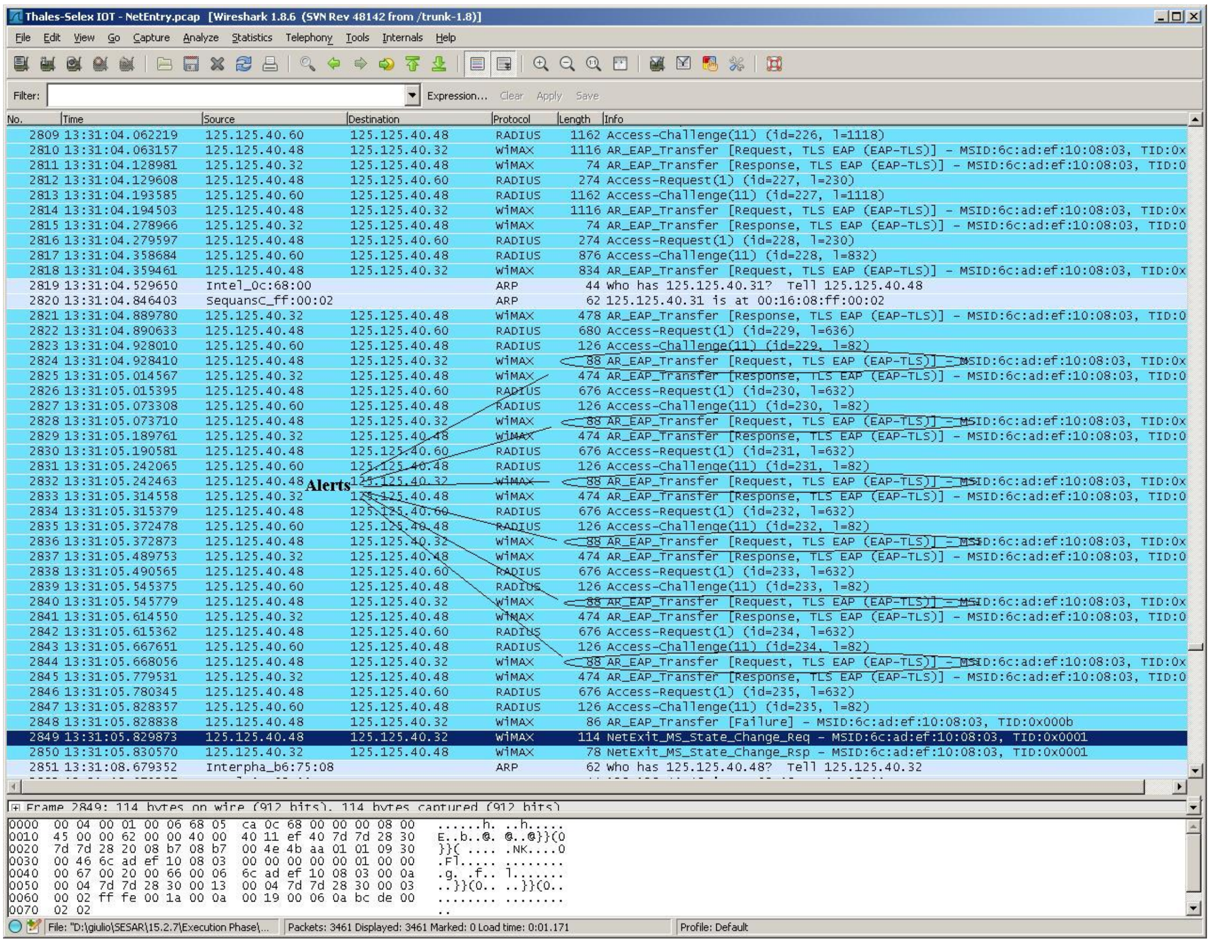
```
⊞ Frame 2821: 478 bytes on wire (3824 bits), 478 bytes captured (3824 bits)
⊞ Linux cooked capture
⊞ Internet Protocol Version 4, Src: 125.125.40.32 (125.125.40.32), Dst: 125.125.40.48 (125.125.40.48)
⊞ User Datagram Protocol, Src Port: wimaxasncp (2231), Dst Port: wimaxasncp (2231)
⊟ WiMAX ASN Control Plane Protocol
    Version: 1
    Flags: 0x00
    Authentication Relay (8)
    OP ID: Indication (100. .... = 4)
    Message Type: AR_EAP_Transfer (...0 0010 = 2)
    Length: 434
    MSID: KzBroadb_10:08:03 (6c:ad:ef:10:08:03)
    Reserved: 0x00000000
```

```
0000  00 00 00 01 00 06 00 00  77 b6 75 08 00 00 08 00   ........ w.u.....
0010  45 00 01 ce 00 00 40 00  40 11 ed d4 7d 7d 28 20   E.....@. @...}}( 
0020  7d 7d 28 30 08 b7 08 b7  01 ba d1 a0 01 00 08 82   }}(0.... ........
0030  01 b2 6c ad ef 10 08 03  00 00 00 00 00 05 00 00   ..l..... ........
0040  00 3e 01 9a 02 05 01 9a  0d c0 00 00 0b 23 16 03   .>...... .....#..
0050  01 09 cd 0b 00 09 c9 00  09 c6 00 04 f4 30 82 04   ........ .....0..
0060  f0 30 82 04 59 a0 03 02  01 02 02 01 03 30 0d 06   .0..Y... .....0..
0070  09 2a 86 48 86 f7 0d 01  01 04 05 00 30 81 ad 31   .*.H.... ....0..1
```

```
File: "D:\giulio\SESAR\15.2.7\Execution Phase\...   Packets: 3461 Displayed: 3461 Marked: 0 Load time: 0:01.171   Profile: Default
```

Figure 7-19: Authentication – Certificates exchange

At this point, after a conversation with the AAA-Server, the ASN-GW answered for 6 times with an Alert message, the MS tried for 6 other times to re-send the certificate, until at packet n°2848 in Figure 7-20 the ASN-GW answered with an Authentication Failure. (This behavior is compliant with RFC5216). The Net Exit was then executed.



```
No.  Time            Source              Destination     Protocol Length Info
2809 13:31:04.062219 125.125.40.60       125.125.40.48   RADIUS   1162 Access-Challenge(11) (id=226, l=1118)
2810 13:31:04.063157 125.125.40.48       125.125.40.32   WiMAX    1116 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
2811 13:31:04.128981 125.125.40.32       125.125.40.48   WiMAX      74 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
2812 13:31:04.129608 125.125.40.48       125.125.40.60   RADIUS    274 Access-Request(1) (id=227, l=230)
2813 13:31:04.193585 125.125.40.60       125.125.40.48   RADIUS   1162 Access-Challenge(11) (id=227, l=1118)
2814 13:31:04.194503 125.125.40.48       125.125.40.32   WiMAX    1116 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
2815 13:31:04.278966 125.125.40.32       125.125.40.48   WiMAX      74 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
2816 13:31:04.279597 125.125.40.48       125.125.40.60   RADIUS    274 Access-Request(1) (id=228, l=230)
2817 13:31:04.358684 125.125.40.60       125.125.40.48   RADIUS    876 Access-Challenge(11) (id=228, l=832)
2818 13:31:04.359461 125.125.40.48       125.125.40.32   WiMAX     834 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
2819 13:31:04.529650 Intel_0c:68:00                      ARP        44 Who has 125.125.40.31?  Tell 125.125.40.48
2820 13:31:04.846403 SequansC_ff:00:02                   ARP        62 125.125.40.31 is at 00:16:08:ff:00:02
2821 13:31:04.889780 125.125.40.32       125.125.40.48   WiMAX     478 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
2822 13:31:04.890633 125.125.40.48       125.125.40.60   RADIUS    680 Access-Request(1) (id=229, l=636)
2823 13:31:04.928010 125.125.40.60       125.125.40.48   RADIUS    126 Access-Challenge(11) (id=229, l=82)
2824 13:31:04.928410 125.125.40.48       125.125.40.32   WiMAX      88 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
2825 13:31:05.014567 125.125.40.32       125.125.40.48   WiMAX     474 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
2826 13:31:05.015395 125.125.40.48       125.125.40.60   RADIUS    676 Access-Request(1) (id=230, l=632)
2827 13:31:05.073308 125.125.40.60       125.125.40.48   RADIUS    126 Access-Challenge(11) (id=230, l=82)
2828 13:31:05.073710 125.125.40.48       125.125.40.32   WiMAX      88 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
2829 13:31:05.189761 125.125.40.32       125.125.40.48   WiMAX     474 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
2830 13:31:05.190581 125.125.40.48       125.125.40.60   RADIUS    676 Access-Request(1) (id=231, l=632)
2831 13:31:05.242065 125.125.40.60       125.125.40.48   RADIUS    126 Access-Challenge(11) (id=231, l=82)
2832 13:31:05.242463 125.125.40.48       125.125.40.32   WiMAX      88 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
2833 13:31:05.314558 125.125.40.32       125.125.40.48   WiMAX     474 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
2834 13:31:05.315379 125.125.40.48       125.125.40.60   RADIUS    676 Access-Request(1) (id=232, l=632)
2835 13:31:05.372478 125.125.40.60       125.125.40.48   RADIUS    126 Access-Challenge(11) (id=232, l=82)
2836 13:31:05.372873 125.125.40.48       125.125.40.32   WiMAX      88 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
2837 13:31:05.489753 125.125.40.32       125.125.40.48   WiMAX     474 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
2838 13:31:05.490565 125.125.40.48       125.125.40.60   RADIUS    676 Access-Request(1) (id=233, l=632)
2839 13:31:05.545375 125.125.40.60       125.125.40.48   RADIUS    126 Access-Challenge(11) (id=233, l=82)
2840 13:31:05.545779 125.125.40.48       125.125.40.32   WiMAX      88 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
2841 13:31:05.614550 125.125.40.32       125.125.40.48   WiMAX     474 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
2842 13:31:05.615362 125.125.40.48       125.125.40.60   RADIUS    676 Access-Request(1) (id=234, l=632)
2843 13:31:05.667651 125.125.40.60       125.125.40.48   RADIUS    126 Access-Challenge(11) (id=234, l=82)
2844 13:31:05.668056 125.125.40.48       125.125.40.32   WiMAX      88 AR_EAP_Transfer [Request, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0x
2845 13:31:05.779531 125.125.40.32       125.125.40.48   WiMAX     474 AR_EAP_Transfer [Response, TLS EAP (EAP-TLS)] - MSID:6c:ad:ef:10:08:03, TID:0
2846 13:31:05.780345 125.125.40.48       125.125.40.60   RADIUS    676 Access-Request(1) (id=235, l=632)
2847 13:31:05.828357 125.125.40.60       125.125.40.48   RADIUS    126 Access-Challenge(11) (id=235, l=82)
2848 13:31:05.828838 125.125.40.48       125.125.40.32   WiMAX      86 AR_EAP_Transfer [Failure] - MSID:6c:ad:ef:10:08:03, TID:0x000b
2849 13:31:05.829873 125.125.40.48       125.125.40.32   WiMAX     114 NetExit_MS_State_Change_Req - MSID:6c:ad:ef:10:08:03, TID:0x0001
2850 13:31:05.830570 125.125.40.32       125.125.40.48   WiMAX      78 NetExit_MS_State_Change_Rsp - MSID:6c:ad:ef:10:08:03, TID:0x0001
2851 13:31:08.679352 Interpha_b6:75:08                   ARP        62 Who has 125.125.40.48?  Tell 125.125.40.32
```

```
⊞ Frame 2849: 114 bytes on wire (912 bits), 114 bytes captured (912 bits)
0000  00 04 00 01 00 06 68 05  ca 0c 68 00 00 00 08 00   ......h. ..h.....
0010  45 00 00 62 00 00 40 00  40 11 ef 40 7d 7d 28 30   E..b..@. @..@}}(0
0020  7d 7d 28 20 08 b7 08 b7  00 4e 4b aa 01 01 09 30   }}( .... .NK....0
0030  00 46 6c ad ef 10 08 03  00 00 00 00 00 01 00 00   .Fl..... ........
0040  00 67 00 20 00 66 00 06  6c ad ef 10 08 03 00 0a   .g. .f.. l.......
0050  00 04 7d 7d 28 30 00 13  00 04 7d 7d 28 30 00 03   ..}}(0.. ..}}(0..
0060  00 02 ff fe 00 1a 00 0a  00 19 00 06 0a bc de 00   ........ ........
0070  02 02                                              ..
```

File: "D:\giulio\SESAR\15.2.7\Execution Phase\... Packets: 3461 Displayed: 3461 Marked: 0 Load time: 0:01.171 Profile: Default

Figure 7-20: Authentication – Net Exit

7.1.6.3.3 Unexpected behaviors/results

The MS Certificate Authentication failure by the AAA Server was investigated by Selex ES and Thales teams, and it was not possible to identify a definitive reason.

One difference noted between the two implementations is that the Thales Ground System and MS Certificate were compliant to a FreeRADIUS version 1.1.7, while the AAA Server used by Selex ES was a FreeRADIUS 2.1.3.1. This could imply differences in the expected MS Certificates, or differences in some expected messages formats (e.g. the AR_EAP_Transfer_Response message sent by the Thales MS and refused by the Selex AAA Server).

Further investigations are recommended, to reach an unambiguous conclusion, using these indications as starting point.

7.1.6.4 Conclusions and recommendations

The testing allowed checking successfully the messages exchanges between BS and MS concerning the phases of Scanning, Synchronization, Initial Ranging, and Basic Capabilities Negotiation. The Authentication failed, and it was not possible to identify a definitive reason. However some useful indications were identified and described in the previous chapters. They can be used as starting point for further investigations.

There are currently discussions ongoing among various standardization Authorities (ICAO, WMF, EUROCAE, RTCA) about the security framework necessary for AeroMACS. There is the need to define a clear Certification Authority scheme, which is required in order to be able to use AeroMACS on a worldwide basis. The results of this test confirm also the need to identify unambiguously the WiMAX network protocols and messages formatting related to Authentication/Encryption.

It is suggested to plan ad-hoc activities with this purpose in the near future (SESAR2020/VLD could be suitable opportunities), to be conducted in strict coordination with the relevant standardization Authorities.

7.2 Thales lab verification exercises

7.2.1 Verification Exercise # TLAB2_010

7.2.1.1 Verification Exercise Scope

Test Service flow control:
Verify the completion of the control messages to successfully complete the creation, change and deletion of a service flow to the MS.

7.2.1.2 Conduct of Verification Exercise

7.2.1.2.1 Verification Exercise Preparation

Lab-test_bed_01 is prepared.

7.2.1.2.2 Verification Exercise execution

Step	action	Action result	PCO	Result
1	Set frequency on the GS : 5093,5 MHz Provision new RF parameter on the GS	New frequency provisioned on GS	GS control MMI Spectrum analyzer	OK
2	Set frequency scan of MS : 5093,5 MHz 5098,5 MHz 50103,5 MHz	MS connects eventually to the GS	GS control MMI	OK
3	Attenuators are tuned to get a high modulation rate (16QAM3/4) Initiate traffic in the DL thanks to the traffic generator (Iperf): Datarate 5 Mbps	Communication established	Iperf	OK
4	Create a new SF: BE with a max datarate of 300 kbps which is far below generated data throughput	A new SF is created	GS control MMI	OK
5	Allocate SF to MS and verify that it is dynamically taken into account	Datarate goes down to 300 kbps	Iperf	OK
6	Delete SF and verify that it is dynamically taken into account	Datarate goes back to 5 Mbps	Iperf	OK

7.2.1.2.3 Deviation from the planned activities

None.

7.2.1.3 Verification exercise Results

7.2.1.3.1 Summary of Verification exercise Results

The SF change is dynamically allocated to the MS and the data traffic is transmitted via the created connection. After SF deletion the data traffic is no more sent on its connection. Hence, the SF creation change and deletion are successfully completed.

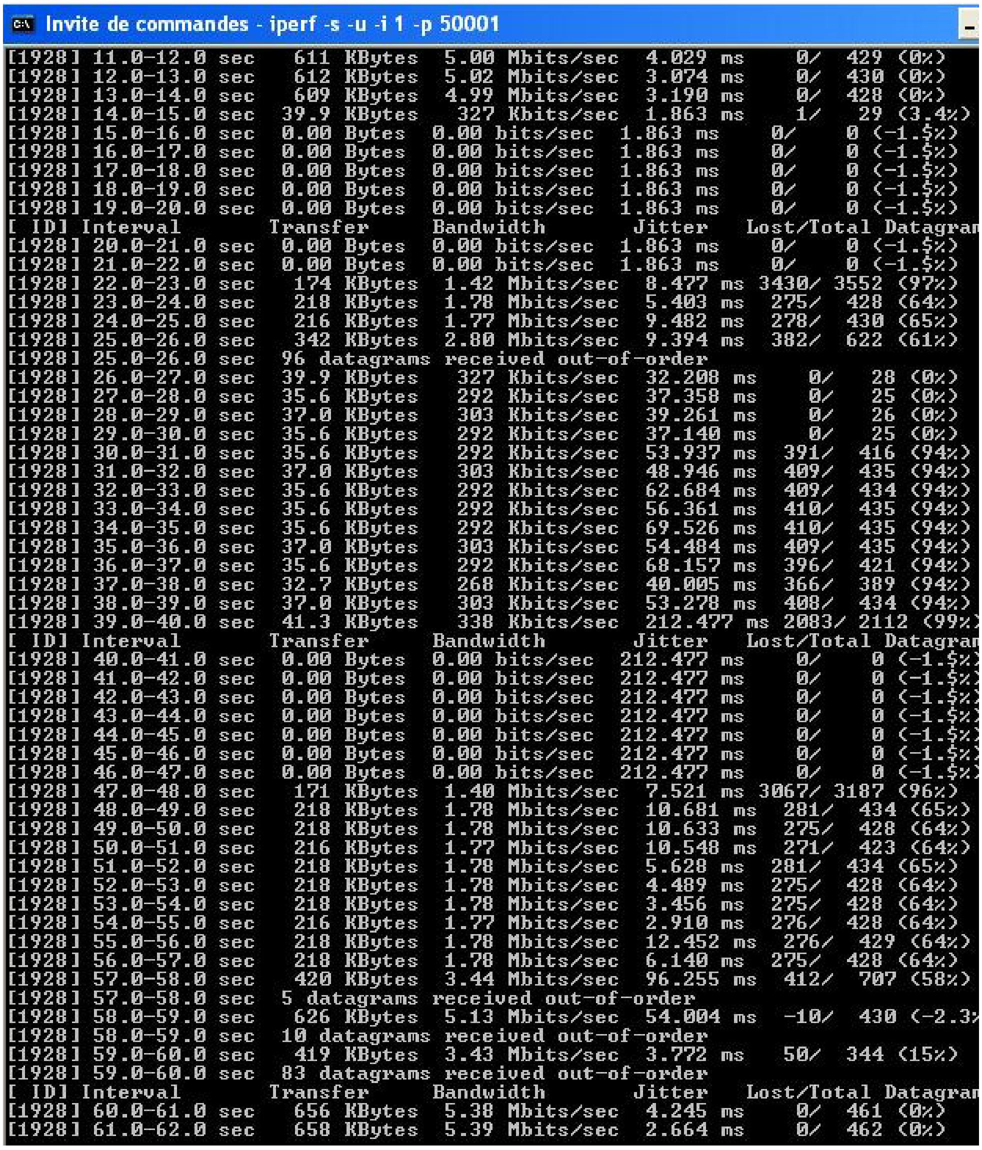
7.2.1.3.2 Analysis of Verification Exercise Results

Below, we put some details on the test execution. The screenshot from iperf server which is located on a PC connected to MS are shown.

One can see that first the data rate is around 5 Mbps which is compliant to what is sent and the default SF that is initially set.

Then the SF that limits the max data rate to 300 kbps is applied. One can see that the data rate received by iperf goes down and stabilizes at the 300 kbps limit.

Then the SF is deleted and the data rate goes back to 5 Mbps.



```
[1928] 11.0-12.0 sec   611 KBytes  5.00 Mbits/sec  4.029 ms    0/  429 (0%)
[1928] 12.0-13.0 sec   612 KBytes  5.02 Mbits/sec  3.074 ms    0/  430 (0%)
[1928] 13.0-14.0 sec   609 KBytes  4.99 Mbits/sec  3.190 ms    0/  428 (0%)
[1928] 14.0-15.0 sec  39.9 KBytes   327 Kbits/sec  1.863 ms    1/   29 (3.4%)
[1928] 15.0-16.0 sec  0.00 Bytes  0.00 bits/sec  1.863 ms    0/    0 (-1.$%)
[1928] 16.0-17.0 sec  0.00 Bytes  0.00 bits/sec  1.863 ms    0/    0 (-1.$%)
[1928] 17.0-18.0 sec  0.00 Bytes  0.00 bits/sec  1.863 ms    0/    0 (-1.$%)
[1928] 18.0-19.0 sec  0.00 Bytes  0.00 bits/sec  1.863 ms    0/    0 (-1.$%)
[1928] 19.0-20.0 sec  0.00 Bytes  0.00 bits/sec  1.863 ms    0/    0 (-1.$%)
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagram
[1928] 20.0-21.0 sec  0.00 Bytes  0.00 bits/sec  1.863 ms    0/    0 (-1.$%)
[1928] 21.0-22.0 sec  0.00 Bytes  0.00 bits/sec  1.863 ms    0/    0 (-1.$%)
[1928] 22.0-23.0 sec   174 KBytes  1.42 Mbits/sec  8.477 ms 3430/ 3552 (97%)
[1928] 23.0-24.0 sec   218 KBytes  1.78 Mbits/sec  5.403 ms  275/  428 (64%)
[1928] 24.0-25.0 sec   216 KBytes  1.77 Mbits/sec  9.482 ms  278/  430 (65%)
[1928] 25.0-26.0 sec   342 KBytes  2.80 Mbits/sec  9.394 ms  382/  622 (61%)
[1928] 25.0-26.0 sec  96 datagrams received out-of-order
[1928] 26.0-27.0 sec  39.9 KBytes   327 Kbits/sec  32.208 ms    0/   28 (0%)
[1928] 27.0-28.0 sec  35.6 KBytes   292 Kbits/sec  37.358 ms    0/   25 (0%)
[1928] 28.0-29.0 sec  37.0 KBytes   303 Kbits/sec  39.261 ms    0/   26 (0%)
[1928] 29.0-30.0 sec  35.6 KBytes   292 Kbits/sec  37.140 ms    0/   25 (0%)
[1928] 30.0-31.0 sec  35.6 KBytes   292 Kbits/sec  53.937 ms  391/  416 (94%)
[1928] 31.0-32.0 sec  37.0 KBytes   303 Kbits/sec  48.946 ms  409/  435 (94%)
[1928] 32.0-33.0 sec  35.6 KBytes   292 Kbits/sec  62.684 ms  409/  434 (94%)
[1928] 33.0-34.0 sec  35.6 KBytes   292 Kbits/sec  56.361 ms  410/  435 (94%)
[1928] 34.0-35.0 sec  35.6 KBytes   292 Kbits/sec  69.526 ms  410/  435 (94%)
[1928] 35.0-36.0 sec  37.0 KBytes   303 Kbits/sec  54.484 ms  409/  435 (94%)
[1928] 36.0-37.0 sec  35.6 KBytes   292 Kbits/sec  68.157 ms  396/  421 (94%)
[1928] 37.0-38.0 sec  32.7 KBytes   268 Kbits/sec  40.005 ms  366/  389 (94%)
[1928] 38.0-39.0 sec  37.0 KBytes   303 Kbits/sec  53.278 ms  408/  434 (94%)
[1928] 39.0-40.0 sec  41.3 KBytes   338 Kbits/sec  212.477 ms 2083/ 2112 (99%
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagram
[1928] 40.0-41.0 sec  0.00 Bytes  0.00 bits/sec  212.477 ms    0/    0 (-1.$%
[1928] 41.0-42.0 sec  0.00 Bytes  0.00 bits/sec  212.477 ms    0/    0 (-1.$%
[1928] 42.0-43.0 sec  0.00 Bytes  0.00 bits/sec  212.477 ms    0/    0 (-1.$%
[1928] 43.0-44.0 sec  0.00 Bytes  0.00 bits/sec  212.477 ms    0/    0 (-1.$%
[1928] 44.0-45.0 sec  0.00 Bytes  0.00 bits/sec  212.477 ms    0/    0 (-1.$%
[1928] 45.0-46.0 sec  0.00 Bytes  0.00 bits/sec  212.477 ms    0/    0 (-1.$%
[1928] 46.0-47.0 sec  0.00 Bytes  0.00 bits/sec  212.477 ms    0/    0 (-1.$%
[1928] 47.0-48.0 sec   171 KBytes  1.40 Mbits/sec  7.521 ms 3067/ 3187 (96%)
[1928] 48.0-49.0 sec   218 KBytes  1.78 Mbits/sec  10.681 ms  281/  434 (65%)
[1928] 49.0-50.0 sec   218 KBytes  1.78 Mbits/sec  10.633 ms  275/  428 (64%)
[1928] 50.0-51.0 sec   216 KBytes  1.77 Mbits/sec  10.548 ms  271/  423 (64%)
[1928] 51.0-52.0 sec   218 KBytes  1.78 Mbits/sec  5.628 ms  281/  434 (65%)
[1928] 52.0-53.0 sec   218 KBytes  1.78 Mbits/sec  4.489 ms  275/  428 (64%)
[1928] 53.0-54.0 sec   218 KBytes  1.78 Mbits/sec  3.456 ms  275/  428 (64%)
[1928] 54.0-55.0 sec   216 KBytes  1.77 Mbits/sec  2.910 ms  276/  428 (64%)
[1928] 55.0-56.0 sec   218 KBytes  1.78 Mbits/sec  12.452 ms  276/  429 (64%)
[1928] 56.0-57.0 sec   218 KBytes  1.78 Mbits/sec  6.140 ms  275/  428 (64%)
[1928] 57.0-58.0 sec   420 KBytes  3.44 Mbits/sec  96.255 ms  412/  707 (58%)
[1928] 57.0-58.0 sec  5 datagrams received out-of-order
[1928] 58.0-59.0 sec   626 KBytes  5.13 Mbits/sec  54.004 ms  -10/  430 (-2.3
[1928] 58.0-59.0 sec  10 datagrams received out-of-order
[1928] 59.0-60.0 sec   419 KBytes  3.43 Mbits/sec  3.772 ms   50/  344 (15%)
[1928] 59.0-60.0 sec  83 datagrams received out-of-order
[ ID] Interval       Transfer     Bandwidth       Jitter   Lost/Total Datagram
[1928] 60.0-61.0 sec   656 KBytes  5.38 Mbits/sec  4.245 ms    0/  461 (0%)
[1928] 61.0-62.0 sec   658 KBytes  5.39 Mbits/sec  2.664 ms    0/  462 (0%)
```

Figure 7-21: TLAB2_010 iperf screenshot

7.2.1.3.3 Unexpected behaviors/Results

None

7.2.1.4 Conclusions and recommendations

The creation, change and deletion of a service flow to the MS have been successfully verified.

7.2.2 Verification Exercise # TLAB2_020

7.2.2.1 Verification Exercise Scope

Test channel selectivity and transmit power measurements:
Verify the receiver adjacent channel selectivity, verify the BS/MS transmission mask in terms of adjacent and non-adjacent channel interferences, verify the BS output power to assess OFDMA crest factor.

7.2.2.2 Conduct of Verification Exercise

7.2.2.2.1 Verification Exercise Preparation

Lab-test_bed_01 is prepared with an additional signal generator to simulate the interfering signal on adjacent and alternate channel.

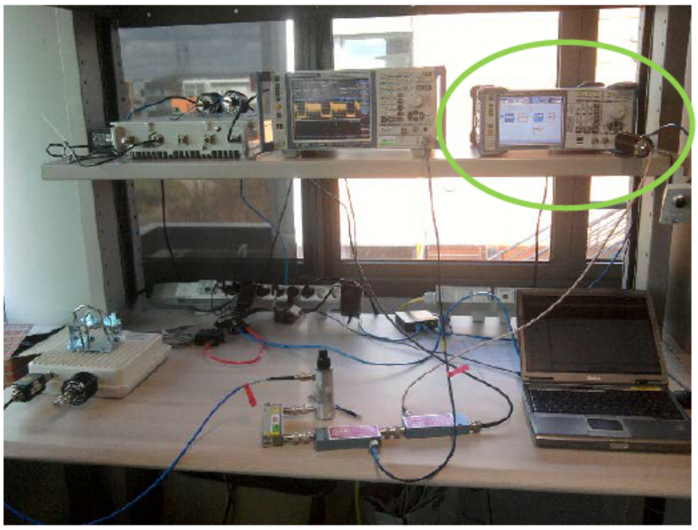


Figure 7-22: test bed configuration with a signal generator

7.2.2.2.2 Verification Exercise execution

See also IEEE 802.16-2009 § 8.3.11.2 "Receiver adjacent and alternate channel rejection".

Step	action	Action result	PCO	Result
Phase 1 Adjacent and non-adjacent channel leakage ratio				
1	Set frequency on the GS : 5093,5 MHz Provision new RF parameter on the GS	New frequency provisioned on GS	GS control MMI Spectrum analyzer	OK
2	Set frequency scan of MS : 5093,5 MHz 5098,5 MHz 5103,5 MHz	MS connects eventually to the GS	GS control MMI	OK
3	Initiate traffic through the traffic generator (Iperf)	Communication established	Iperf	OK

4	Measure through spectrum analyzer adjacent and alternate channel leakage ration of MS and BS	Spectrum Analyzer ACPR menu selected and spectrum measurement done	Spectrum Analyzer	OK
Phase 2 ACS (Receiver adjacent channel selectivity)				
1	Set frequency on the GS : 5093,5 MHz Fix modulation to 64QAM3/4 Provision new RF parameter on the GS	New frequency provisioned on GS	GS control MMI Spectrum analyzer	OK
2	Set frequency scan of MS : 5093,5 MHz 5098,5 MHz 5103,5 MHz	MS connects eventually to the GS	GS control MMI	OK
3	Initiate traffic through the traffic generator (Iperf)	Communication established	Iperf	OK
4	Increase attenuation to set the signal's strength close to the rate dependent receiver sensitivity (+3 dB)	Attenuator tuned	Iperf	OK
5	Generate the interfering signal on adjacent channel. Raise its power level until the error rate is obtained. Note down the difference between the interfering signal and the desired channel: it is the corresponding adjacent channel rejection.	Adjacent Channel rejection characterized for 64QAM3/4	Spectrum Analyzer Iperf	OK
6	Generate the interfering signal on alternate channel. Raise its power level until the error rate is obtained. Note down the difference between the interfering signal and the desired channel: it is the corresponding adjacent channel rejection.	Alternate Channel rejection characterized for 64QAM3/4	Spectrum Analyzer	OK
7	Fix modulation to 16QAM3/4 And redo step 3, 4, 5, and 6	Adjacent Channel rejection characterized for 16QAM3/4 Alternate Channel rejection characterized for 64QAM3/4	Spectrum Analyzer	OK
Phase 3 Crest factor measurement				
1	Set frequency on the GS : 5093,5 MHz	New frequency provisioned on GS	GS control MMI Spectrum	OK

	Provision new RF parameter on the GS		analyzer	
2	Set frequency scan of MS : 5093,5 MHz 5098,5 MHz 5103,5 MHz	MS connects eventually to the GS	GS control MMI	OK
3	Initiate traffic through the traffic generator (Iperf)	Communication established	Iperf	OK
4	Measure the crest factor on the spectrum analyzer	Measurement around 9 dB	Spectrum Analyzer	OK

7.2.2.2.3 Deviation from the planned activities

None.

7.2.2.3 Verification exercise Results

7.2.2.3.1 Summary of Verification exercise Results

Phase 1: ACLR

The measured adjacent and non-adjacent channel interference levels of GS / MS mask are given in table below:

Adjacent Channel Leakage Ratio of GS Mask	Alternate Channel Leakage Ratio of GS Mask
-42 dB	-51 dB
Adjacent Channel Leakage Ratio of MS Mask	Alternate Channel Leakage Ratio of MS Mask
-44 dB	-53 dB

Phase 2: ACS

The adjacent and alternate channel selectivity gives following results:

Modulation / coding	Adjacent channel Rejection (dB) / limit in IEEE 802.16-2009 table 313 (dB)	Alternate channel Rejection (dB) / limit in IEEE standard 802.16-2009 table 313 (dB)
16 QAM ¾	24 / 10	38 / 29
64 QAM ¾	20 / 4	29 / 23

Phase 3: crest factor

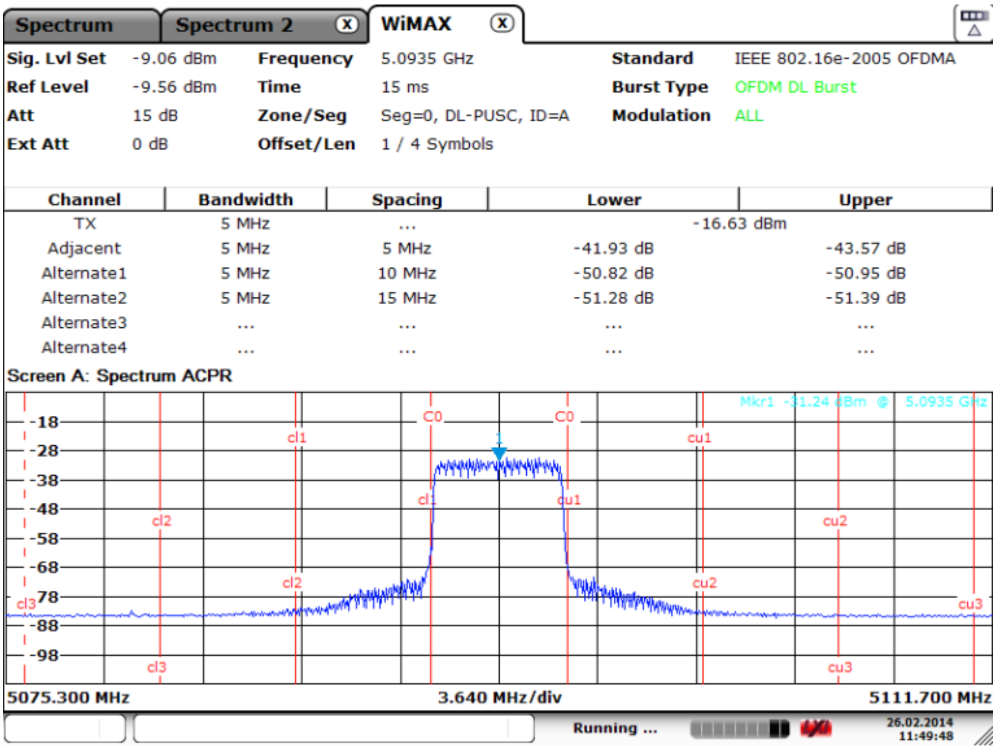
The measured crest factor with traffic is about 9 dB, which corresponds to what is expected.

7.2.2.3.2 Analysis of Verification Exercise Results

Phase 1: ACLR

Adjacent Channel Power Ratio (ACPR) or Adjacent Channel Leakage Ratio (ACLR) is a measure of the transmitter energy that is ‘leaking’ into an adjacent or alternate channel. Ideally, a transmitter could keep all of its transmitted energy in its assigned channel, but realistically some small amount of the transmitter energy will show up in other nearby channels. A spectrum analyzer is used to make this measurement: the first step is to measure the in-channel power; after this, the analyzer measures the frequency offset 1 channel away, and the ‘leakage’ power is measured as the difference in these two measurements (called ACP ratio or ACLR).

Below we see the result for the DL (values expressed in difference compared to central channel (TX)):



Sig. Lvl Set	-9.06 dBm	**Frequency**	5.0935 GHz	**Standard**	IEEE 802.16e-2005 OFDMA
Ref Level	-9.56 dBm	**Time**	15 ms	**Burst Type**	OFDM DL Burst
Att	15 dB	**Zone/Seg**	Seg=0, DL-PUSC, ID=A	**Modulation**	ALL
Ext Att	0 dB	**Offset/Len**	1 / 4 Symbols		

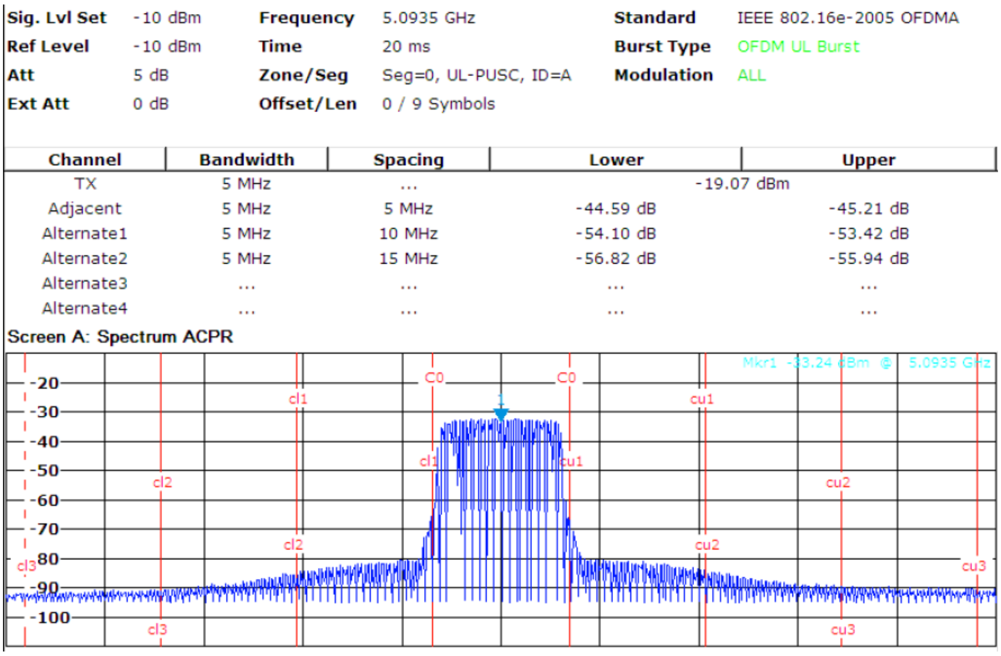
Channel	Bandwidth	Spacing	Lower	Upper
TX	5 MHz	...	-16.63 dBm	
Adjacent	5 MHz	5 MHz	-41.93 dB	-43.57 dB
Alternate1	5 MHz	10 MHz	-50.82 dB	-50.95 dB
Alternate2	5 MHz	15 MHz	-51.28 dB	-51.39 dB
Alternate3	...	...	...	...
Alternate4	...	...	...	...

Screen A: Spectrum ACPR

5075.300 MHz 3.640 MHz/div 5111.700 MHz

Date: 26.FEB.2014 11:49:48

Below we see the result for the UL (values expressed in difference compared to central channel (TX)):



Sig. Lvl Set	-10 dBm	**Frequency**	5.0935 GHz	**Standard**	IEEE 802.16e-2005 OFDMA
Ref Level	-10 dBm	**Time**	20 ms	**Burst Type**	OFDM UL Burst
Att	5 dB	**Zone/Seg**	Seg=0, UL-PUSC, ID=A	**Modulation**	ALL
Ext Att	0 dB	**Offset/Len**	0 / 9 Symbols		

Channel	Bandwidth	Spacing	Lower	Upper
TX	5 MHz	...	-19.07 dBm	
Adjacent	5 MHz	5 MHz	-44.59 dB	-45.21 dB
Alternate1	5 MHz	10 MHz	-54.10 dB	-53.42 dB
Alternate2	5 MHz	15 MHz	-56.82 dB	-55.94 dB
Alternate3	...	...	...	...
Alternate4	...	...	...	...

Screen A: Spectrum ACPR

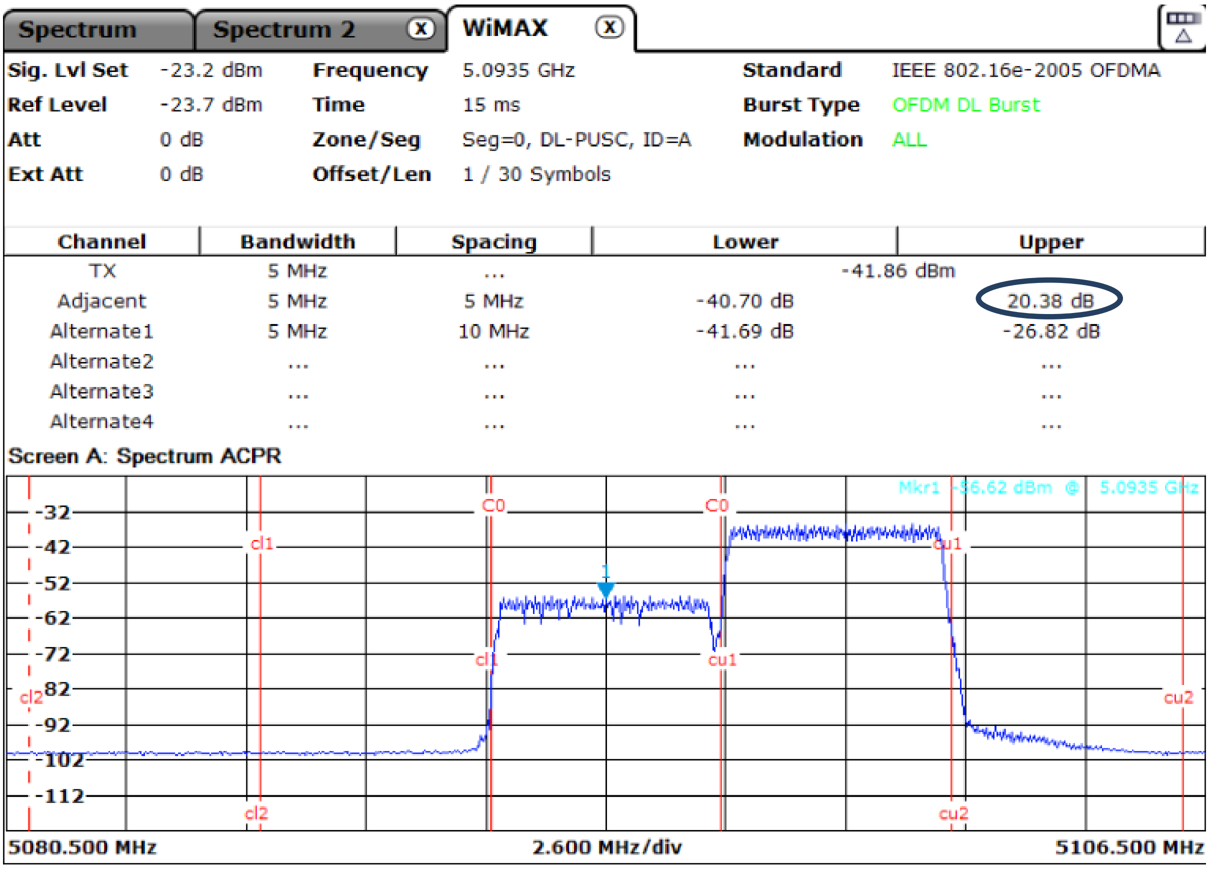
Phase 2: ACS

The adjacent channel rejection and alternate channel rejection is measured by setting the desired signal's strength above but close to (3 dB) the rate dependent receiver sensitivity and raising the power level of the interfering signal until the sensitivity specified error rate is obtained. The power difference between the interfering signal and the desired channel is the corresponding adjacent channel rejection.

The interfering signal in the adjacent or alternate channel is a conforming OFDMA signal, not synchronized with the signal in the channel under test but with same type of parameters: 5ms frame, 5MHz bandwidth.

The screenshot below from the spectrum analyser shows the spectrum of the signal under test (central) and the spectrum of the interfering signal either in adjacent channel or alternate channel. The difference between both signal power is highlighted.

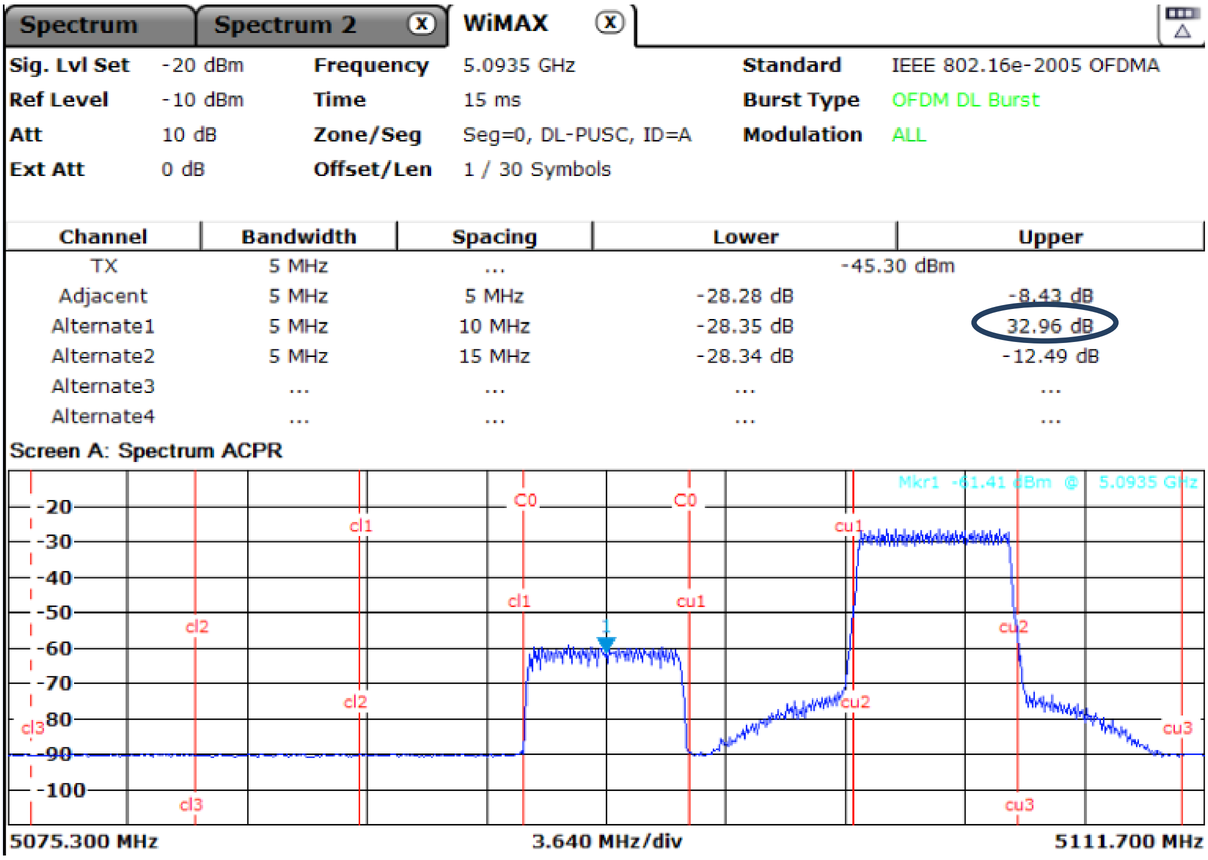
64QAM ¾ case:



Sig. Lvl Set	-23.2 dBm	**Frequency**	5.0935 GHz	**Standard**	IEEE 802.16e-2005 OFDMA
Ref Level	-23.7 dBm	**Time**	15 ms	**Burst Type**	OFDM DL Burst
Att	0 dB	**Zone/Seg**	Seg=0, DL-PUSC, ID=A	**Modulation**	ALL
Ext Att	0 dB	**Offset/Len**	1 / 30 Symbols		

Channel	Bandwidth	Spacing	Lower	Upper
TX	5 MHz	...	-41.86 dBm	
Adjacent	5 MHz	5 MHz	-40.70 dB	20.38 dB
Alternate1	5 MHz	10 MHz	-41.69 dB	-26.82 dB
Alternate2	...	...	...	...
Alternate3	...	...	...	...
Alternate4	...	...	...	...

Screen A: Spectrum ACPR

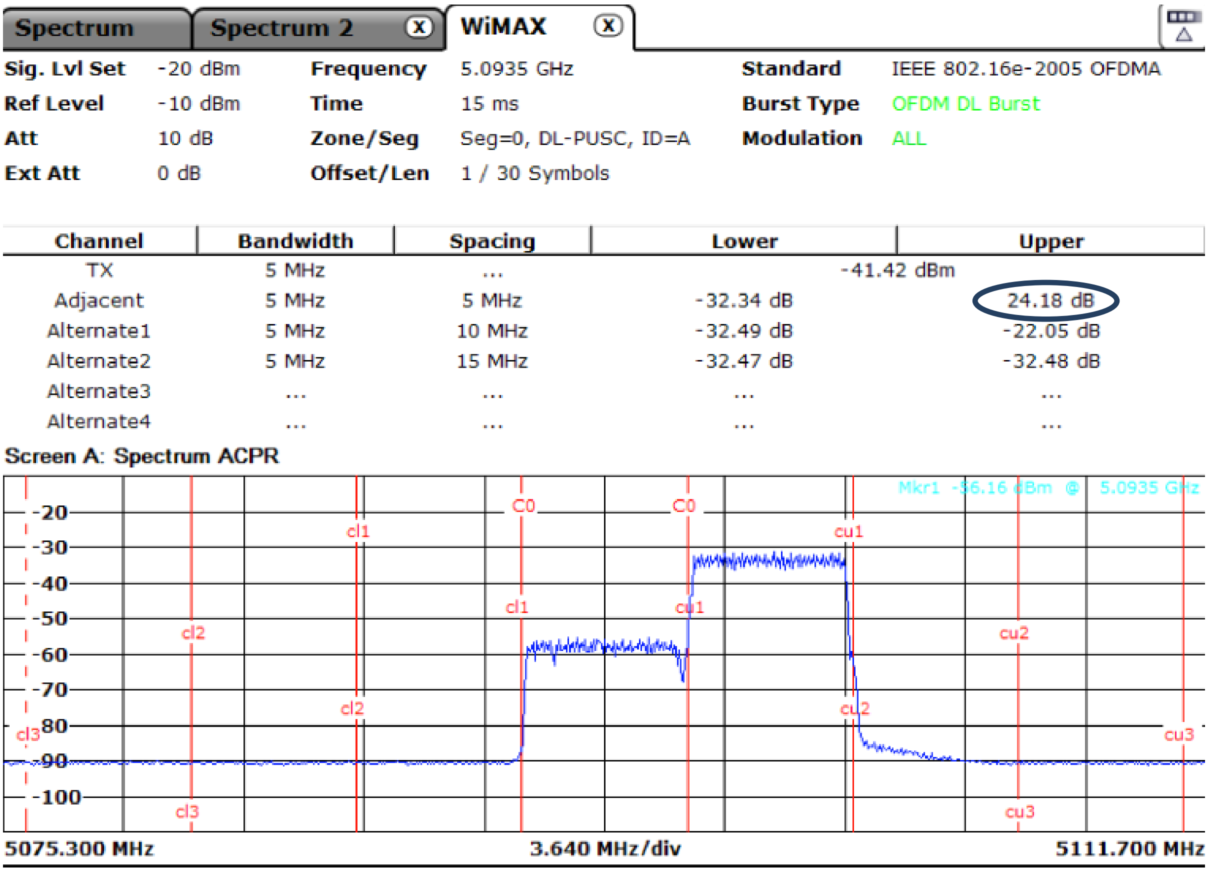


Sig. Lvl Set	-20 dBm	**Frequency**	5.0935 GHz	**Standard**	IEEE 802.16e-2005 OFDMA
Ref Level	-10 dBm	**Time**	15 ms	**Burst Type**	OFDM DL Burst
Att	10 dB	**Zone/Seg**	Seg=0, DL-PUSC, ID=A	**Modulation**	ALL
Ext Att	0 dB	**Offset/Len**	1 / 30 Symbols		

Channel	Bandwidth	Spacing	Lower	Upper
TX	5 MHz	...	-45.30 dBm	
Adjacent	5 MHz	5 MHz	-28.28 dB	-8.43 dB
Alternate1	5 MHz	10 MHz	-28.35 dB	32.96 dB
Alternate2	5 MHz	15 MHz	-28.34 dB	-12.49 dB
Alternate3	...	...	...	...
Alternate4	...	...	...	...

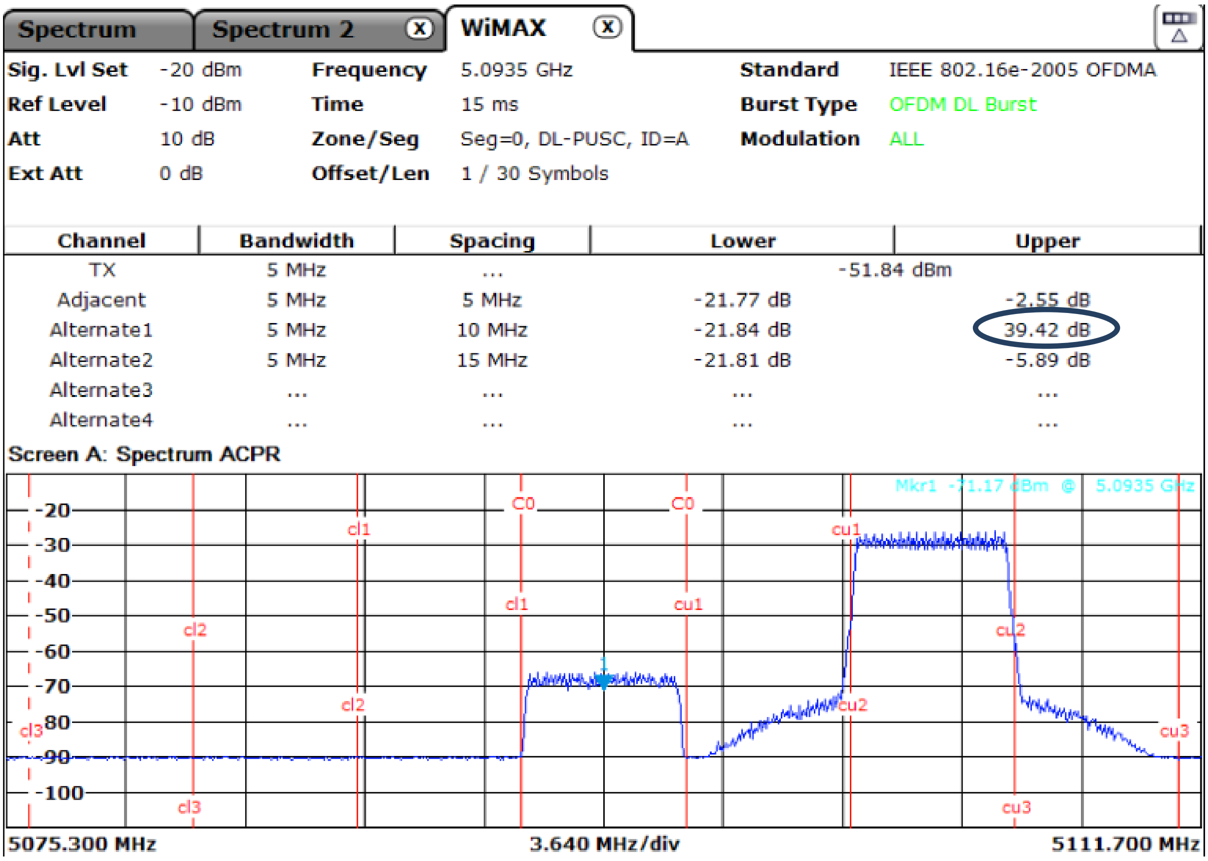
Screen A: Spectrum ACPR

16 QAM ¾ case:



Sig. Lvl Set -20 dBm
Ref Level -10 dBm
Att 10 dB
Ext Att 0 dB
Frequency 5.0935 GHz
Time 15 ms
Zone/Seg Seg=0, DL-PUSC, ID=A
Offset/Len 1 / 30 Symbols
Standard IEEE 802.16e-2005 OFDMA
Burst Type OFDM DL Burst
Modulation ALL

Channel	Bandwidth	Spacing	Lower	Upper
TX	5 MHz	...	-41.42 dBm	
Adjacent	5 MHz	5 MHz	-32.34 dB	24.18 dB
Alternate1	5 MHz	10 MHz	-32.49 dB	-22.05 dB
Alternate2	5 MHz	15 MHz	-32.47 dB	-32.48 dB
Alternate3	...	...	...	...
Alternate4	...	...	...	...



Sig. Lvl Set	-20 dBm	**Frequency**	5.0935 GHz	**Standard**	IEEE 802.16e-2005 OFDMA
Ref Level	-10 dBm	**Time**	15 ms	**Burst Type**	OFDM DL Burst
Att	10 dB	**Zone/Seg**	Seg=0, DL-PUSC, ID=A	**Modulation**	ALL
Ext Att	0 dB	**Offset/Len**	1 / 30 Symbols		

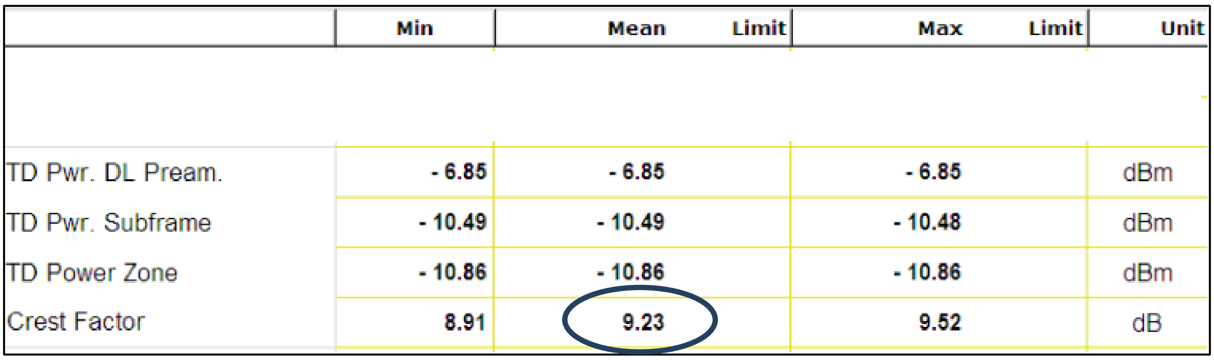
Channel	Bandwidth	Spacing	Lower	Upper
TX	5 MHz	...	-51.84 dBm	
Adjacent	5 MHz	5 MHz	-21.77 dB	-2.55 dB
Alternate1	5 MHz	10 MHz	-21.84 dB	39.42 dB
Alternate2	5 MHz	15 MHz	-21.81 dB	-5.89 dB
Alternate3	...	...	...	...
Alternate4	...	...	...	...

Screen A: Spectrum ACPR

We can see the 16QAM3/4 is more robust than the 64QAM3/4 by around 7 dB which is what was expected.

Phase 3: Crest factor

The WiMAX option of our spectrum analyser directly computes the crest factor as one can see in following picture. The crest factor with data transmission active is around 9 dB, in conformance with what was expected.



	Min	Mean	Limit	Max	Limit	Unit
TD Pwr. DL Pream.	- 6.85	- 6.85		- 6.85		dBm
TD Pwr. Subframe	- 10.49	- 10.49		- 10.48		dBm
TD Power Zone	- 10.86	- 10.86		- 10.86		dBm
Crest Factor	8.91	9.23		9.52		dB

7.2.2.3.3 Unexpected behaviors/Results

None.

7.2.2.4 Conclusions and recommendations

The prototypes present a good behaviour compared to what is expected in standard.

7.2.3 Verification Exercise # TLAB2_030

7.2.3.1 Verification Exercise Scope

MS channel quality report and MS transmit synchronisation
Verify that MS channel quality report to BS and verify the MS transmitted centre frequency precision.

7.2.3.2 Conduct of Verification Exercise

7.2.3.2.1 Verification Exercise Preparation

Lab-test_bed_01 is prepared.
Spectrum Analyzer is moved to replace MS in order to measure the actual received power of the MS

7.2.3.2.2 Verification Exercise execution

Step	action	Action result	PCO	Result
Phase 1 MS feedback to BS				
1	Set frequency on the GS : 5093,5 MHz Provision new RF parameter on the GS	New frequency provisioned on GS	GS control MMI Spectrum analyzer	OK
2	Set frequency scan of MS : 5093,5 MHz 5098,5 MHz 5103,5 MHz	MS connects eventually to the GS	GS control MMI	OK
3	Initiate traffic through the traffic generator (Iperf)	Communication established	Iperf	OK
4	Measure through spectrum analyzer the received level at MS antenna port and compare with the RSSI measured by MS itself and received on BS	Measured level on Spectrum Analyzer RSSI at MS And BS side	Spectrum Analyzer MS MMI GS control MMI	OK
Phase 2 Central frequency measurement				
1	Set frequency on the GS : 5093,5 MHz Provision new RF parameter on the GS	New frequency provisioned on GS	GS control MMI Spectrum analyzer	OK
2	Set frequency scan of MS : 5093,5 MHz 5098,5 MHz 5103,5 MHz	MS connects eventually to the GS	GS control MMI	OK
3	Initiate traffic through the traffic generator (Iperf)	Communication established	Iperf	OK
4	Measure through spectrum analyzer the central frequency of MS	Measured frequency on Spectrum Analyzer	Spectrum Analyzer	OK

7.2.3.2.3 Deviation from the planned activities

None.

7.2.3.3 Verification exercise Results

7.2.3.3.1 Summary of Verification exercise Results

Phase 1: Measured RSSI on the MS is in good correlation with measured power from the spectrum analyser. The RSSI transmitted by MS to the BS is good (1 dB rounding) except for RSSI above -40 dBm, as they are floored to -40 dBm on BS control MMI.

Phase 2: The measured centre frequency on the UL doesn't deviate more than 2% of the subcarrier spacing compared to the BS center frequency.

7.2.3.3.2 Analysis of Verification Exercise Results

Phase 1: MS feedback

	received Power On Spectrum Analyzer	MS MMI	BS control MMI
Att 1	TD Power DL preamble -56 dBm Power DL Preamble -51 dBm	RSSI -54 dBm	RSSI -55 dBm
Att 2	TD Power DL preamble -46 dBm Power DL Preamble -41 dBm	RSSI -44 dBm	RSSI -45 dBm
Att 3	TD Power DL preamble -36 dBm Power DL Preamble -31 dBm	RSSI -34 dBm	RSSI -40 dBm
Att 4	TD Power DL preamble -26 dBm Power DL Preamble -21 dBm	RSSI -24 dBm	RSSI -40 dBm
Att 5	- Non synchronized -	RSSI -64 dBm	RSSI -65 dBm
Att6	- Non synchronized -	RSSI -75 dBm	RSSI -76 dBm

Phase 2:

The measured centre frequency on the DL is : 5 093 464 737 Hz (5093,5 MHz – 35263,17 Hz)

Sig. Lvl Set	-38.2 dBm	**Frequency**	5.0935 GHz	**Standard**	IEEE 802.16e-2005 OFDMA
Ref Level	-28.2 dBm	**Time**	20 ms	**Burst Type**	OFDM DL Burst
Att	0 dB	**Zone/Seg**	Seg=0, DL-PUSC, ID=A	**Modulation**	ALL
Ext Att	0 dB	**Offset/Len**	1 / 4 Symbols		

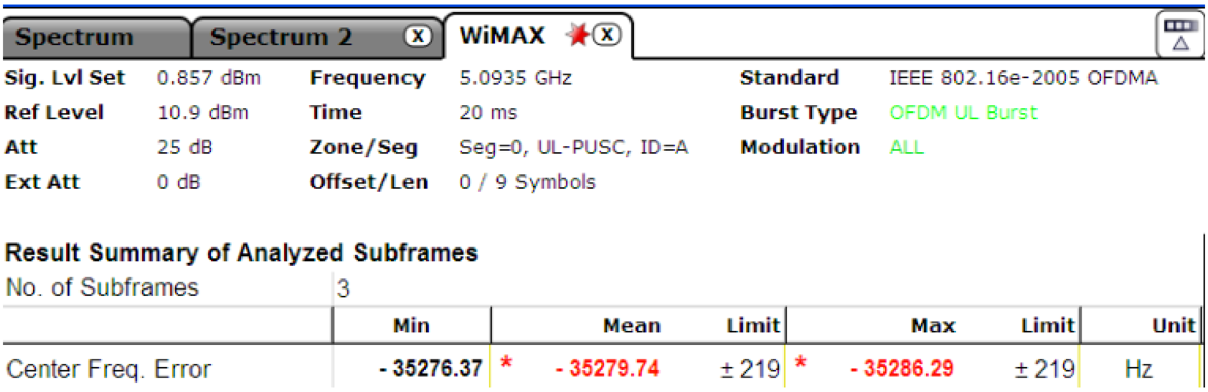
Result Summary of Analyzed Subframes

No. of Subframes 3

	Min	Mean	Limit	Max	Limit	Unit
Center Freq. Error	- 35260.39	- 35263.17	± 40748	- 35266.85	± 40748	Hz

The center frequency of the Spectrum analyser is tuned to 5 093 464 737 Hz and the spectrum analyser is plugged in the UL to measured the MS spectrum.

The measured UL centre frequency is: 5 093 464 720 Hz (5 093 500 – 35279,74)



Sig. Lvl Set	0.857 dBm	**Frequency**	5.0935 GHz	**Standard**	IEEE 802.16e-2005 OFDMA
Ref Level	10.9 dBm	**Time**	20 ms	**Burst Type**	OFDM UL Burst
Att	25 dB	**Zone/Seg**	Seg=0, UL-PUSC, ID=A	**Modulation**	ALL
Ext Att	0 dB	**Offset/Len**	0 / 9 Symbols		

Result Summary of Analyzed Subframes

No. of Subframes 3

	Min	Mean	Limit	Max	Limit	Unit
Center Freq. Error	- 35276.37 *	- 35279.74	± 219 *	- 35286.29	± 219	Hz

The subcarrier spacing is: 5 600 000 / 512 = 10937,5 Hz

2% of subcarrier spacing is: 219 Hz

The deviation of the MS centre frequency compared to the BS frequency divided by to the subcarrier spacing is < 2%: 5 093 464 737 - 5 093 464 720 = 17 Hz compared to 219 Hz

7.2.3.3.3 Unexpected behaviors/Results

The DL RSSI read on the BS control MMI is at maximum -40 dBm. This behaviour doesn't prevent performing the outdoor testing as the DL RSSI is generally well below -40 dBm and the RSSI shown on MS MMI is correct.

7.2.3.4 Conclusions and recommendations

The testing allowed checking successfully the feedback of MS information to the BS and the MS centre frequency precision.

7.2.4 Verification Exercise # TLAB2_040

7.2.4.1 Verification Exercise Scope

IOT testing
Verify the interoperability of Selex MS with Thales GS over the air interface.

7.2.4.2 Conduct of Verification Exercise

7.2.4.2.1 Verification Exercise Preparation

Lab-test_bed_01 is prepared.
Selex MS replaced Thales MS.

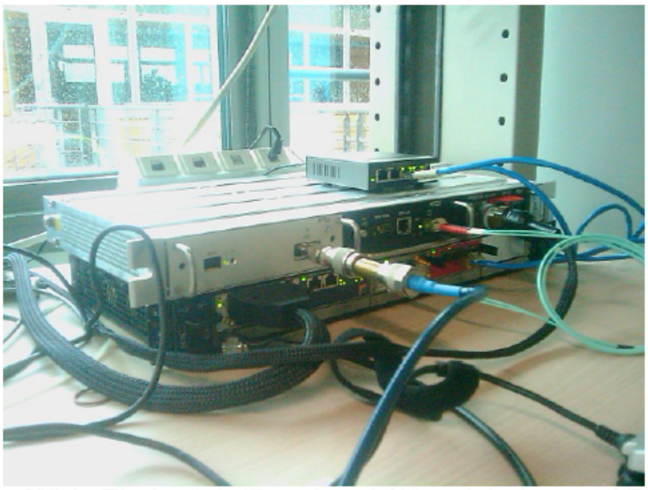


Figure 7-23: Selex MS in Thales lab (Baseband 1U rack below and RF 1U rack above)

7.2.4.2.2 Verification Exercise execution

Step	Action	Action result	PCO	Result
Phase 1				
	Set frequency on the GS : 5093,5 MHz Provision new RF parameter on the GS	New frequency provisioned on GS	GS control MMI Spectrum analyzer	OK
2	Set frequency scan of Selex MS : 5093,5 MHz	MS performs successive stages for registration: Scanning / synchronization Initial ranging Basic capabilities negotiation Admission control Registration And connects eventually to the GS	GS control MMI	pOK

7.2.4.2.3 Deviation from the planned activities

Only the first step of the verification exercise could be successfully verified: scanning and preamble detection.
It is noted that the testing session was held as planned during July in Thales lab with remote assistance of Selex team. Despite numerous attempts to identify the source of the problem, no improvement was achieved, and the test campaign was closed.
A tentative second session was initially identified in September, but it was not possible to conduct it as the equipment could not finally be made available due to budget limitations and high activity in other AeroMACS related projects.

7.2.4.3 Verification exercise Results

7.2.4.3.1 Summary of Verification exercise Results

The results are:

Scanning / preamble detection => OK

Synchronization => NOK

Initial ranging => NT

Basic capabilities negotiation => NT

Admission control => NT

Registration => NT

7.2.4.3.2 Analysis of Verification Exercise Results

The Thales BS is switched on and starts transmitting broadcast information.

The Selex MS is switched on and starts the Spectrum Scanning.

Selex MS Logs indicate that the MS, after scanning, stops on the BS frequency and identifies the preamble sent by the BS: scanning and preamble detection is achieved.

After this first synchronization step, the MS logs indicate a “FCH decoding failed”, meaning that the MS doesn’t decode successfully the Frame Control Header (FCH) sent by the BS. As a result, synchronization is not finalized and the subsequent Network Entry phases are not executed.

During the tests, this situation was observed irrespectively of the value of attenuation inserted between MS and BS and various parameterizations.

7.2.4.3.3 Unexpected behaviors/Results

Only a part of this IOT is OK: scanning and preamble detection. Despite both Selex ES and Thales teams’ investigation efforts, it was not possible to demonstrate further interoperability in the frame of this test campaign.

7.2.4.4 Conclusions and recommendations

Only a small part of this interoperability testing is OK (additional IOT results can be found in 7.1.6).

It is suggested to plan ad-hoc activities with the purpose to complete IOT in the near future (SESAR2020/VLD could be suitable opportunities) in coordination with the relevant standardization authorities.

7.3 Thales Toulouse airport verification exercises

7.3.1 Introduction

Thanks to an appropriate preparation, the optimized test schedule is planned as follows:

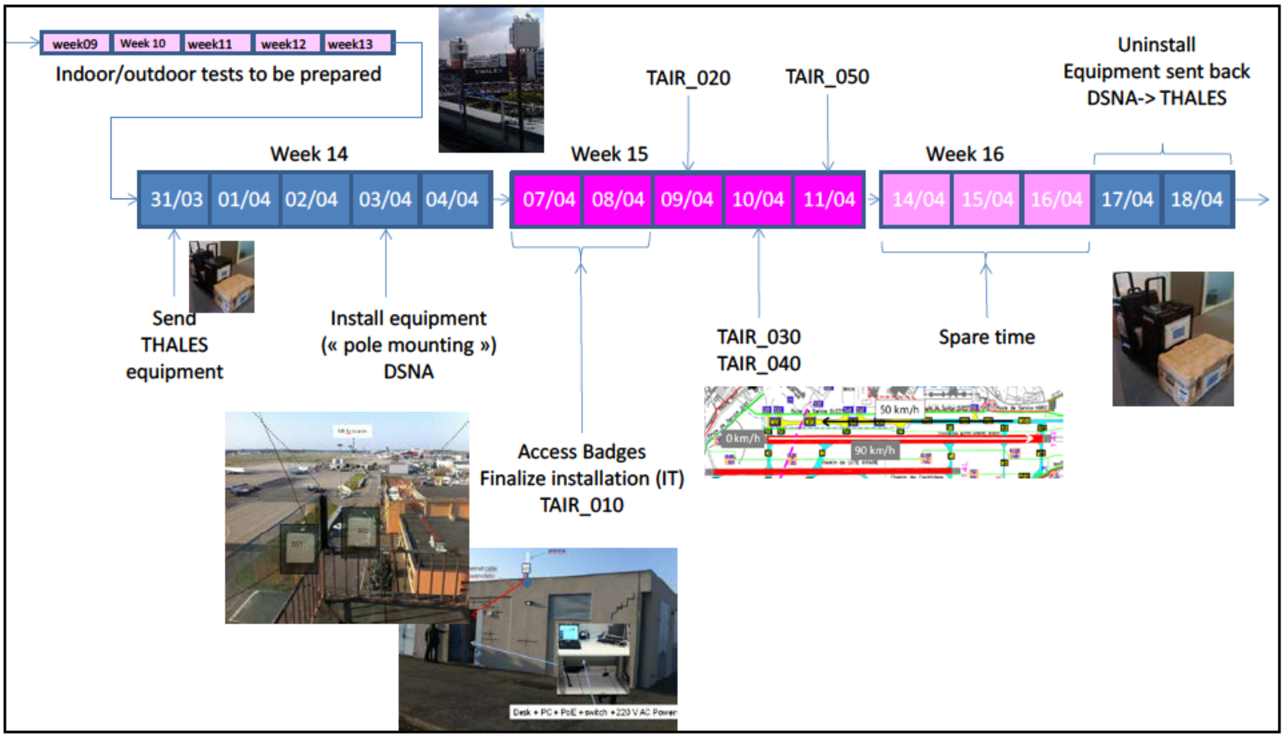


Figure 7-24: Detailed Airport schedule

Four Thales engineers were trained to have access to the Airport and Airport tests exercises were written and presented by THALES and then, analyzed and accepted by DSNA prior the testing period.


Project Number 15.02.07
D10 - AeroMACS Airport Verification Plan
Edition 00.00.01

Authoring & Approval

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Name & Company	Position & Title

AeroMACS Airport Verification Plan

Document information

Task contributors

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Please complete the advanced properties of the document

Abstract

The general purpose of the 15.2.7 is to verify the AeroMACS Data Link. This document describes the Verification Plan applied within the 15.2.7 Project for phase 2 Airport field testing.

Figure 7-25: Training for Airport Clearance and test plan preparation (TAIR_10 up to TAIR_50)

Below, the results of the preparation phase before Toulouse Airport test campaign are summarized. Outdoor tests were performed in the vicinity of Thales premises in order to assess the behavior of the equipment in different propagation conditions that will be met at Toulouse: LOS, NLOS, and mobility.

Two main setups were used:

- Installation in the countryside near Thales test premises near Paris: test up to 4 km in LOS.

Figure 7-26: Setup of the BS on a tower and MS on a truck for outdoor tests

- Installation in Thales premises Gennevilliers: test in NLOS and mobility, registration to the two base stations. Furthermore, the testing software that records positions along with MS measurements (called survey tool) was also verified.

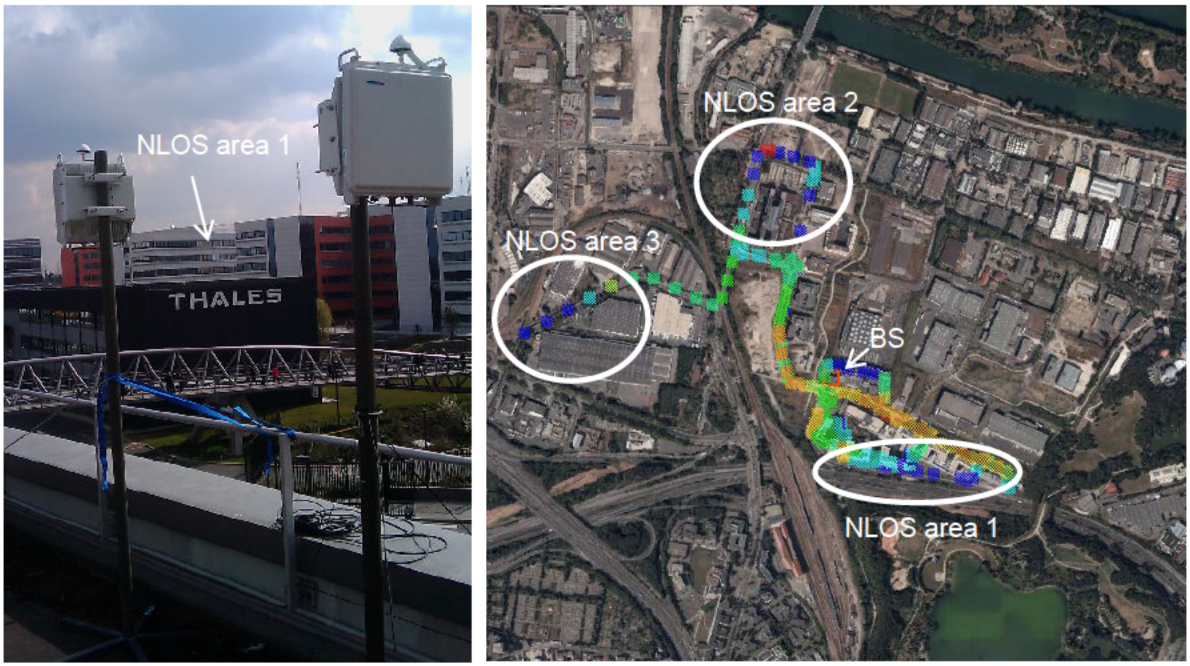


Figure 7-27: Outdoor tests in gennevilliers premises in NLOS

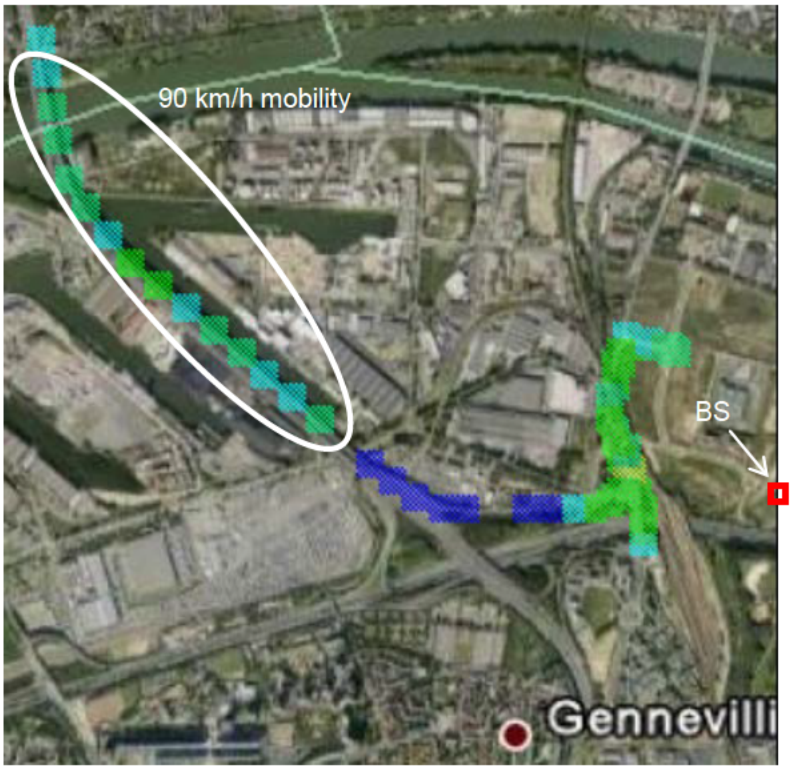


Figure 7-28: Outdoor tests in Gennevilliers @ 80 km/h

7.3.2 Verification Exercise # TAIR_010

7.3.2.1 Verification Exercise Scope

Installation and Main performances verification on the field:
1) Install BS1 and BS2 in PB and fix MS in PA
2) Perform main AeroMACS performances measurements at fix MS point:
Scanning, ranging, registration, throughput, QOS, mean power …
3) Install one MS in car.

- BS1 on (BS2 off): perform a lap on the “route de service” (green below) and record MS RSSI on the fly
- BS2 on (BS1 off): perform a lap again and record MS RSSI on the fly

7.3.2.2 Conduct of Verification Exercise

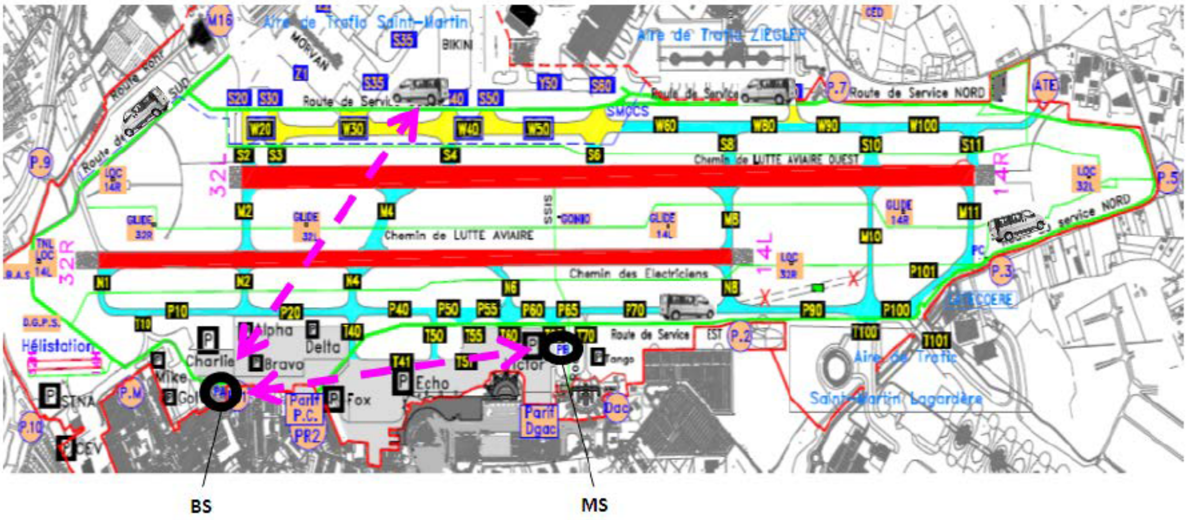
7.3.2.2.1 Verification Exercise Preparation

Equipment: BS1&2 + 1 fix MS + 1 MS in a car+ Spectrum Analyzer

Resources:

- Thales: 2 engineers
- DSNA: Required people for installation, one driver with a car.

Links and car trajectories: (the “route de service” will be used twice)



7.3.2.2.2 Verification Exercise execution

Step	action	Action result	PCO	Result
Phase 1 installation, scanning performance and successful completion of the ranging process				
1	Install GS 1 and GS 2 as depicted in § 3.5.3.2 Orientation: BS1_TH : az 300° tilt : -3° BS2_TH : az 210° tilt : -3° Take pictures of installation	GS started GPS synchronized Photos saved	GS control MMI	OK

2	GS2 is switched off. Set frequency on the GS 1: 5093,5 MHz Provision new RF parameter on the GS 1	New frequency provisioned on GS	GS control MMI	OK
3	Install fix MS as depicted in § 3.5.3.3 Take pictures of installation	MS installed MS accessed through its computer Photos saved	MS Web interface	OK
4	Set frequency list of MS : 5093,5 MHz 5098,5 MHz 5103,5 MHz	MS connects eventually to the GS 1 F=5093,5 MHz	GS control MMI MS web interface	OK
5	Initiate traffic in the UL or DL thanks to the traffic generator (Iperf) Check RSSI on both side : MS and BS	Communication established in both directions (UL and DL) Store information about RSSI / modulation	Iperf BS/MS MMI	OK -61 dBm
76	GS1 is switched off. GS2 is switched ON Set frequency on the GS 2: 5103,5 MHz Provision new RF parameter on the GS 2	New frequency provisioned on GS	GS control MMI	OK
7	Fix MS eventually connects to GS2	MS frequency 5103,5 MHz Store information about RSSI / modulation	MS web interface	OK -73 dBm
Phase 2 Lap on the Airport surface / fast coverage survey				
1	GS 2 is switched OFF GS 1 is switched ON Switch off MS 1 Install MS 2 in a DSNA car Switch ON MS2 Take pictures of installation Set frequency list of MS 2 : 5093,5 MHz 5098,5 MHz 5103,5 MHz	MS 2 connects eventually to the GS 1 F=5093,5 MHz Photos saved	GS control MMI MS web interface	OK

2	Perform a lap on the "route de service" (green road on previous picture) and record MS RSSI on the fly with survey tool	RSSI recorded BS1 Coverage of Airport done	Test application	OK
3	Switch OFF GS 1 Switch ON GS 2	MS2 connects eventually to the GS 2 F=5103,5 MHz	GS or MS MMI	OK
5	Perform a lap on the "route de service" and record MS RSSI on the fly with survey tool	RSSI recorded BS2 Coverage of Airport	Test application	OK
Phase 3 MLS interferences measurements				
1	Measure the possible interferences with Spectrum Analyzer: MLS signal near MLS emitter (F_{MLS} = 5038,8 MHz) (Check if there is any AMT perturbation F_{AMT}= 5126 and above)	Measurements achieved	Spectrum Analyzer	OK MLS detected No AMT
2	Perform a communication between MS2 and BS while closed to MLS	Communication performed	Iperf	OK
Phase 4 Modulation performances				
1	GS 1 is ON Switch on MS1 (fix location) Switch off GS 2 Switch off MS 2	MS 1 connects eventually to the GS 1 F=5093,5 MHz	GS or MS MMI	OK
2	Fix modulation to 64QAM 5/6 in DL in the GS Start iperf in DL with a 10Mbps datarate	MS 1 connects eventually to the GS 1 in the selected modulation Read the DL max datarate	Iperf	OK Up to 64QAM 3/4
3	Go back to step 2 after switching successively to 64QAM ¾, 64QAM 2/3, 64QAM ½, 16 QAM ¾, 16 QAM ½, QPSK ¾ and QPSK ½			-
4	Fix modulation to 64QAM 5/6 in UL in the GS Sart iperf in UL with a 3Mbps datarate	MS 1 connects eventually to the GS 1 in the selected modulation Read the UL max datarate	Iperf	OK Up to 64QAM 2/3
5	Go back to step 2 after switching successively to 64QAM ¾, 64QAM 2/3, 64QAM ½, 16 QAM ¾, 16 QAM ½, QPSK ¾ and QPSK ½			-

Phase 5 QOS performances				
1	GS 1 is ON and MS1 (fix location) is ON GS 2 and other MS are OFF	MS 1 connects eventually to the GS 1 F=5093,5 MHz	GS or MS MMI	OK
2	Fix the QOS scheme to BE Start iperf in DL with a 10Mbps datarate	Read the DL max datarate And check that it is limited as indicated by the QOS policy	Iperf	OK
3	Go back to step 2 after switching the QOS to n-RT, RT, UGS	QOS changed	GS MMI	OK

7.3.2.2.3 Deviation from the planned activities

None.
The exercise was performed as expected. Two days were needed, first day was dedicated to installation and first lap of the Airport, and second day was dedicated to MLS interferences and modulation performances measurements.

7.3.2.3 Verification exercise Results

Phase 1: Installation, and completion of the scanning, synchronization, ranging process

GS 1 and GS 2 are installed on the former control tower and the fix MS in the building called “PB”. Once the pieces of equipment are started, the fix MS connects successfully to both BS:

- DL RSSI from GS1 is -61 dBm (f=5093,5 MHz),
- DL RSSI from GS2 is -73 dBm (f=5103,5 MHz)

The pictures below show the installation on the field.

Figure 7-29: The former control tower with the 2 Thales BS

Figure 7-30: BS orientation and operator position

Figure 7-31: MS1 at "PB" fix location (+ two equipped vehicles with MS2 and MS3)

Phase 2 Lap on the Airport surface / fast coverage survey

Additionally to the one installed at the fix point, two MS were installed in DSNA cars to perform tests all around the Toulouse Airport. One or two antennas are installed on the vehicle roof and connected to the MS via RF cables. The MS is connected to a PC which is equipped with a special survey tool that is able to record at the same time the vehicle position (thanks to a GPS installed on the vehicle roof and connected to the PC) and the RSSI level (from MS). The results are displayed in real time on the Airport map in THALES survey tool.

The following pictures show the vehicle installation.

Figure 7-32: 2 DGAC Vehicle installation with 2 Thales MS

The following pictures show the coverage map of the BS 1 and the BS 2. They are obtained while driving around the airport at a speed between 30 to 50 km/h speed. They are similar to the simulations: the whole Airport is covered. It was reported that the MIMO A for the MS equipped with two antennas gives an additional 2 to 3 dB reception gain (compensating loss in antenna cables).

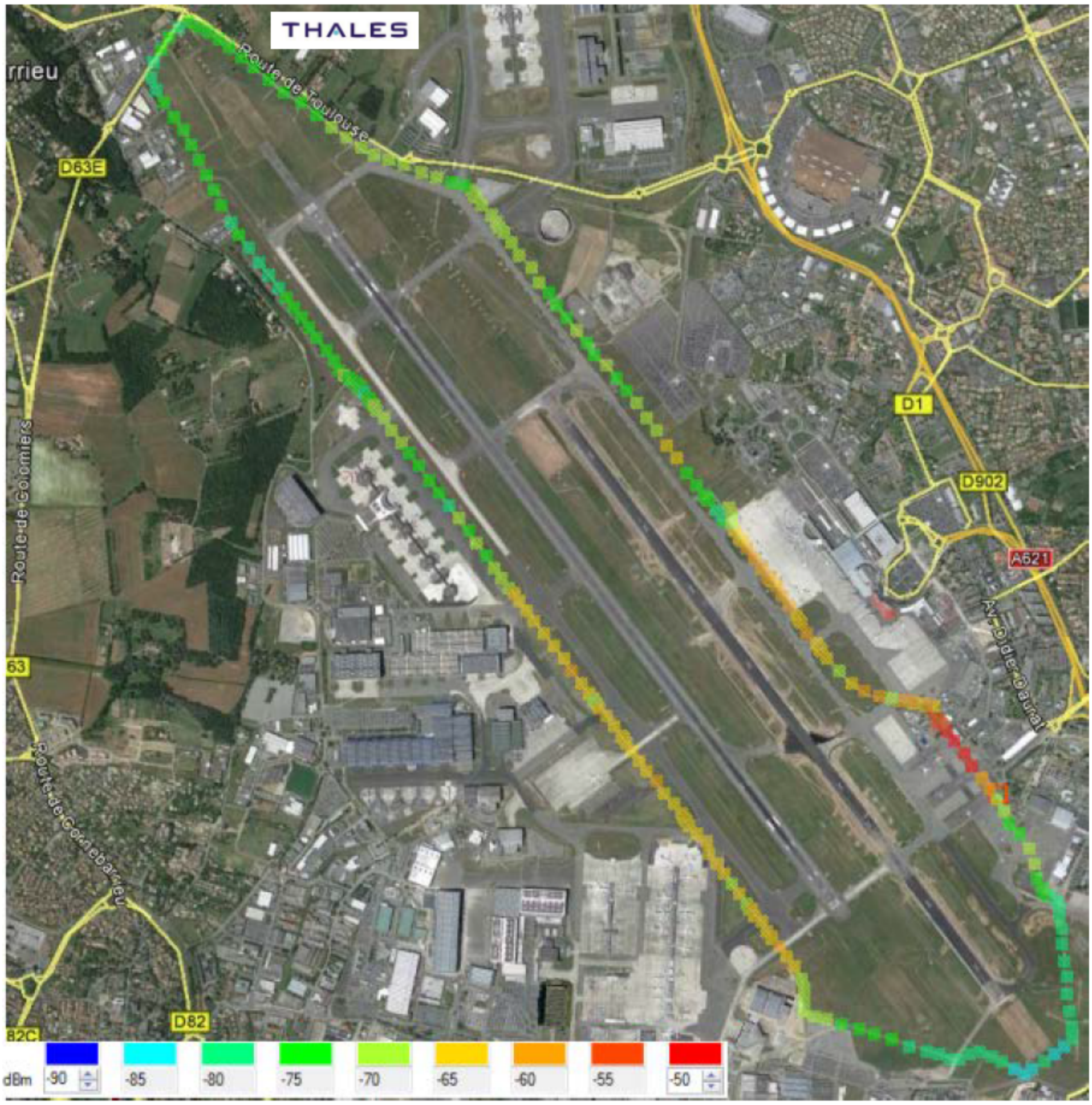


Figure 7-33: BS1 Airport measured coverage (BS 2 off)

Simulations with a propagation tool were done to compare the field results with simulations. The results can be found on map below. The same scale of colours for the RSSI is used in order to have a quick visual comparison: the measured levels are similar to the simulations. Additional analysis is given in the TAIR_020 test (see § 7.3.3.3).

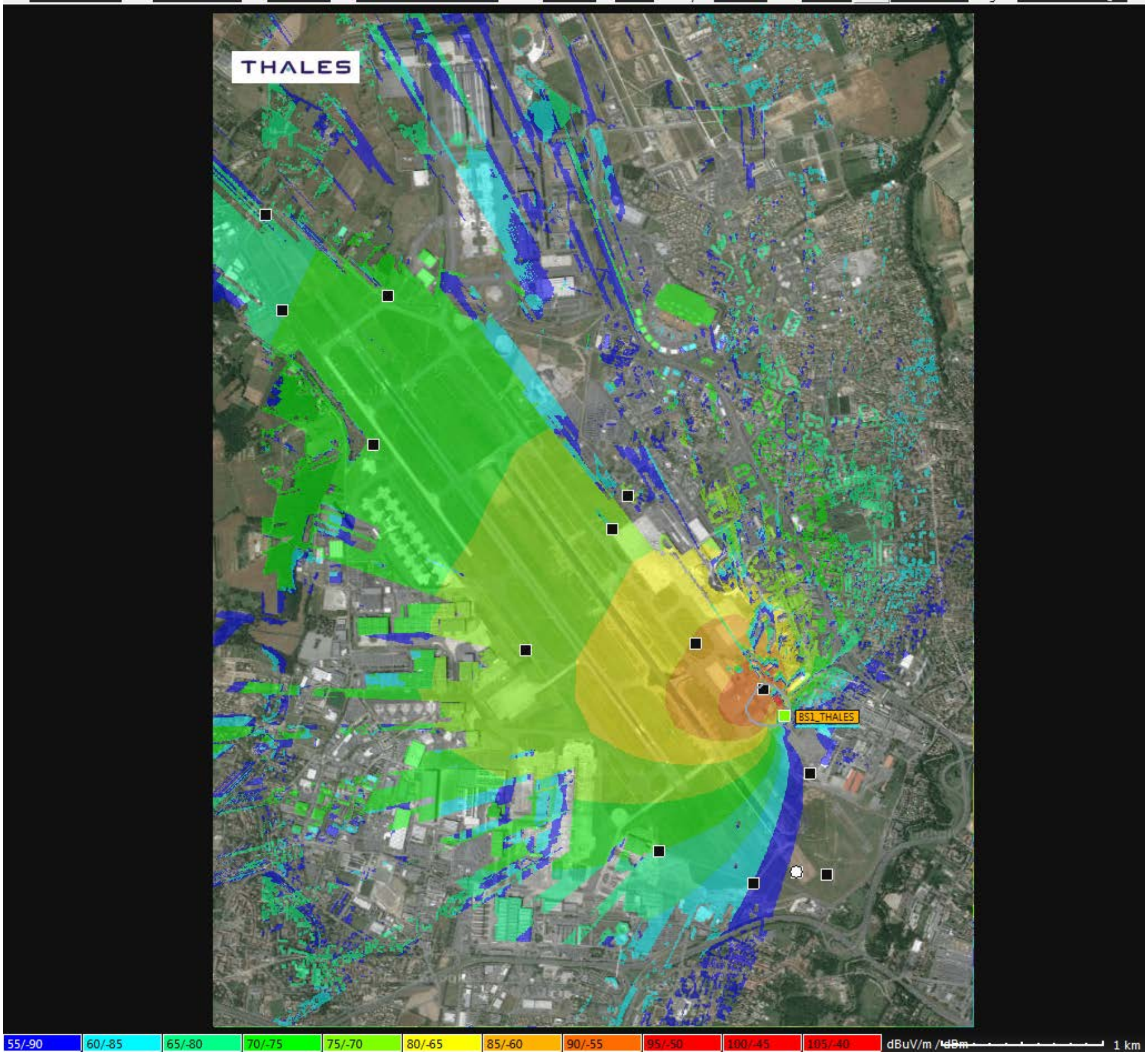


Figure 7-34: Thales BS1 coverage calculation

Figure 7-35: Thales BS2 Airport measured coverage (BS1 off)

Simulations with a propagation tool were done to compare the field results with simulations. The results can be found on map below. The same scale of colours for the RSSI is used in order to have a quick visual comparison. The measured levels are similar to the simulations once we considered side lobe of the antenna in the simulation (it explains the propagation up to the remote end of the airport).

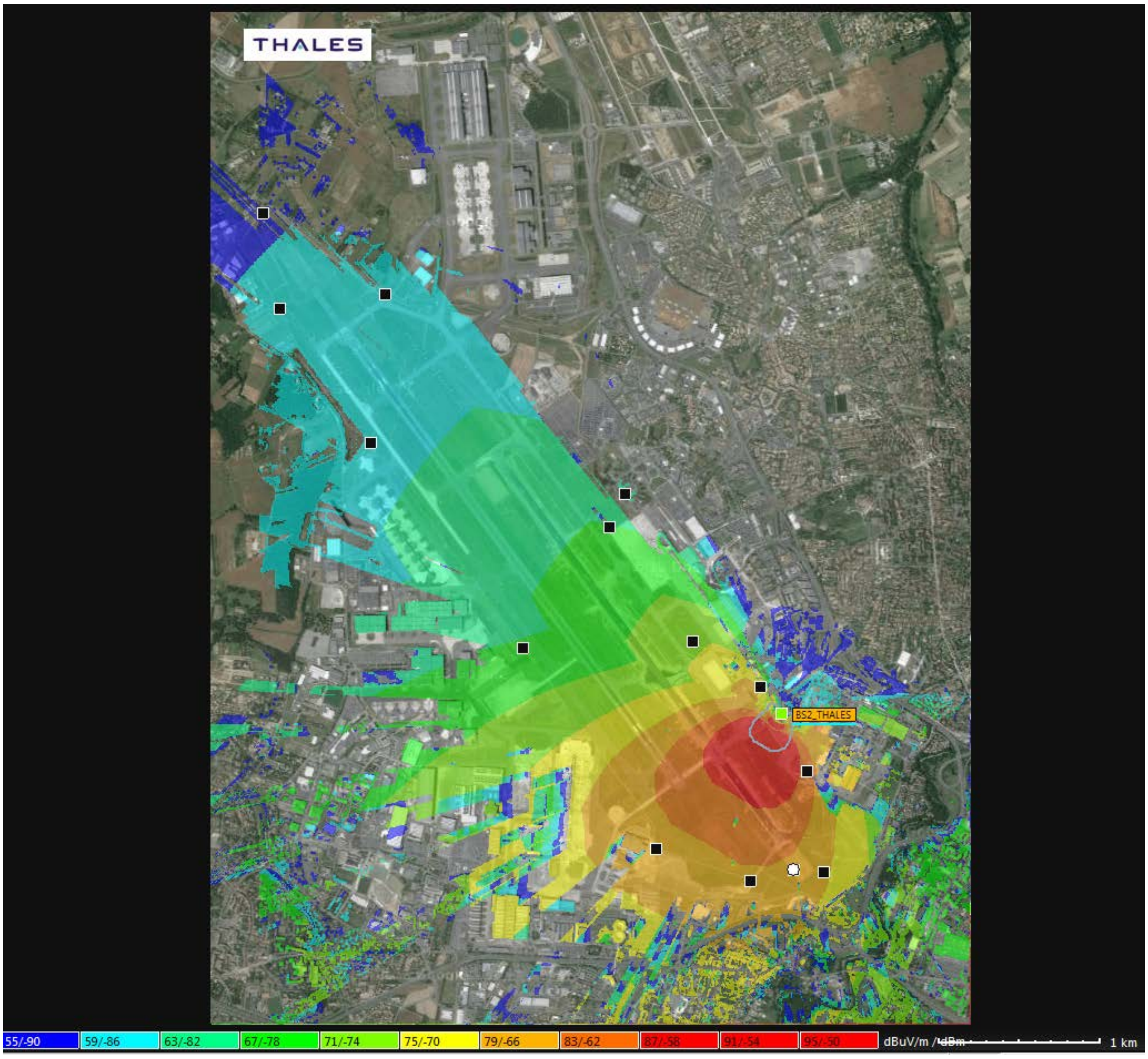


Figure 7-36: Thales BS2 coverage calculation

Phase 3 MLS Spectrum measurements

The MLS (Microwave Landing Systems) signal use Time Division Multiplexing (TDM) including azimuth and elevation signals. These signals are Continuous Wave (CW) with DPSK preambles with 3 dB bandwidth of 15.626 kHz. It is the preambles that may interfere with other systems and notably AeroMACS due to its low out-of-band attenuation. The frequency of MLS is 5038,8 MHz.
In P15.02.07. D04 deliverable, it was stated that "MLS transmitters may cause harmful interference to AeroMACS receivers when installed at the same airport, even when the two systems are separated in frequency by several tens of MHz".
Some measurements were made nearby the MLS (see picture below) in Toulouse to see the impact of MLS on AeroMACS.

Figure 7-37: MLS (south) test location

The frequency gap between Toulouse minimum authorized frequency (5093,5 MHz) and the MLS is: 54,7 MHz. Based on D04, such a frequency gap means that no interferences are expected above a distance of 250 m.

More precisely, in D04 assuming a rejection of -70 dB (more than 3 channels spacing from MLS frequency), the interference zone was defined as follow:

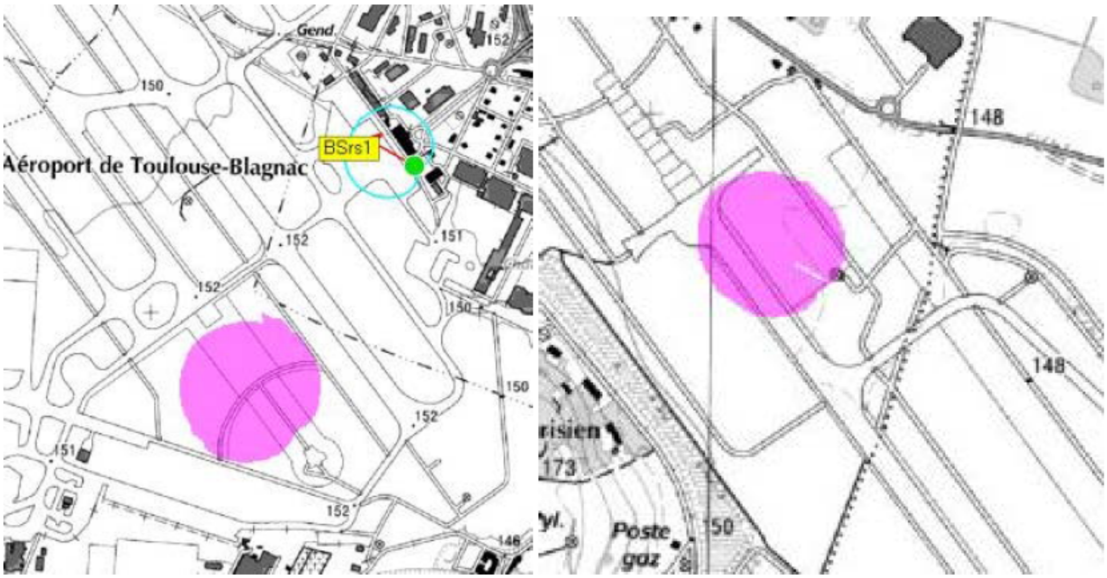


Figure 7-38: MLS (south & north) interference zone with 70dB rejection (source D04)

We went as close as possible from the MLS sites see trajectory below (distance approximately 150 m) to be in the computed interfered area of MLS.

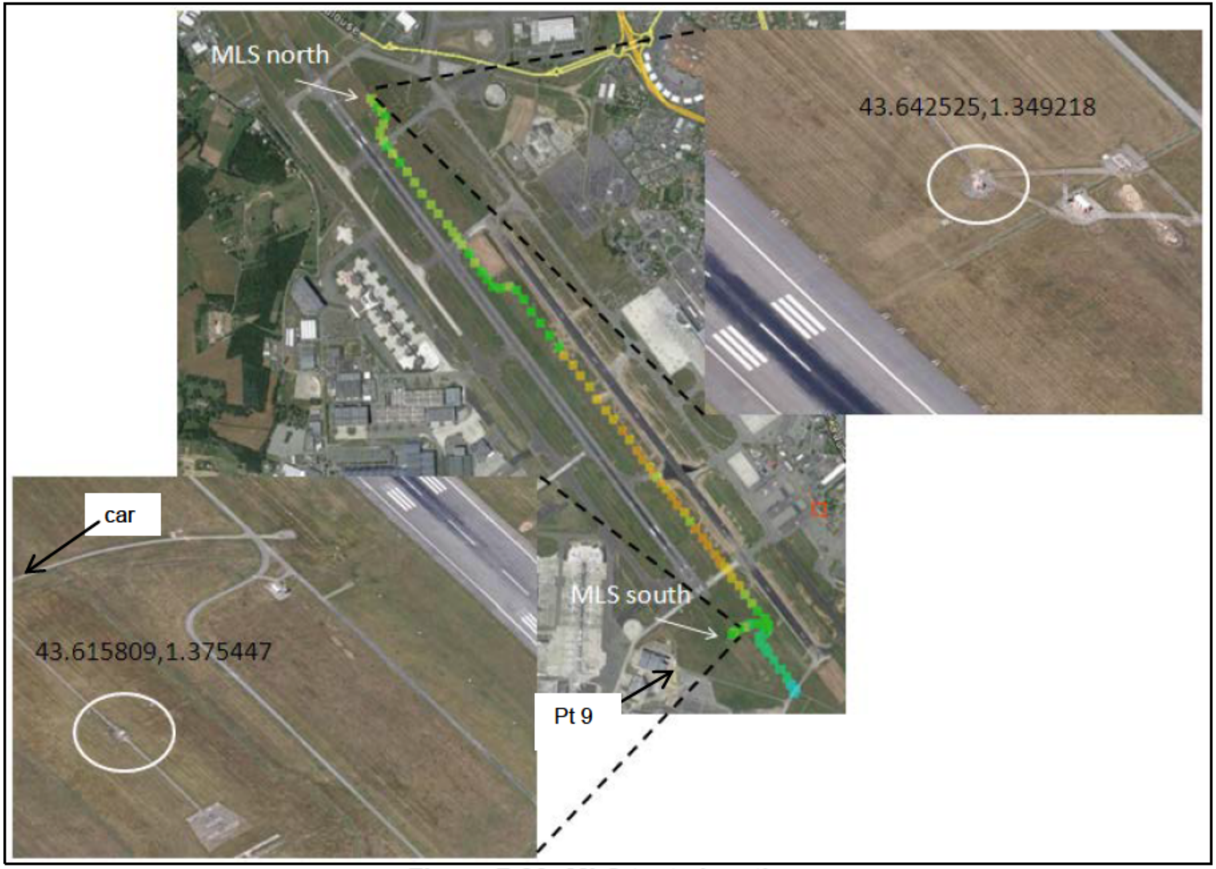


Figure 7-39: MLS tests location

- Close to MLS north (MLS for site angles), we performed in DL a constant 8.9 Mbps communication (modulation between 64QAM ¾ and 64QAM 5/6) with a DL RSSI of -68 dB: no interferences were apparently noticed.

- In the vicinity of MLS south (MLS for azimuth angles), we performed a DL communication: the DL data rate varied between 3,5 and 5 Mbps (modulation between 16 QAM ½ and 64 QAM 1/2). These variations lead us think about experiencing interferences from the MLS.
- A close up on the recordings near MLS South seems to confirm this assumption: one can see below that the RSSI seems sometimes increased artificially potentially due to MLS interference (left picture), while the CINR is at the same time comparatively low (right picture), confirming the hypothesis of the interferences presence, close to the MLS signal source. A degradation of about 4 dB in CINR (light blue points at center of image) while CINR can increase of about 4 dB (red point at center of image).

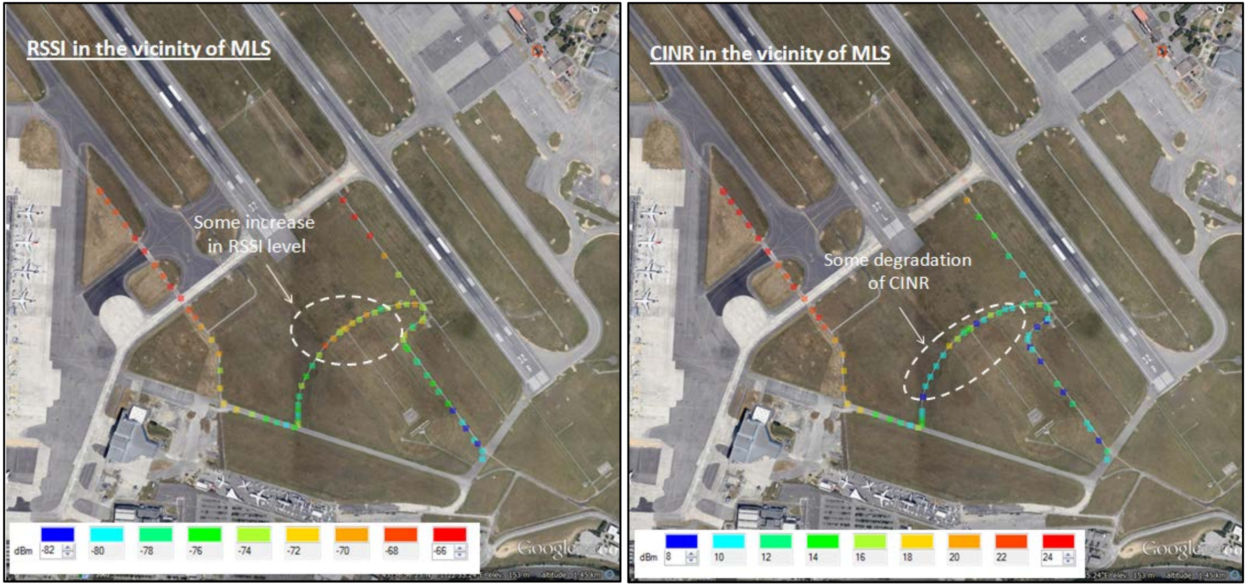


Figure 7-40: Close analyse in the vicinity of MLS

Concerning other potential sources of interferences, note that no AMT and no other AeroMACS system signals were detected on the Airport during our field trials. Below the spectrum measurements:

Figure 7-41: Spectrum measurement near MLS signal (south)

Figure 7-42: Spectrum measurements near MLS signal (north)

Phase 4 Modulation performances

All the modulations were tested in DL and UL from the MS1 on the fix point (PB) and the BS1. Additionally, a test was performed closer from BS1 location with a MS in car to test the upper modulations 64QAM5/6 (see TAIR_20, point 1) as it happens they would not be working at PB.

The results are summarized in following table and are similar to what was measured in lab.
Note: the throughput comes from the information displayed by `iperf`. It is an “UDP” throughput: the effective radio throughput is a bit higher if one considers the UDP headers.

MCS	UL throughput	DL throughput
QPSK1/2	0,4 Mbps	1,7 Mbps
QPSK3/4	0,7 Mbps	2,6 Mbps
16QAM1/2	0,9 Mbps	3,5 Mbps
16QAM3/4	1,4 Mbps	5,3 Mbps
64QAM1/2	1,4 Mbps	5,3 Mbps
64QAM2/3	1,9 Mbps	7,0 Mbps
64QAM3/4	KO at fix point (PB) which is too far No other measurement attempt performed	8,0 Mbps
64QAM5/6	KO at PB 2,3 Mbps measured nearer to BS1	KO at PB 8,9 Mbps measured nearer to BS1

Phase 5 QOS performances

Each QOS service flow (BE, nRTP, RTP, eRTP, UGS) was successively and dynamically assigned to the MS while having a 1 Mbps communication. The max data rate of each service flow was set to 300 kbps. As expected, the throughput of the communication was limited to 300 kbps once the SF is allocated to the MS.

Additional results

The fix MS at PB is most of the time in line of sight with the BS. In fact, as it is located near the terminal area, it happens that the aircrafts drives close to PB and generates a mask between the MS antenna and the BS antenna (as one can see on the picture below taken from the BS location). The corresponding RSSI degradation was between 10 to 15 dB.

Figure 7-43: Mask due to aircraft which hide the antenna on PB

A measurement of the net entry time was also performed:

- The MS scan is programmed to scan all frequencies between 5093,5 MHz (included) and 5147,5 (included), with a step size of 250 kHz (217 frequencies) (note: all the frequencies are scanned equivalently, no signal threshold etc…)
- The MS is off
- The time between the moment when the MS is switched on and a ping is performed successfully through the AeroMACS link is around: 2 minutes and 10 seconds. All the frequencies were scanned.

7.3.2.3.1 Unexpected behaviors/Results

None

7.3.2.4 Conclusions and recommendations

The TAIR-10 test case allows controlling the installation of the pieces of equipment (BS1 and BS2 in the former control tower, MS in cars and in fix location) and verifying the main performances of AeroMACS on the field.

Additionally, interferences in the vicinity of the MLS were evaluated and the potential effects of Aircraft masks were quantified.

Main conclusion is that the coverage of the whole Toulouse Airport can be achieved with two BS in LOS conditions.

7.3.3 Verification Exercise # TAIR_020

7.3.3.1 Verification Exercise Scope

Cell coverage and MS channel quality reporting:
Verify the maximum distance in the airport where the datalink is synchronized, and assess the different modulation schemes and the throughput hence supported.

At each point of the “route de service’ in green, stop and perform measurements in LOS (RSSI, max throughput, jitter and delay). The “route de service” is used twice to assess the coverage of the two servicing cells:

- first time with BS 1 on (BS 2 off)
- and second time with BS2 on (BS 1 off)

7.3.3.2 Conduct of Verification Exercise

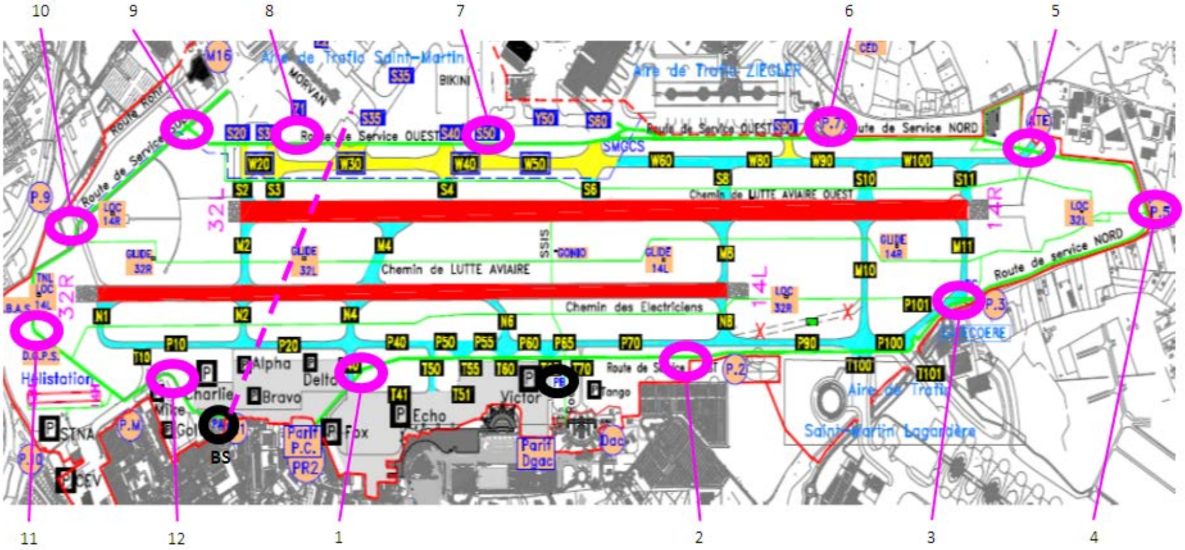
7.3.3.2.1 Verification Exercise Preparation

Equipment: BS1&2 + 1 MS in a car+ Spectrum Analyzer

Resources:

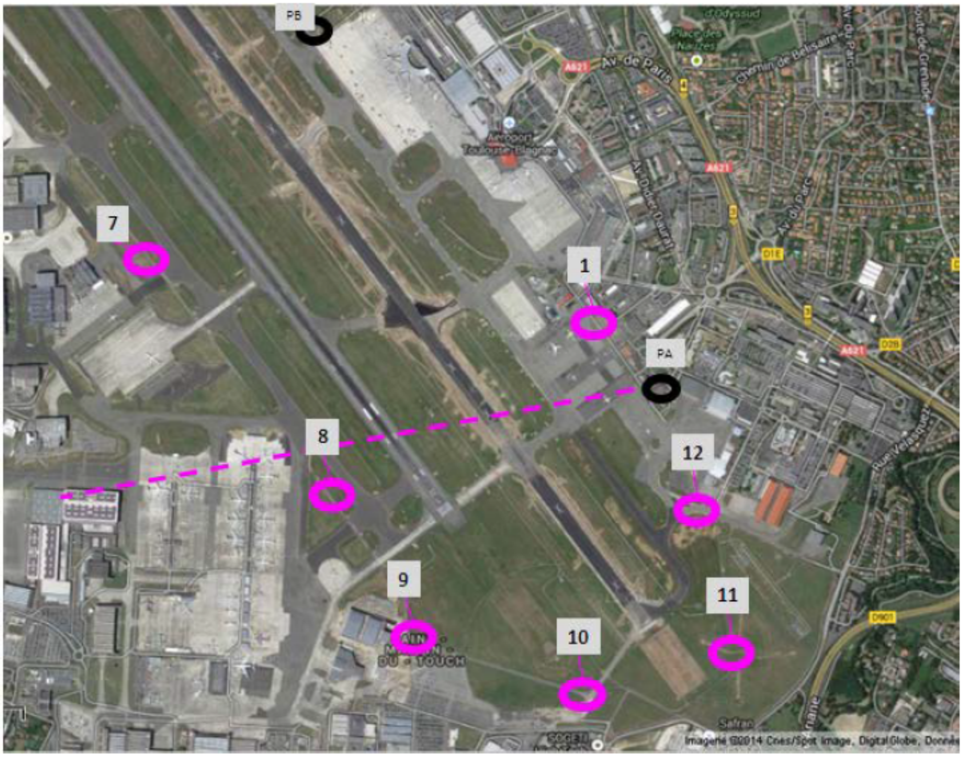
- Thales: 2 engineers
- DSNA: a driver with a car.

Potential measurement points and car trajectories:




4
D63E
D1
Route de Toulouse
3
Route de Toulouse
D1
Route de Cornebarrieu
5
Av. Latecoere


D1
Route de Cornebarrieu
D1
D1
Voie Lactée
D902
2
6
D902
McDonald's
D1
PB
Av. de Paris
A621
Aéroport Toulouse-Blagnac
7
Airbus
GRAMONT



7.3.3.2.2 Verification Exercise execution

Step	action	Action result	PCO	Result
Phase 1 Cell coverage of GS 1				
1	GS1 is switched ON GS2 is switched OFF GS1 is provisioned with frequency: 5093,5 MHz Fix MS 1 is OFF	GS 1 is started	GS control MMI	OK
2	Set frequency scan of MS 2 (mobile) : 5093,5 MHz 5098,5 MHz 5103,5 MHz Go to point 1 and stop	MS connects eventually to the GS F=5093,5 MHz	MS MMI	OK
3	Adaptive modulation is selected on the GS as MS profile Site survey tool is shut down Perform measurements: Write down geo-localization Write down measured RSSI / CINR on MS MMI and on BS MMI 'ping' in both direction and write down	Written down are the different measurements	GPS MMI GS/MS MMI MS MMI ping cmd iperf cmd	OK

	mean Round Trip Time Initiate a bidirectional 'iperf' communications to evaluate DL and UL throughput: Write down mean maximum throughput Write down mean jitter Write down the UL and DL modulations (during 'iperf')			
4	Go to most approrpiate points around airport from 2 to 12 and stop and perform steps 3 to 5 to characterize cell coverage	-	-	OK
Phase 2 Cell coverage of GS 2				
1	GS1 is switched OFF GS2 is switched ON GS2 is provisioned with frequency: 5103,5 MHz Fix MS 1 is OFF	GS 2 is started	GS control MMI	OK
2	Set frequency scan of MS 2 (mobile) : 5093,5 MHz 5098,5 MHz 5103,5 MHz	MS connects eventually to the GS F=5103,5 MHz	MS MMI	OK
3	Adaptive modulation is selected on the GS as MS profile Go to point 1 and stop Perform measurements: Write down geo-localization Write down measured RSSI / CINR on MS MMI (site survey tool is shut down) and on BS MMI 'ping' in both direction and write down mean Round Trip Time (RTT) Initiate a bidirectional 'iperf' communications to evaluate DL and UL throughput: Write down mean maximum throughput Write down mean jitter / latency Write down the UL and DL modulations (during 'iperf')	Written down are the measurements.	GPS MMI GS/MS MMI ping cmd iperf cmd	OK
6	Go to the most appropriate points 2 to		-	OK

	12 and stop and perform steps 3 to 5 to characterize cell coverage.			

7.3.3.2.3 Deviation from the planned activities

None.
TAIR_20 was performed on day 3 as expected.

7.3.3.3 Verification exercise Results

Phase 1 Cell coverage of GS 1

A circle trip was performed all around the airport with stops at some points to perform communications and measurements. It was verified that the modulation and coding scheme were changed accordingly to the received level and signal to noise ratio. The results are also compared with the coverage simulations. The complete set of measurements of BS1 is reported below.

Point 1.1:

- DL RSSI: -47 dBm, UL RSSI: -110[2] dBm, UL CINR: 22 dB, DL CINR: 30.5 dB
- Max MCS: 64QAM 5/6 (DL) 64QAM 5/6 (UL)
- Max throughput: 8.91 Mbits/sec (DL), 2.29 Mbits/sec (UL)
- Mean RTT: 72 ms, mean latency: 36 ms, mean jitter: 7 ms

Point 3:

- DL RSSI: -68 dBm, UL RSSI: -117 dBm, UL CINR: 15 dB, DL CINR: 25.5 dB
- Max MCS: 64QAM 5/6 (DL) / 64QAM ½ (UL)
- Max throughput: 8.00 Mbits/sec (DL) / 1.37 Mbits/sec (UL)
- Mean RTT: 70 ms, mean latency: 35 ms , mean jitter: 3 to 8 ms

Point 4:

- DL RSSI: -78 dBm, UL RSSI: -125.0 dBm, UL CINR: 10 dB, DL CINR: 18.3 dB
- Max MCS: 64QAM ½ (DL), QPSK ¾ (UL)
- Max throughput: 4.53 Mbits/sec (DL), 680 Kbits/sec (UL)
- Mean RTT: 78 ms, mean latency: 39 ms , mean jitter: 4 to 7,5 ms

Point 6:

- DL RSSI: -72 dBm, UL RSSI: -121.5 dBm, UL CINR: 11.5 dB, DL CINR: 21.4 dB
- Max MCS: 64QAM 5/6 (DL) 16QAM 1/2 (UL)
- Max throughput: 6.60 Mbits/sec (DL), 743 Kbits/sec (UL)
- Mean RTT: 72 ms, mean latency: 36 ms, mean jitter: 3 to 4 ms

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[2] In UL the RSSI is measured by subcarrier

Point 7:

- DL RSSI: -68 dBm, UL RSSI: -114 dBm, UL CINR: 16.5 dB, DL CINR: 23.2 dB
- Max MCS: 64QAM 5/6(DL) / 64QAM ½ (UL)
- Max throughput: 6.79 Mbits/sec (DL) / 1.24 Mbits/sec (UL)
- Mean RTT: 71 ms , mean latency: 36 ms , mean jitter: 3 to 8 ms

Point 9:

- DL RSSI: -70 dBm, UL RSSI: -115,5 dBm, UL CINR: 15 dB, DL CINR: 18.5 / 21.0 dB
- Max MCS: 64QAM ½ (DL) 16QAM ¾ (UL)
- Max throughput: 4.00 Mbits/sec (DL) / 1.25 Mbits/sec (UL)
- Mean RTT: 70 ms, mean latency: 35 ms , mean jitter: 2.5 to 7.5 ms

Point 11:

- DL RSSI: -87 to -84 dBm, UL RSSI: -126,5 dBm, UL CINR: 0.5, DL CINR: 0 to 2 dB
- Max MCS / Max throughput: no measurements as iperf didn't work
- Mean RTT: 91 ms (DL: 10% of ping lost, max RTT 341 ms / UL: 28% of ping lost max RTT: 172 ms)

⇨ As expected from simulations, this point is at the limit of coverage of BS1.

Point 12:

- DL RSSI: -75 dBm, UL RSSI: -118,5 dBm, UL CINR: 8 dB, DL CINR: 11.0 dB
- Max MCS: 16QAM ½ (DL) / 16QAM ½ (UL)
- Max throughput: 2.27 Mbits/sec (DL) / 745 Kbits/sec (UL)
- Mean RTT: 70 ms, mean latency: 35 ms , mean jitter: 2.7 to 4.8 ms

⇨ Contrary to simulations, this point is still reachable from BS1..

The measurements are compared to the simulations below. Globally the results are similar to simulations. The received level at point 11 and point 12 are much better than expected: it was analysed that it is due to the side lobe of the antenna that was not sufficiently considered in simulation[3]. Point 9 is not as good as expected (when compared to point 6 for example). It is believed that MLS interference could have influenced the data rate at this point.

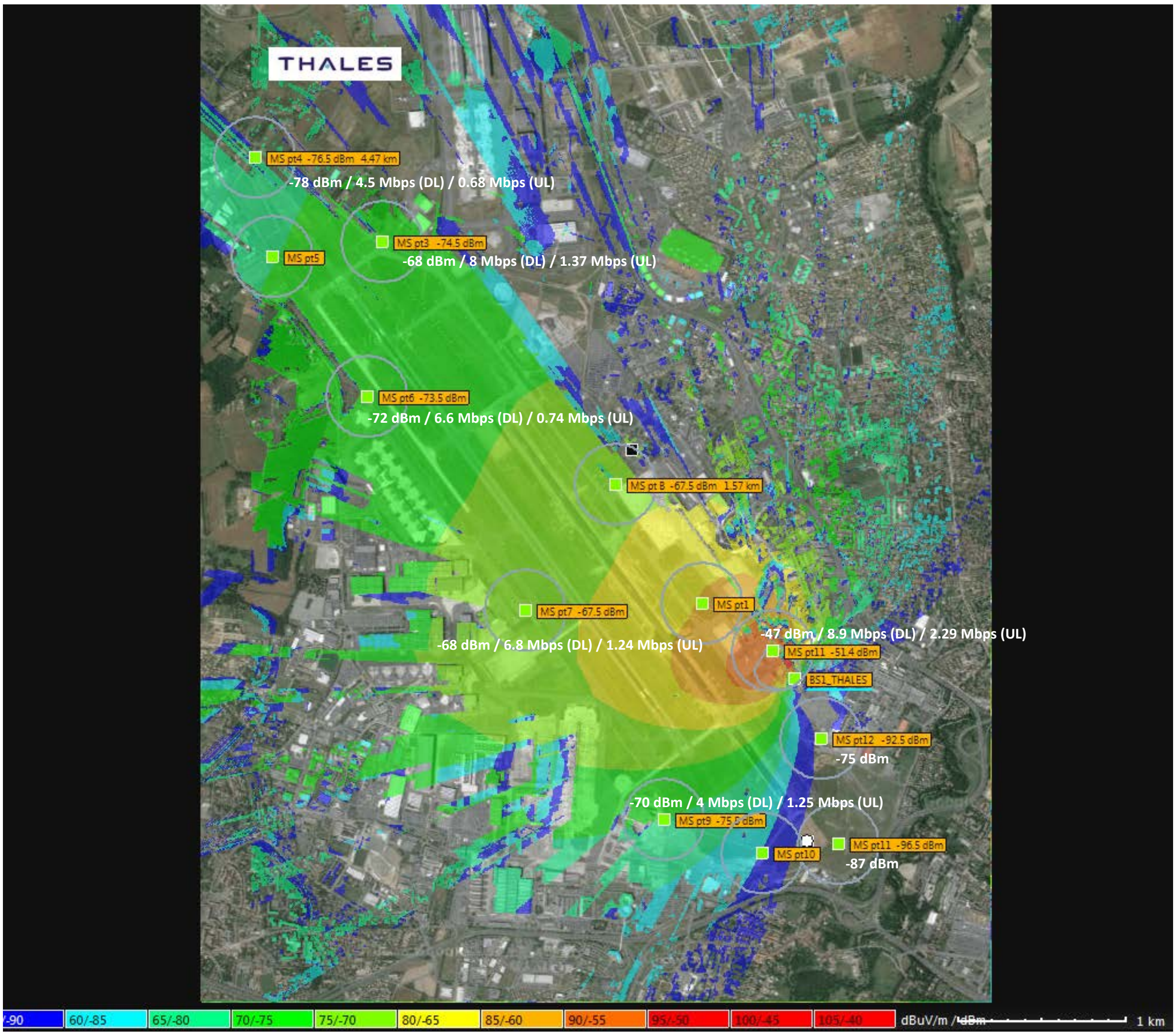

Figure 7-44: THALES BS1 coverage measurements versus simulation

Phase 2 Cell coverage of GS 2

The complete set of measurements for BS2 is reported below.

Point 1:

- DL RSSI: -70 dBm, UL RSSI: -118.0 dBm, UL CINR: 14.5 dB, DL CINR: 12 dB
- Max MCS: 16QAM ¾ (DL) /16QAM ¾ (UL)
- Max throughput: 3.69 Mbits/sec (DL) / 1.20 Mbits/sec (UL)
- Mean RTT: 72ms, mean latency: 36 ms, mean jitter: 4 to 7,5 ms

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[3] BS2 coverage simulation was considered with antenna side lobe to confirm this assumption.

Point B:

- DL RSSI: -79 dBm, UL RSSI: -127.5 dBm, UL CINR: 6 dB, DL CINR: 9,5 dB
- Max MCS: 16QAM ½ (DL) /QPSK ¾ (UL)
- Max throughput: 3.2 Mbits/sec (DL) / 583 Kbits/sec (UL)
- Mean RTT: 73ms, mean latency: 36 ms, mean jitter: 6.5 to 7.5 ms

Point 3:

- DL RSSI: -81 dBm, UL RSSI: -124.5 dBm, UL CINR: 7 dB, DL CINR: 8.79
- Max MCS: QAM16 ½ (DL) / QPSK ½ (UL)
- Max throughput: 3.40 Mbits/sec (DL) / 188 Kbits/sec (UL)
- Mean RTT: 71 ms, mean latency: 35 ms, mean jitter: up to 16 ms (UL)

Point 4:

- DL RSSI: - 86 dBm, UL RSSI: -123.5 dBm, UL CINR: 8 dB, DL CINR: 6.5 dB
- Max MCS: QPSK ½ (DL) / QPSK ½ (UL)
- Max throughput: 2.43 Mbits/sec (DL) / 111 Kbits/sec (UL)
- Mean RTT: 77 ms, Mean latency: 38 ms, mean jitter: 7 up to 22 ms (UL)

Point 5:

- DL RSSI: -83 dBm, UL RSSI: -126 dBm, UL CINR: 7 dB, DL CINR: 9.5 dB
- Max MCS: QAM16 ½ (DL) / QPSK ¾ (UL)
- Max throughput: 3.34 Mbits/sec (DL) / 378 Kbits/sec (UL)
- Mean RTT: 72 ms, mean latency: 36 ms, mean jitter: 5.5 ms

Point 6:

- DL RSSI: -79 dBm, UL RSSI: -125.5 dBm, UL CINR: 7.5 dB, DL CINR: 12.5 dB
- Max MCS: 64QAM ½ (DL) / QPSK ¾ (UL)
- Max throughput: 4.41 Mbits/sec (DL) / 644 Kbits/sec (UL)
- Mean RTT: 63 ms, mean latency: 36 ms, mean jitter: 3.3 to 7.6 ms

Point 7:

- DL RSSI: -67 dBm, UL RSSI: -115.5 dBm, UL CINR: 19.5 dB, DL CINR: 21 dB
- Max MCS: 64QAM 5/6 (DL) / 64QAM 2/3 (UL)
- Max throughput: 8.66 Mbits/sec (DL) / 1.52 Mbits/sec (UL)
- Mean RTT:70 ms , mean latency: 35 ms, mean jitter: 7 to 9 ms

Point 9:

- DL RSSI: -68 dBm, UL RSSI: -114.5 dBm, UL CINR: 20 dB, DL CINR: 21 dB
- Max MCS: 64QAM 5/6 (DL) / 64QAM 2/3 (UL)
- Max throughput: 8.68 Mbits/sec (DL) / 1,5 Mbits/sec (UL)
- Mean RTT: 70 ms, mean latency: 35 ms, mean jitter: 2.5 ms to 8.5 ms

Point 10:

- DL RSSI: -60 dBm, UL RSSI: -110.0 dBm, UL CINR: 22.5 dB, DL CINR: 22 dB
- Max MCS: 64QAM 5/6 (DL) / 64QAM 5/6 (UL)
- Max throughput: 8.90 Mbits/sec / 1.59 Mbits/sec
- Mean RTT: 69 ms, mean latency: 35 ms, mean jitter: 2.5 ms to 8.5 ms

Point 11:

- DL RSSI: -65, UL RSSI: -110.0, UL CINR: 23.0, DL CINR: 21
- Max MCS: 64QAM 5/6 (DL) / 64QAM 5/6 (UL)
- Max throughput: 7.94 Mbits/sec (DL) / 1.46 Mbits/sec (UL)
- Mean RTT: 70 ms, mean latency: 35 ms, mean jitter: 3 to 6.5 ms

Point 12:

- DL RSSI: -59 dBm, UL RSSI: -108.5 dBm, UL CINR: 21.5 dB, DL CINR: 16.5 dB
- Max MCS: 64QAM ¾ (DL) / 64QAM 5/6 (UL)
- Max throughput: 7.34 Mbits/sec / 1.97 Mbits/sec
- Mean RTT: 77 ms, mean latency: 38 ms, mean jitter: 3 to 6,5 ms

The measurements are compared to the simulations below. Globally the results are similar to simulations.

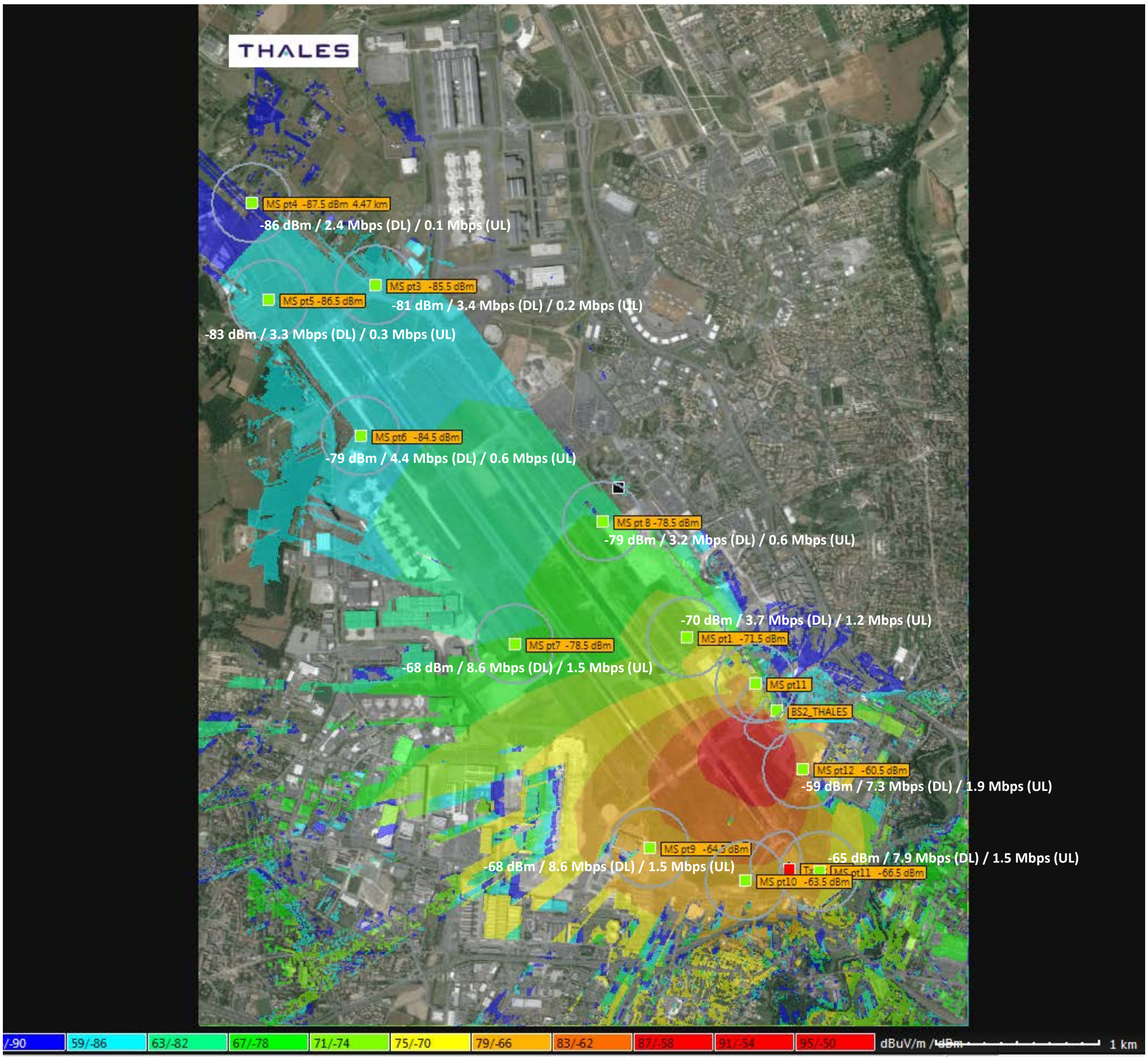


Figure 7-45: BS2 coverage measurements versus coverage simulation

Additional measurements

A measurement was done in extremely low reception conditions in the DGAC parking. With a RSSI around -91 dBm, a DL communications was established in QPSK ½ still offering 1 Mbps DL (TDD ratio 32/15).

7.3.3.3.1 Unexpected behaviors/Results

None

7.3.3.4 Conclusions and recommendations

The test allowed making cell coverage for BS1 on one side and BS2 on the other side. Good performances were reported. They are generally in accordance with simulations.

7.3.4 Verification Exercise # TAIR_030

7.3.4.1 Verification Exercise Scope

Real deployment and NLOS performances:
Evaluate the impact of buildings, hangars on the strength of the signal.
Stop in places with near-LOS or Non-LOS conditions. As far as possible, different kind of zones of the Airport are visited: ramp Area, parking Area, Tower Area, Access roads to installations for maintenance operations.

7.3.4.2 Conduct of Verification Exercise

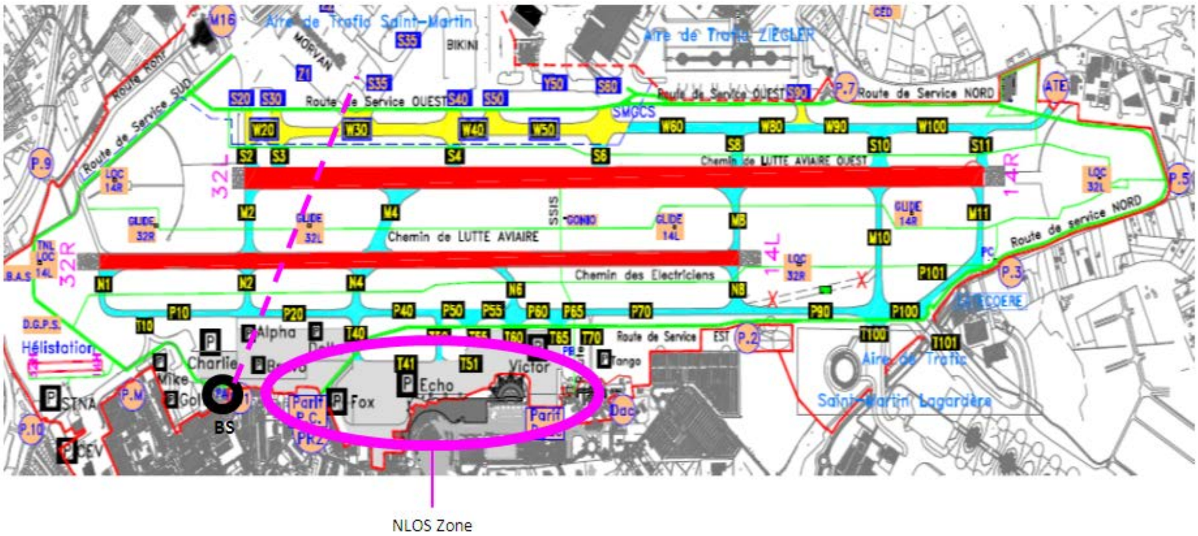
7.3.4.2.1 Verification Exercise Preparation

Equipment: BS1&2 + 1 MS in a car+ Spectrum Analyzer

Resources:

- Thales: 2 engineers
- DSNA: a driver with a car.

Measurement points and car trajectories:




NLOS car full trajectory
BS1
Aeroport Toulouse Blagnac
Av de Rome
Plan
Trafic
Av Didier Daurat
Rue Charles Lindbergh
Allée Henri Potez
Av Emile Dewoitine


4
3
2
1
Plan
Trafic


12
11
10
9
8
7
6
5
4
3
2
Plan
Trafic


20
19
18
17
16
15
14
13
12
Plan
Trafic

7.3.4.2.2 Verification Exercise execution

Step	action	Action result	PCO	Result
1	GS1 is switched ON GS2 is switched OFF GS1 is provisioned with frequency: 5093,5 MHz Fix MS is OFF Adaptive modulation is selected on the GS as MS profile	GS 1 is started	GS control MMI	OK
2	Set frequency scan of mobile MS: 5093,5 MHz 5098,5 MHz 5103,5 MHz	MS connects eventually to the GS F=5093,5 MHz	MS MMI	OK
3	Perform a trip on the “NLOS car trajectory” (green below) and record MS RSSI on the fly with survey tool	RSSI recorded on the map	Survey tool	OK
4	Go to point 1 and stop	-	-	
5	Adaptive modulation is selected on the GS as MS profile Perform measurements: Write down geo-localization / (Take a picture to illustrate the NLOS conditions) Write down measured RSSI / CINR on MS MMI (site survey tool is shut down) and on BS MMI ‘ping’ in both direction and write down mean Round Trip Time Initiate a bidirectional ‘iperf’ communications to evaluate DL and UL throughput: Write down mean maximum throughput Write down mean jitter Write down the UL and DL modulations (during ‘iperf’)	Written down are the measurements	GS/MS MMI ping cmd iperf cmd GPS MMI	OK
8	Go to ‘NLOS’ measurement point 3, 5, 7, 9, 11, 13, 15, 18, 19 and stop where possible and perform steps 5 to 7		-	OK

7.3.4.2.3 Deviation from the planned activities

None.

7.3.4.3 Verification exercise Results

The recordings of the DL RSSI on the fly are in accordance with the NLOS conditions: the more obstacles, the less signal. Communications are still possible even in very important NON LOS conditions. The distances are between 330 m (point #1) and 1400 m (point #19). Detailed performances and pictures of the “NLOS” position are displayed in following pages.

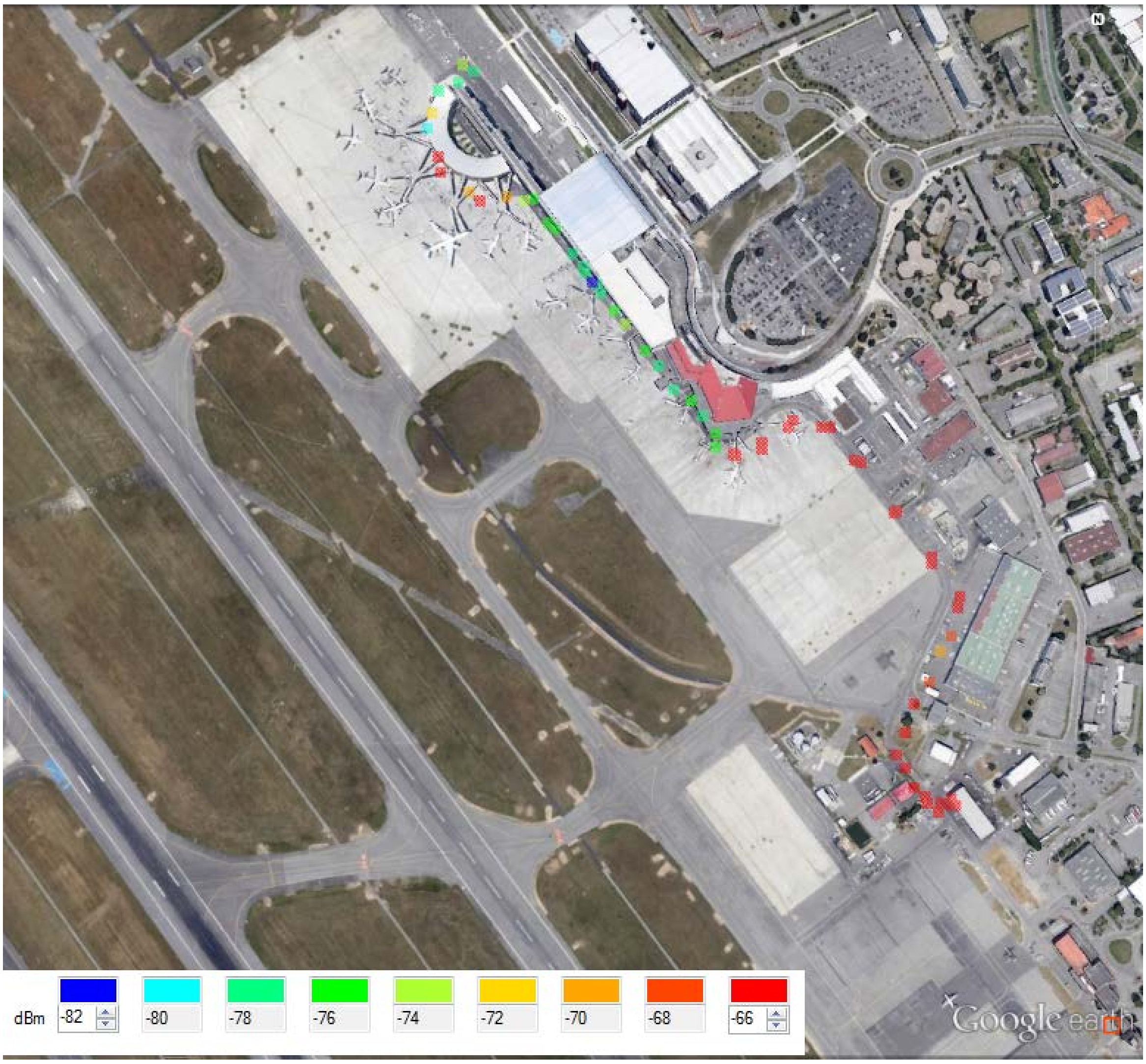
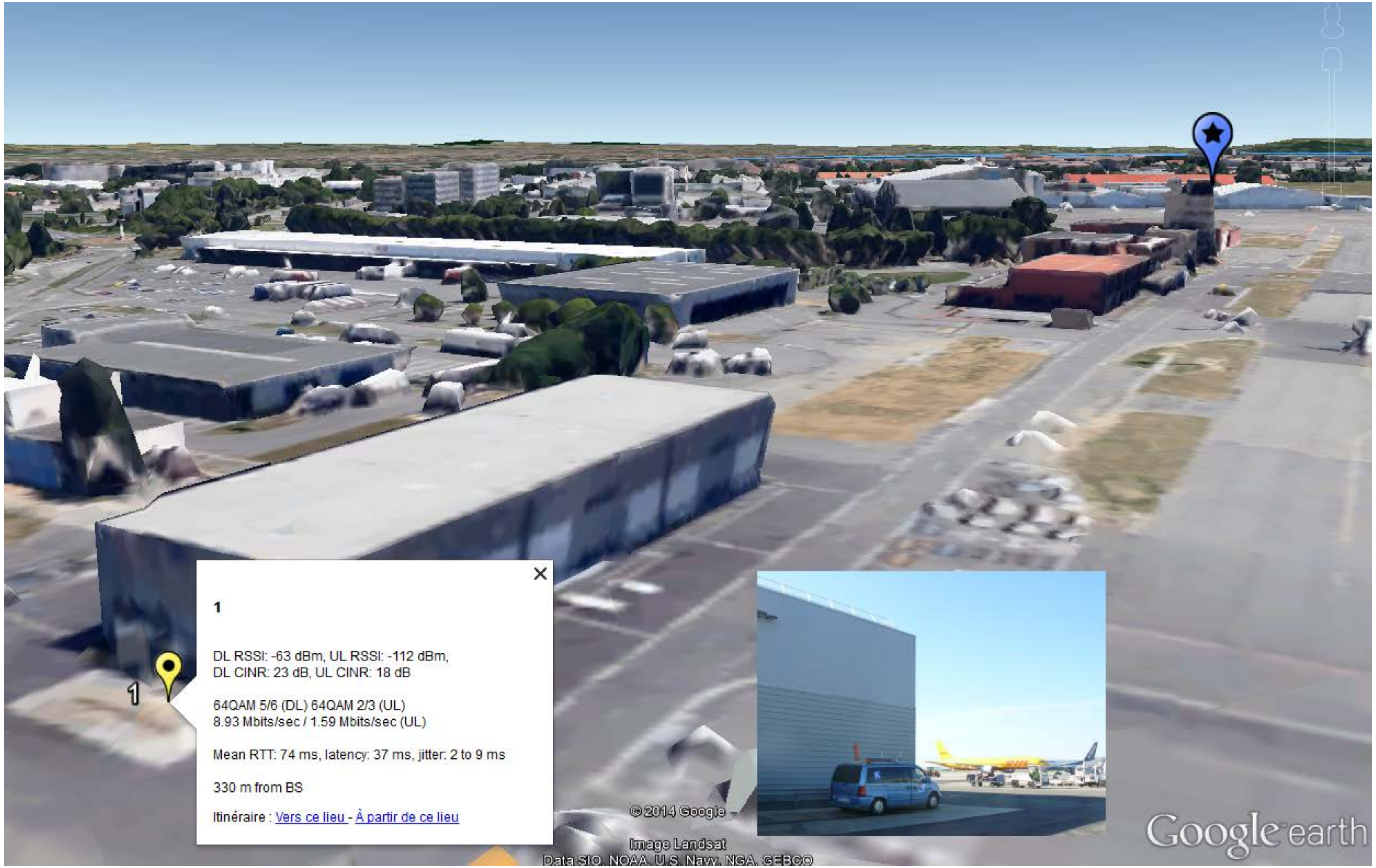


Figure 7-46: Recordings on the Fly of the RSSI in NLOS conditions



1

DL RSSI: -63 dBm, UL RSSI: -112 dBm,
DL CINR: 23 dB, UL CINR: 18 dB

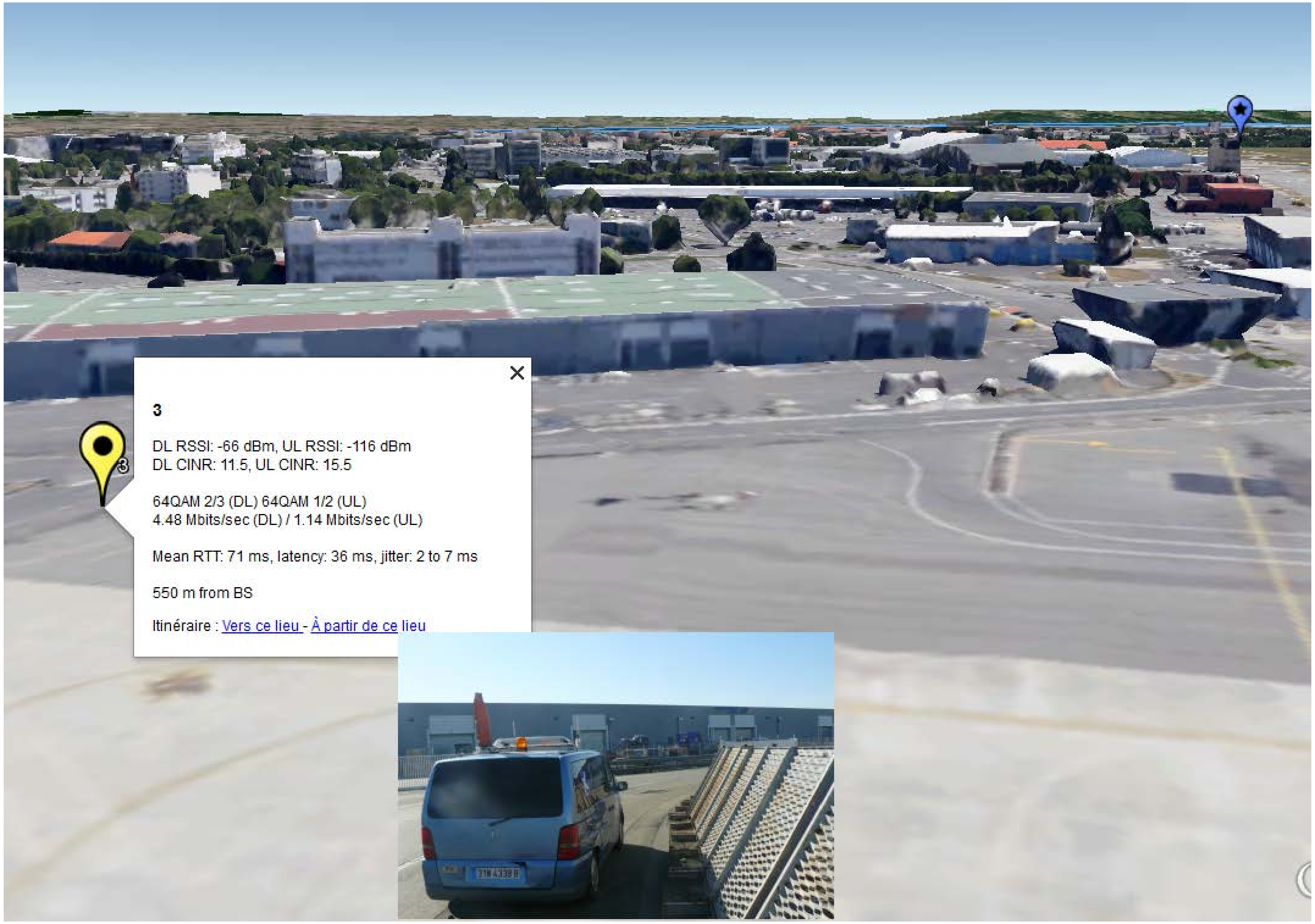
64QAM 5/6 (DL) 64QAM 2/3 (UL)
8.93 Mbits/sec / 1.59 Mbits/sec (UL)

Mean RTT: 74 ms, latency: 37 ms, jitter: 2 to 9 ms

330 m from BS

Itinéraire : Vers ce lieu - À partir de ce lieu

Figure 7-47: NLOS point #1 measurement details



3

DL RSSI: -66 dBm, UL RSSI: -116 dBm
DL CINR: 11.5, UL CINR: 15.5

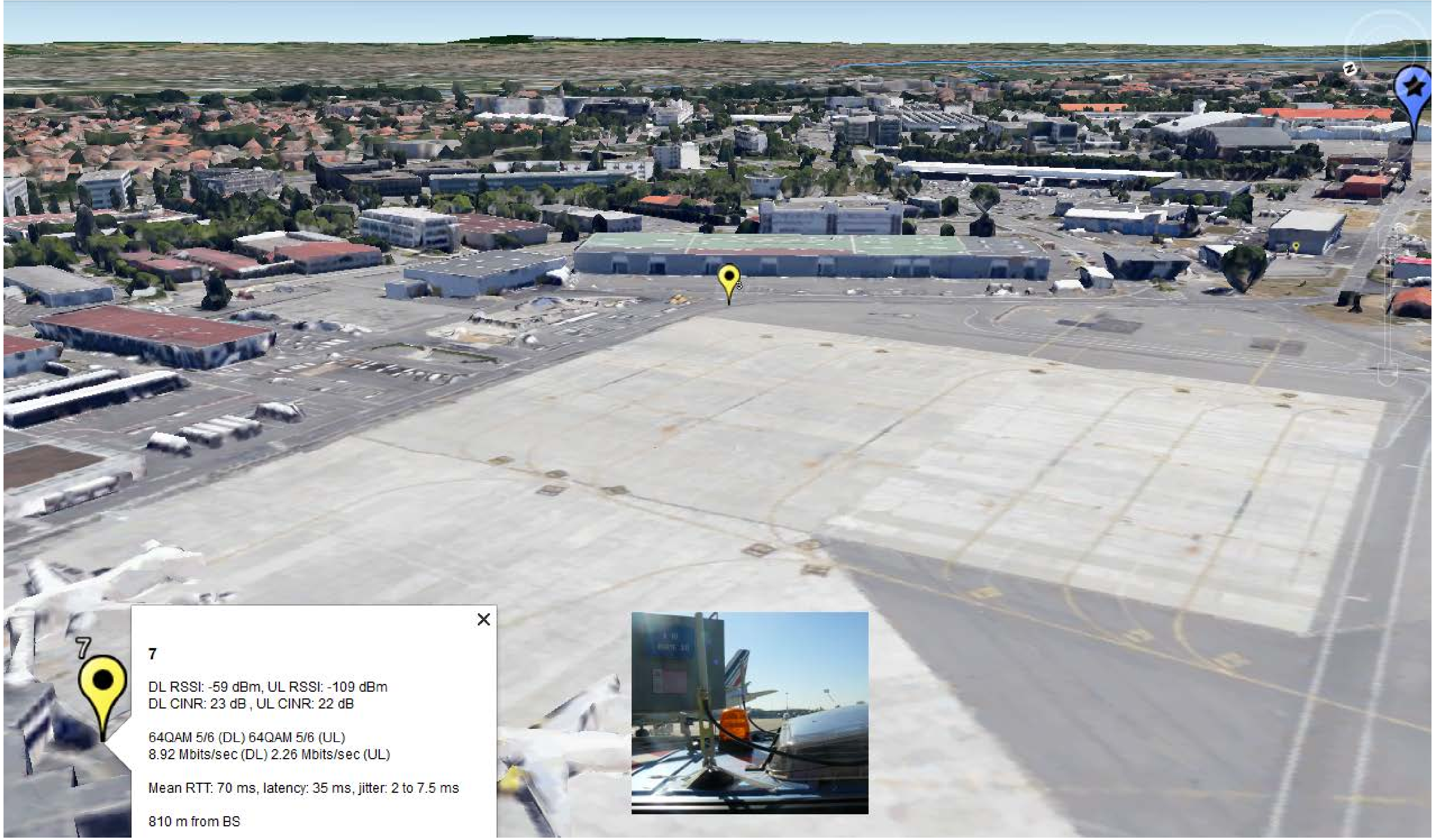
64QAM 2/3 (DL) 64QAM 1/2 (UL)
4.48 Mbits/sec (DL) / 1.14 Mbits/sec (UL)

Mean RTT: 71 ms, latency: 36 ms, jitter: 2 to 7 ms

550 m from BS

Itinéraire : Vers ce lieu - À partir de ce lieu

Figure 7-48: NLOS point #3 measurement details



7

DL RSSI: -59 dBm, UL RSSI: -109 dBm
DL CINR: 23 dB , UL CINR: 22 dB

64QAM 5/6 (DL) 64QAM 5/6 (UL)
8.92 Mbits/sec (DL) 2.26 Mbits/sec (UL)

Mean RTT: 70 ms, latency: 35 ms, jitter: 2 to 7.5 ms

810 m from BS

Figure 7-49: NLOS point #7 measurement details

Note: This point was quite in visibility with the BS although it was located at the ramp access.

9

DL RSSI: -75 dBm, UL RSSI: -122.5 dBm
UL CINR: 9 dB, DL CINR: 10 dB

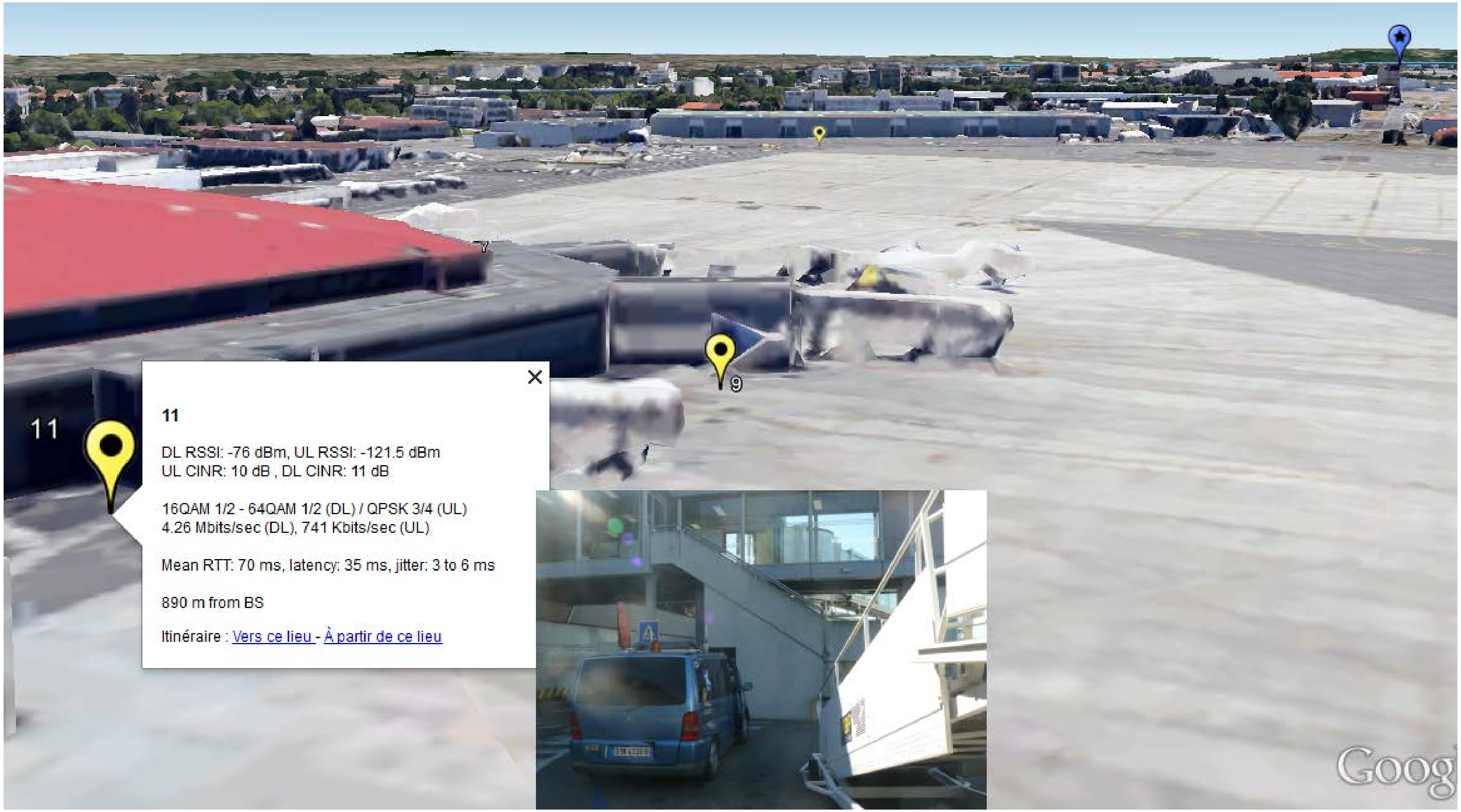
16QAM 1/2 - QPSK 3/4 (DL) QPSK 3/4 (UL)
2.46 Mbits/sec (DL), 622 Kbits/sec (UL)

Mean RTT: 71 ms, latency: 36 ms, jitter: 4 to 6 ms

850 m from BS

Itinéraire : Vers ce lieu - À partir de ce lieu

Figure 7-50: NLOS point #9 measurement details



11

DL RSSI: -76 dBm, UL RSSI: -121.5 dBm
UL CINR: 10 dB , DL CINR: 11 dB

16QAM 1/2 - 64QAM 1/2 (DL) / QPSK 3/4 (UL)
4.26 Mbits/sec (DL), 741 Kbits/sec (UL)

Mean RTT: 70 ms, latency: 35 ms, jitter: 3 to 6 ms

890 m from BS

Itinéraire : Vers ce lieu - À partir de ce lieu

Figure 7-51: NLOS point #11 measurement details

13

DL RSSI: -80 dBm, UL RSSI: -124 dBm,
UL CINR: 8.5 dB, DL CINR: 8.5 dB

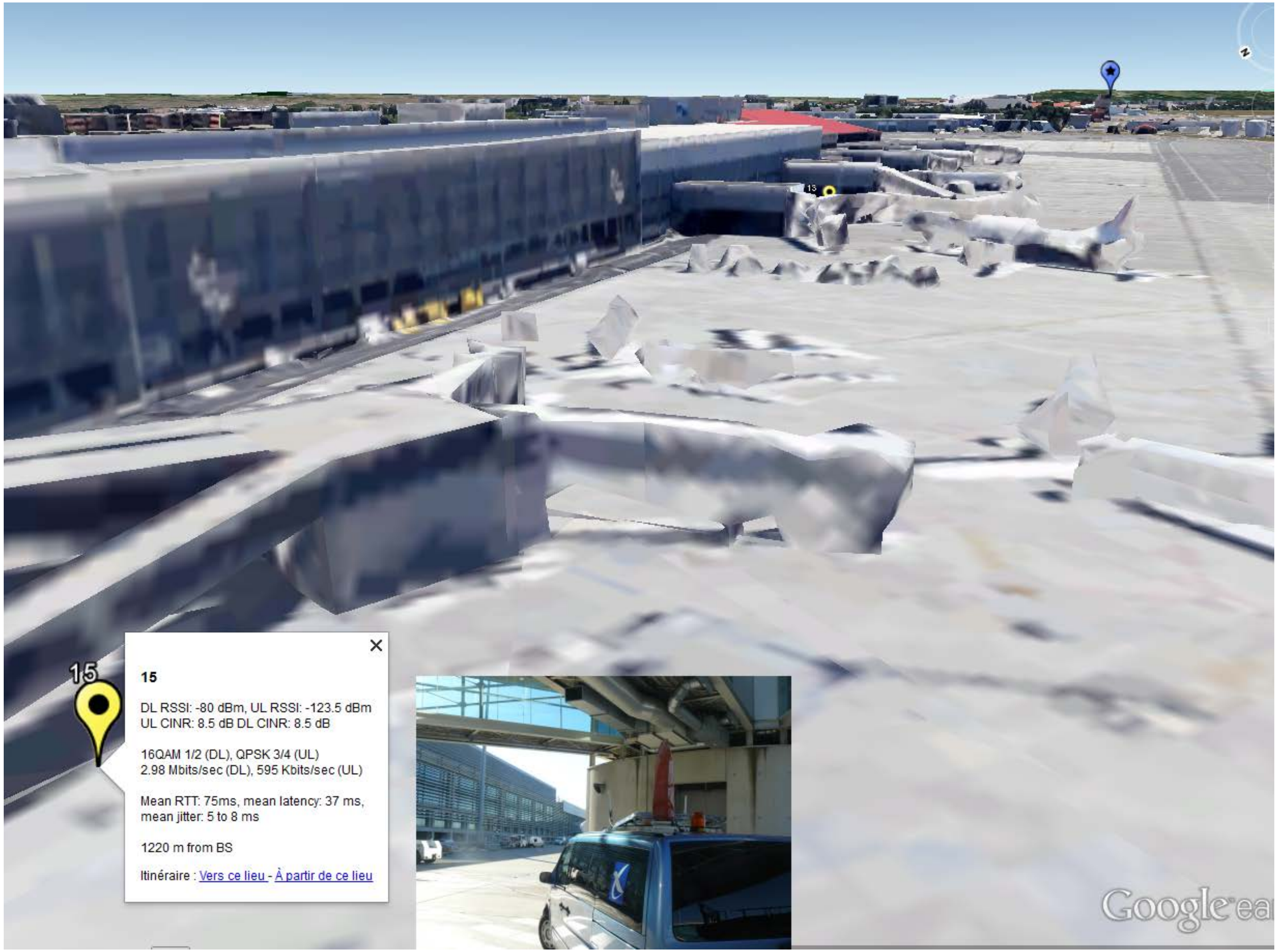
16QAM 1/2 (DL), QPSK 3/4 (UL)
2.94 Mbits/sec (DL), 601 Kbits/sec (UL)

Mean RTT: 73 ms, latency: 37 ms, jitter: 6 to 13 ms

1010 m from BS

Itinéraire : Vers ce lieu - À partir de ce lieu

Figure 7-52: NLOS point #13 measurement details



15

DL RSSI: -80 dBm, UL RSSI: -123.5 dBm
UL CINR: 8.5 dB DL CINR: 8.5 dB

16QAM 1/2 (DL), QPSK 3/4 (UL)
2.98 Mbits/sec (DL), 595 Kbits/sec (UL)

Mean RTT: 75ms, mean latency: 37 ms,
mean jitter: 5 to 8 ms

1220 m from BS

Itinéraire : Vers ce lieu - À partir de ce lieu

Figure 7-53: NLOS point #15 measurement details

18

DL RSSI: -80 dBm, UL RSSI: -127.5 dBm
DL CINR: 7 dB, UL CINR: 6 dB

16QAM 1/2 (DL) / QPSK 3/4 (UL)
2.71 Mbits/sec (DL) / 320 Kbits/sec (UL)

Mean RTT: 74 ms, mean Latency: 37 ms, mean jitter: 4 to 30 ms

1300 m from BS

Itinéraire : Vers ce lieu - À partir de ce lieu

Figure 7-54: NLOS point #18 measurement details

19

DL RSSI: -82 (dBm), UL RSSI: -128 (dBm)
DL CINR: (dB), UL CINR: 5.5 (dB)

QAM16 CTC 1/2 (DL), QPSK CTC 3/4 (UL)
2.33 Mbits/sec (DL), 205 kbits/sec (UL)

Mean RTT: 72 ms, mean Latency: 36 ms,
mean jitter: 6 to 30 ms

1400 m from BS

Itinéraire : Vers ce lieu - À partir de ce lieu

Figure 7-55: NLOS point #19 measurement details

Additional measurements

We had an opportunity to do some measurements outside of the Airport; these measurements are reported below.

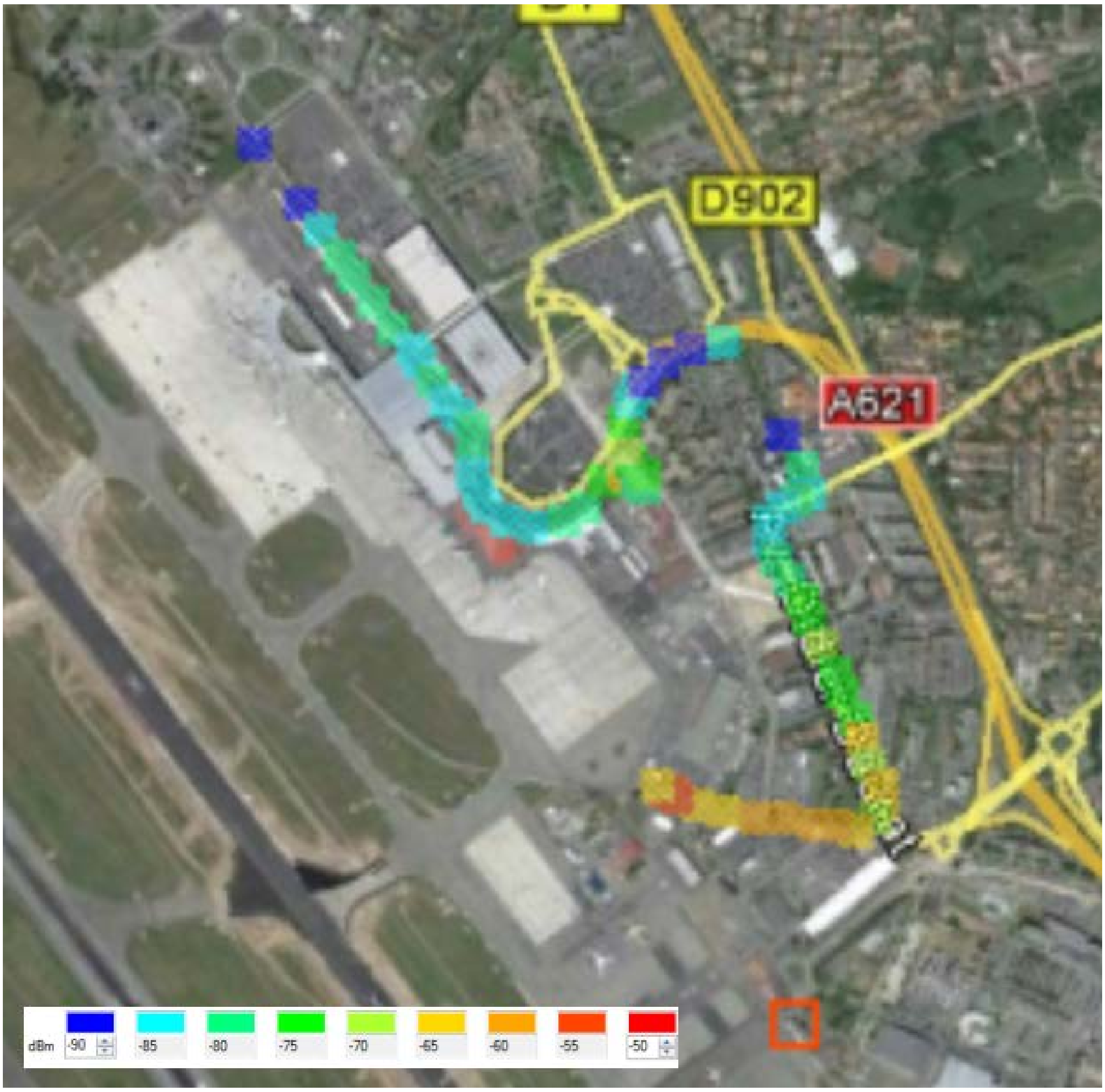


Figure 7-56: Measurements on the outside of the Airport

7.3.4.3.1 Unexpected behaviors/Results

None

7.3.4.4 Conclusions and recommendations

The testing allowed showing the impact of NLOS conditions of propagation.

Up to 10-20 dB of attenuation can be noticed in the worst case (NLOS point 19 compared to LOS PB point (fix MS)). Still the communications are still possible with off course limited data rates compared with LOS conditions (fix MS in PB compared to NLOS point 19 for example).

Simulations were also performed but they are too much pessimistic compared to field results. As an example the figure below shows that no communications are expected in the gates area. One should note that even if we use a clutter map to represent the obstacles above the ground this represents not all the real phenomena explaining the differences between simulations and field measurements.

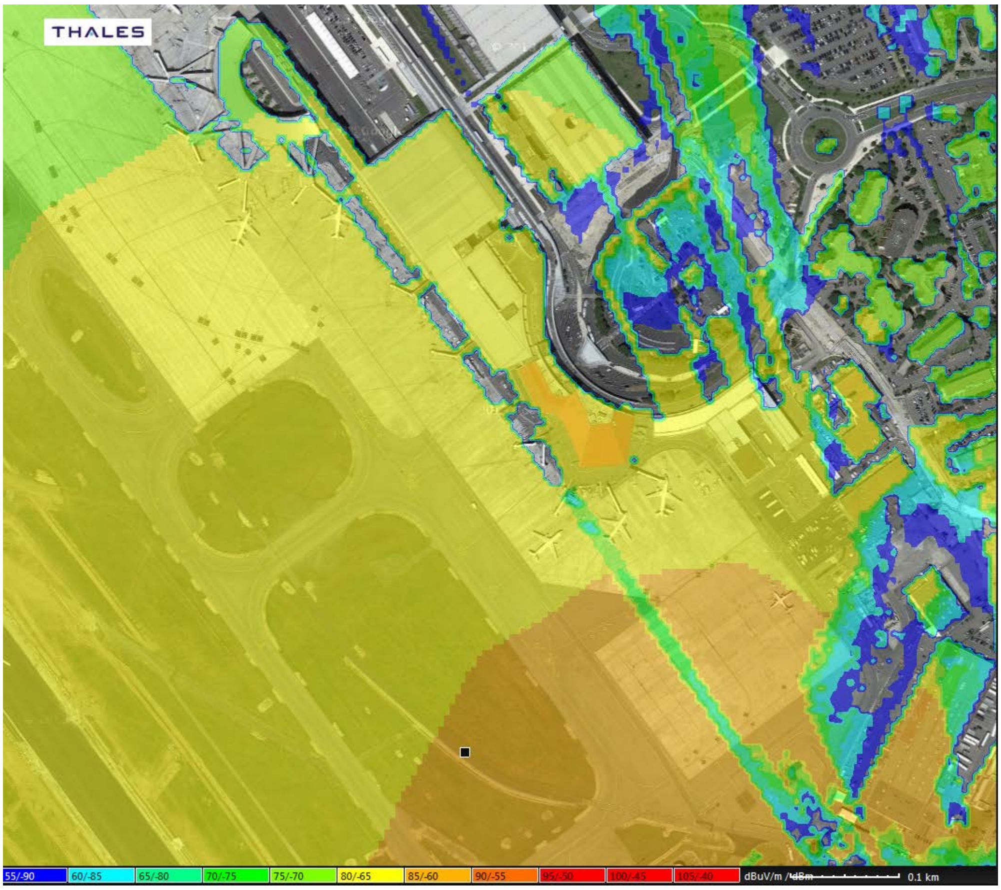


Figure 7-57: Simulated field strength near the terminal

In general, we found in the NLOS conditions:

- Mean UL modulation: QPSK ¾, Mean DL modulation : 16QAM ½
- UL Throughput from 200 kbits/s up to 750 kbits/s in the most adverse situations in the Toulouse configuration (point #9 up to # 19) and from 1 to 1.5 Mbit/s in nearer NLOS location from BS (point #3 and point #1). 2.26 Mbits/s in point #7 which was more in LOS.
- DL Throughput from 2.3 Mbits/s up to 4.2 Mbits/s in the most adverse situations in the Toulouse configuration (point #9 up to # 19) and up to 8.9 Mbits/s in the nearest NLOS location (point #1).

In the case of AeroMACS on board an aircraft, we can expect far better propagation conditions as the antenna will be at the top of the Aircraft (several meters above the ground) and the Aircraft in front of the terminals. In this case, it is expected to be very often in the best case situation represented by point #7.

Finally, we were able to perform a relatively good (video tuned to a 500 kbps constant bit rate) quality video communications between the MS and the BS to confirm this good behaviour.

7.3.5 Verification Exercise # TAIR_040

7.3.5.1 Verification Exercise Scope

Mobility performances / Channel selectivity:
Evaluate the impact of mobility on the data communications and channel selectivity

- 0 km/h: performance check before mobility, registration to the servicing BS.
- At 50 km/h: uses of taxiway or runway (depending upon authorization),
    - parameters are recorded while driving at a constant speed of 50 km/h,
    - MS being preliminary.
- At 90 km/h: use of runway (depending upon authorization and vehicle capacity).

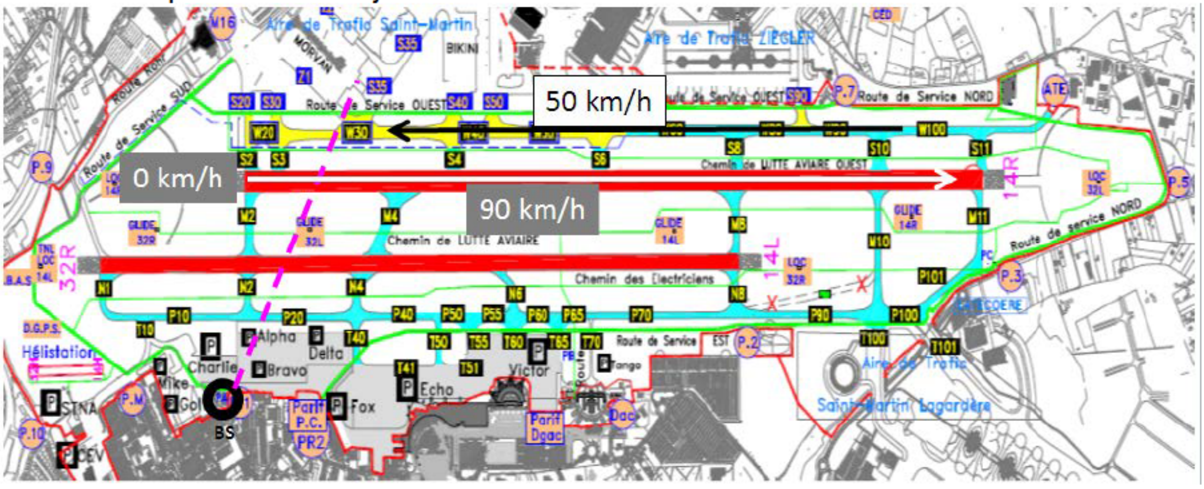
7.3.5.2 Conduct of Verification Exercise

7.3.5.2.1 Verification Exercise Preparation

Equipment: BS1&2 + 1 MS in a car+ Spectrum Analyzer
Resources:

- Thales: 2 engineers
- DSNA: a driver with a car.

Measurement points and car trajectories:



7.3.5.2.2 Verification Exercise execution

Step	action	Action result	PCO	Result
Phase 1 Mobility @ 50 km/h				
1	GS1 is switched ON GS2 is switched OFF GS1 is provisioned with frequency: 5093,5 MHz Fix MS is OFF Adaptive modulation is selected on the GS as MS profile	GS 1 is started	GS control MMI	OK
2	Set frequency scan of mobile MS : 5093,5 MHz	MS connects eventually to the GS F=5093,5 MHz	MS MMI	OK

	5098,5 MHz 5103,5 MHz			
3	Vehicle is stopped at the start of the runway or taxiway. Start survey tool. Perform a trip @ 50 km/h on the car trajectory (runway or taxiway) and record MS RSSI on the fly with survey tool.	RSSI recorded on the map	Survey tool	OK
4	Vehicle is stopped at the start of the runway or taxiway. Survey tool is shut down. Start “iperf” with a duration greater than trip duration in both direction Perform a second trip @ 50 km/h on the car trajectory (runway or taxiway). Stop iperf and write down iperf results	Results recorded	Iperf cmd	OK
5	Perform step 3 & 4 at 90 km/h	Results recorded		OK 120 km/h also done

7.3.5.2.3 Deviation from the planned activities

The mobility tests were done on the day planned. The speed tests were done on the taxiway at 50 km/h, 90 km/h and also up to 120 km/h. Finally the mobility test was located on the Whisky Taxiway from W60 to W100 which was more convenient regarding aircraft traffic and was also interesting in terms of distance from the BS (the farthest possible location). Off course, we gave priority to the Aircrafts, as shown below.

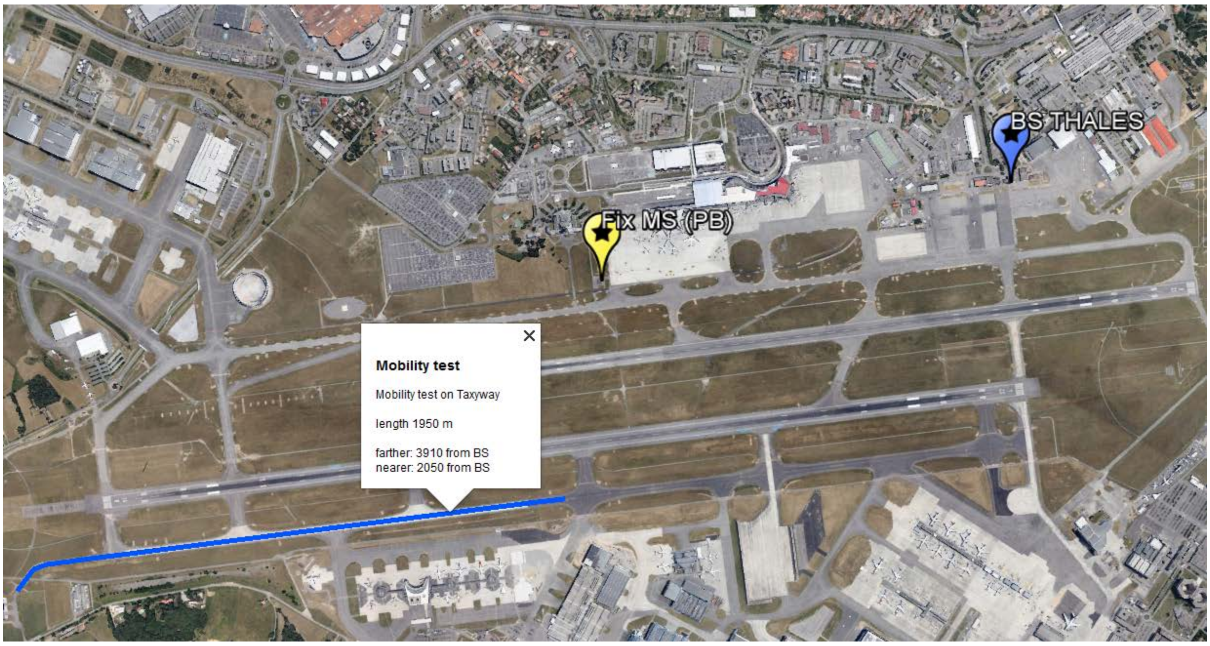


Figure 7-58: Mobility test location (ATE -> Taxiway W 100 to W 60 – round trip)

Figure 7-59: Priority to the Aircrafts traffic on the taxiway

7.3.5.3 Verification exercise Results

Below, the maps show the recordings of the DL RSSI at the different speed: 50 km/h, 90 km/h and 120 km/h. The mean achieved data rates are also mentioned.

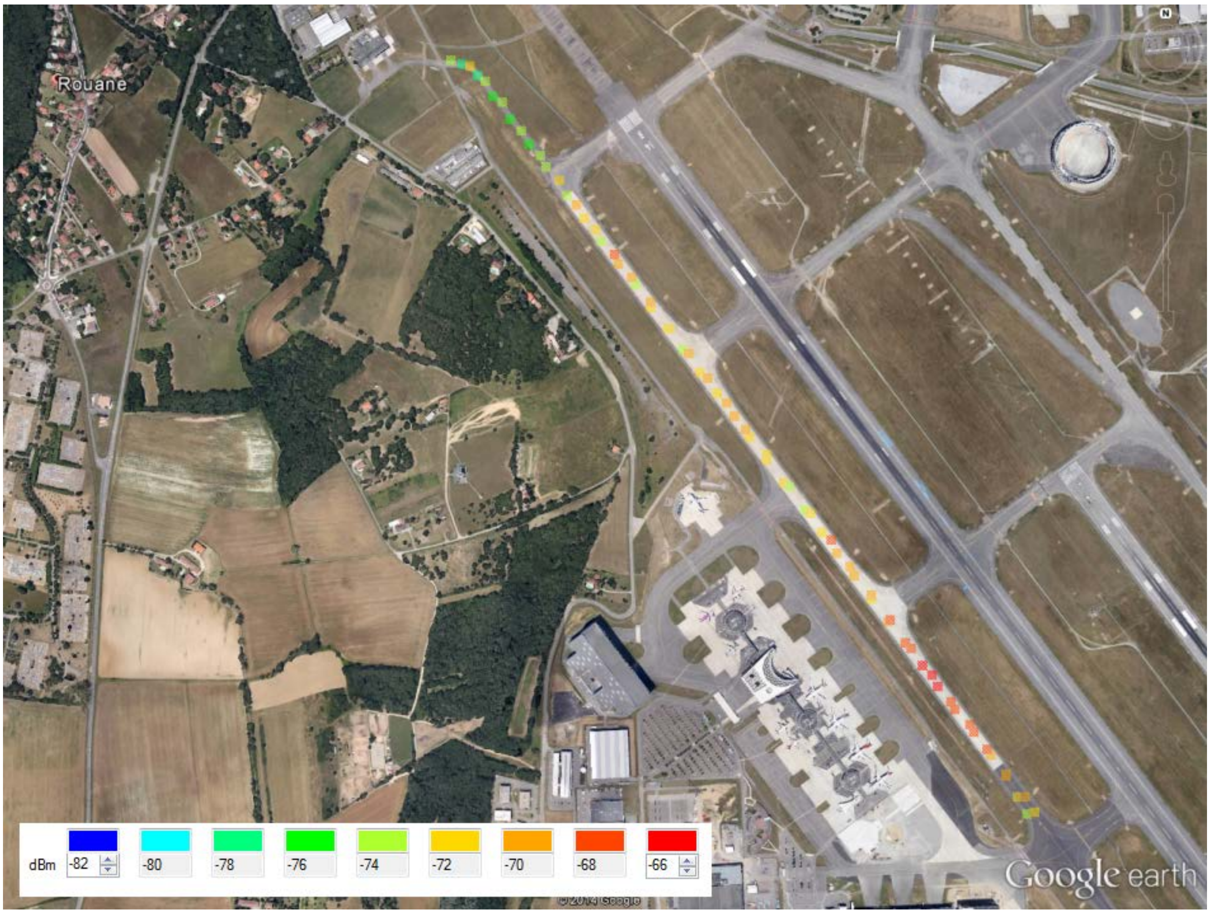


Figure 7-60: recorded RSSI of mobility test at 50 km/h

The mean data throughputs obtained during the round trip at 50 km/h are:

- 7,4 Mbits/sec in DL
- 1 Mbits/sec in UL

We did also a round trip with fix data rates lower than the maximum achievable ones:

- In UL 400 Kbits/sec was generated and transmitted with no errors
- In DL 1.50 Mbits/sec was generated and transmitted with no errors

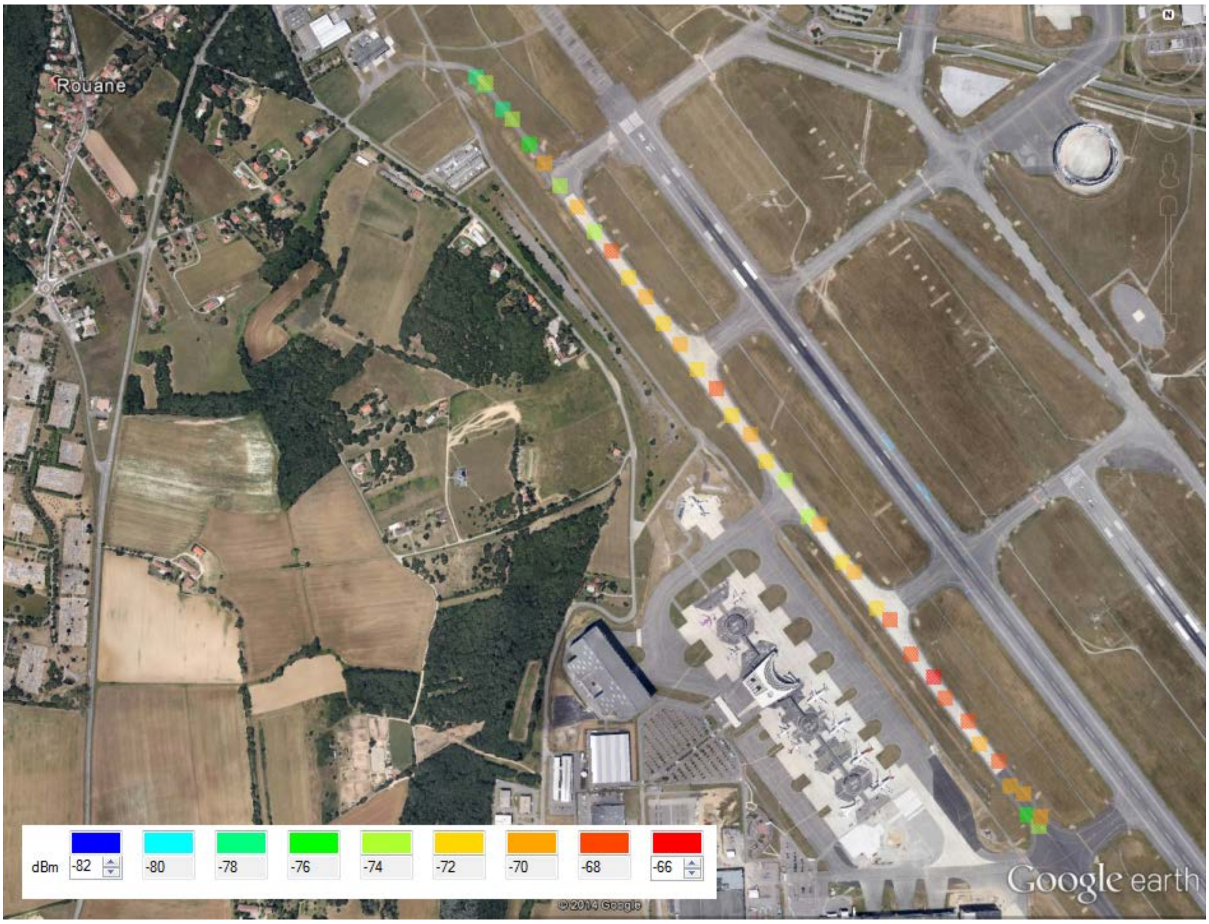


Figure 7-61: recorded RSSI of mobility test at 90 km/h

The mean data throughputs obtained during the round trip at 90 km/h are:

- 6,98 Mbits/sec in DL,
- 918 kbits/sec in UL.

We did also a round trip with fix data rates lower than the maximum achievable ones:

- In UL a data stream of 400 Kbits/sec was generated and transmitted with no errors,
- In DL a data stream of 1.50 Mbits/sec was generated and transmitted with no errors.

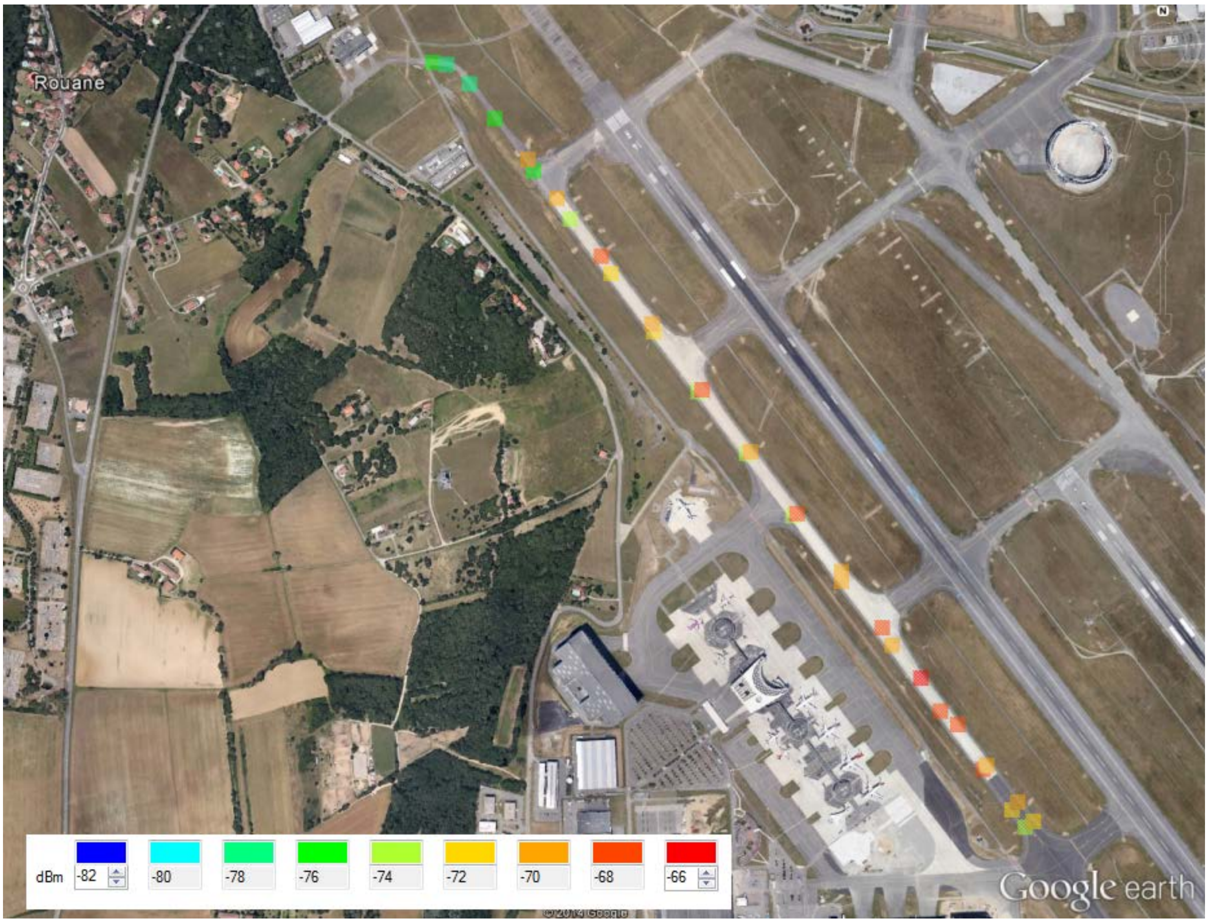


Figure 7-62: recorded RSSI of mobility test at 120 km/h

7.3.5.3.1 Unexpected behaviors/Results

None

7.3.5.4 Conclusions and recommendations

The testing allowed measuring the performances of AeroMACS in mobility conditions up to 120 km/h.

When observing the recordings, one can see that there are more data rates fluctuations at 90 km/h than at 50 km/h triggering a mean data rate lower at 90 km/h. Nonetheless, it shall be noted that globally the performances are similar: RSSI mean around -71 dBm and CINR mean around 25 dB in both cases (including at 120 km/h).

7.3.6 Verification Exercise # TAIR_050

7.3.6.1 Verification Exercise Scope

Multi-channel test:
Evaluate the impact of 2 BS with overlapping coverage using alternate or adjacent channels

- BS1 and BS2 are on,
- 3 MS used: 2 vehicles and 1 fix point.

7.3.6.2 Conduct of Verification Exercise

7.3.6.2.1 Verification Exercise Preparation

Equipment: BS1&2 + 2 MS in a car + 1 fix MS
Resources:

- Thales: 3 engineers
- DSNA: 2 drivers / 2 cars.

In order to define the car trajectories, the best server map was calculated:

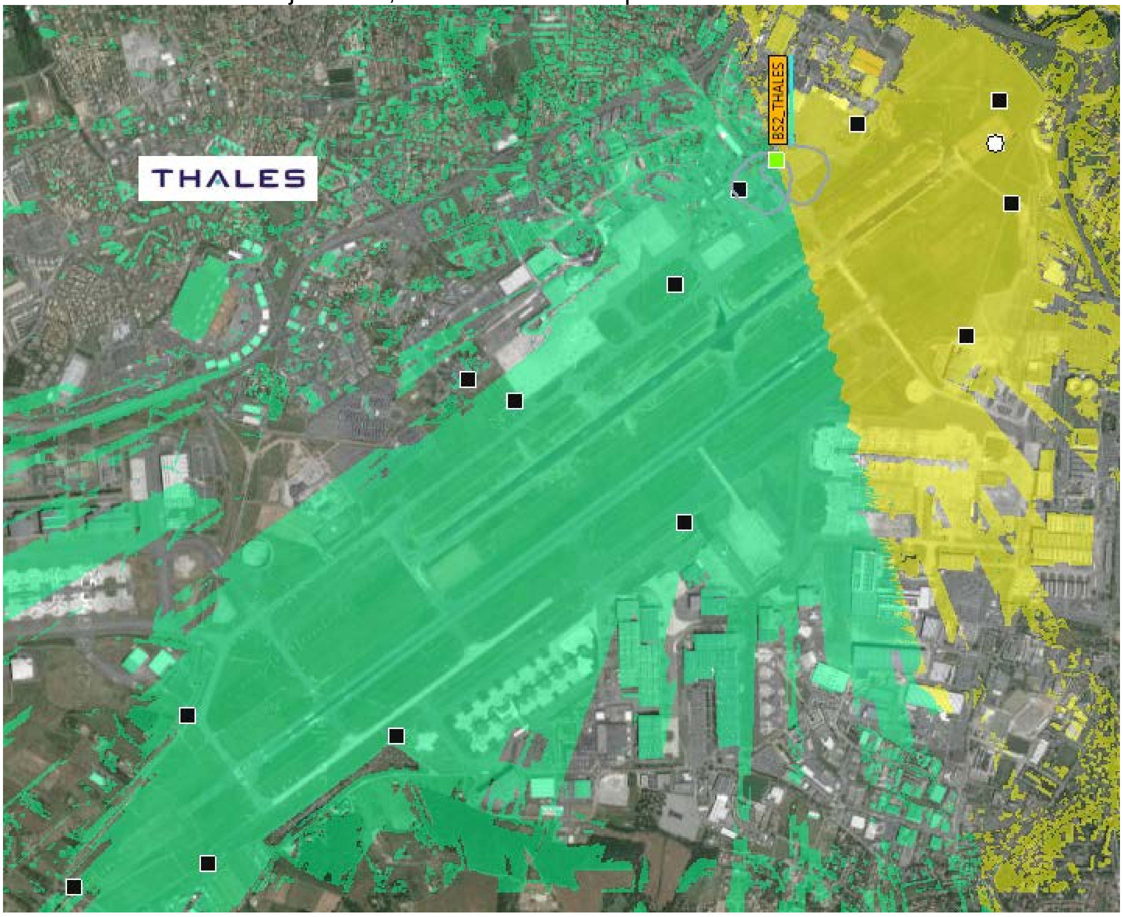
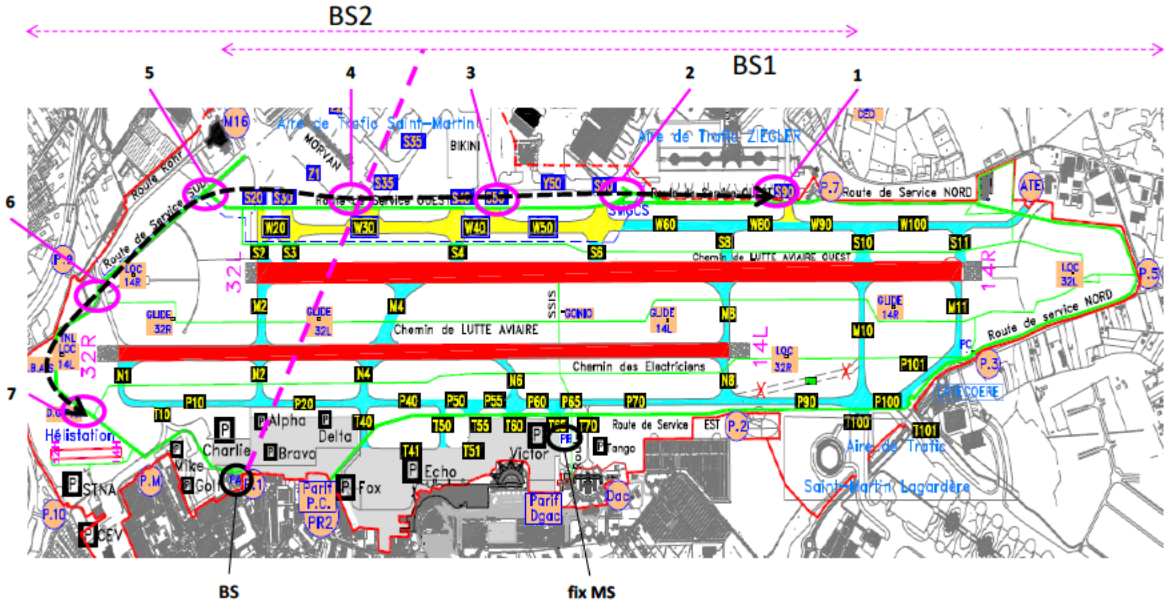


Figure 7-63: THALES BS1 / BS2 best server map

Measurement points and car trajectories:



7.3.6.2.2 Verification Exercise execution

Step	action	Action result	PCO	Result
Phase 1 Multi-channel tests with alternate channels spacing				
1	GS1 is switched ON F=5093,5 MHz GS2 is switched ON F=5103,5 MHz Adaptive modulation is selected on the GS as MS profile	GS 1 is started GS 2 is started	GS control MMI	OK
2	Go to fix MS location Set frequency on fix MS to 5093,5 MHz Write down RSSI	Fix MS connects eventually to the GS 1 F=5093,5 MHz (screenshot of MS MMI)	MS MMI	OK
3	Set frequency on the two mobile MS: MS in car 1 5093,5 MHz MS in car 2 5103,5 MHz Go to point 1 with cars Write down RSSI	MS in car 1 connects eventually to the GS 1 F=5093,5 MHz MS in car 2 connects eventually to the GS 2 F=5103,5 MHz RSSI written down for both MS (screenshot of MS MMI)	MS MMI	OK
4	Start survey tool. GO with both cars from point 1 to point	RSSI recorded on the map	Survey tool	OK

	7 with no stop (the cars are going through the overlapping area) During the trip, record on the fly the car trajectory with DL RSSI & CINR with survey tool (for both MS)			
Phase 2 Multi-channel tests with adjacent channels spacing				
1	GS2 frequency is switched to adjacent channel frequency of GS1 F=5098,5 MHz	GS2 is re-provisioned to adjacent channel frequency	GS MMI	OK
2	The frequency of the MS in car 2 is set to 5098,5 MHz (car are still on point 7)	MS in car 2 connects eventually to the GS 2 F=5098,5 MHz	MS MMI	OK
3	Start survey tool with new file name. GO with both cars from point 7 back to point 1 (the cars are going through the overlapping area) During the trip, record on the fly the car trajectory with DL RSSI & CINR with survey tool (for both MS)	RSSI recorded on the map	Survey tool	OK
Phase 3 Complementary measurement with adjacent channels spacing				
1	Survey tool is shut down. Stop in point 1 (max influence of BS1 on BS2) or alternatively 2 depending on capacity at connecting on BS2 at point 1: Perform iperf in DL and record iperf results Perform ping in DL Write down: DL Modulation DL CINR / DL RSSI Mean DL throughput Mean DL RTT	Measurements performed and recorded.	Iperf Ping MS MMI	OK
2	Stop in point 4 (equivalent influence between BS1 and BS2). Do the same measurements as in step 1.	Measurements performed and recorded.	Iperf Ping MS MMI	OK
3	Stop in point 7 (max influence of BS2 on BS1) or 6 depending on capacity of connecting on BS1 at point 7 Do the same measurements as in step 1.	Measurements performed and recorded.	Iperf Ping MS MMI	OK

7.3.6.2.3 Deviation from the planned activities

None: measurements done with the 3 MS and 2 BS.

Figure 7-64: The two MS at point 7

Figure 7-65: 3 MS at PB

7.3.6.3 Verification exercise Results

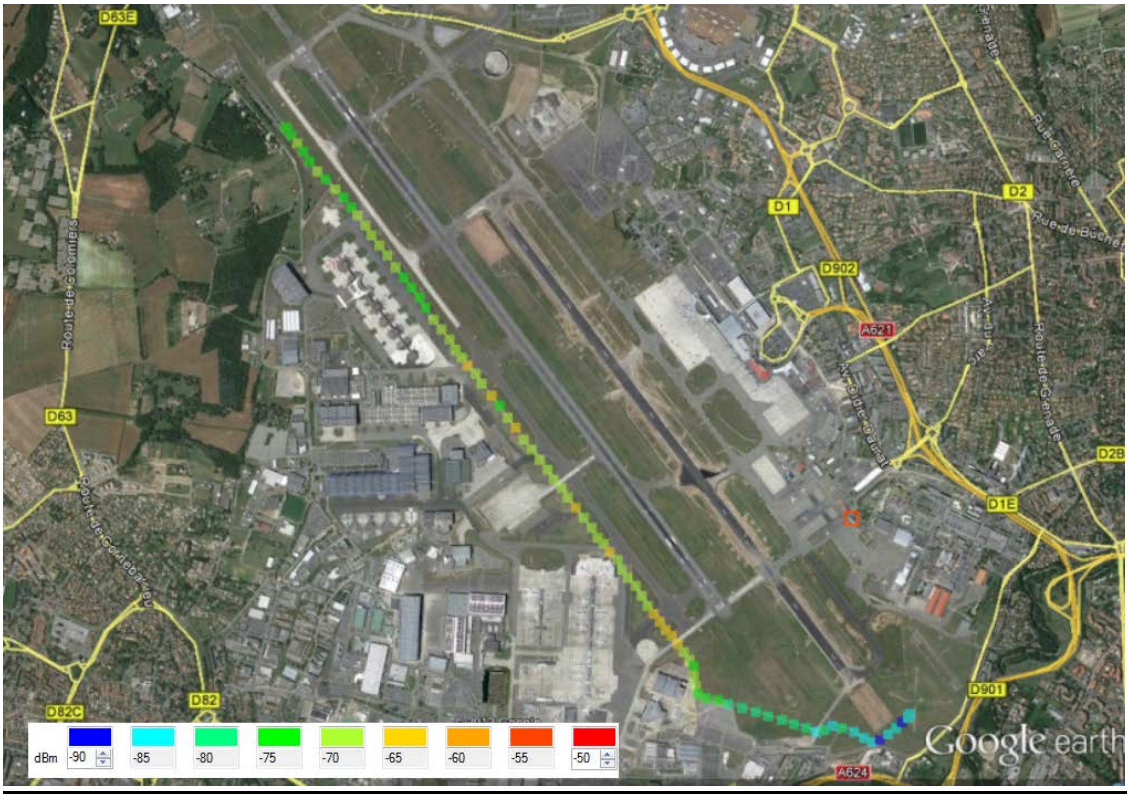


Figure 7-66: Alternate channels - BS1 measurements

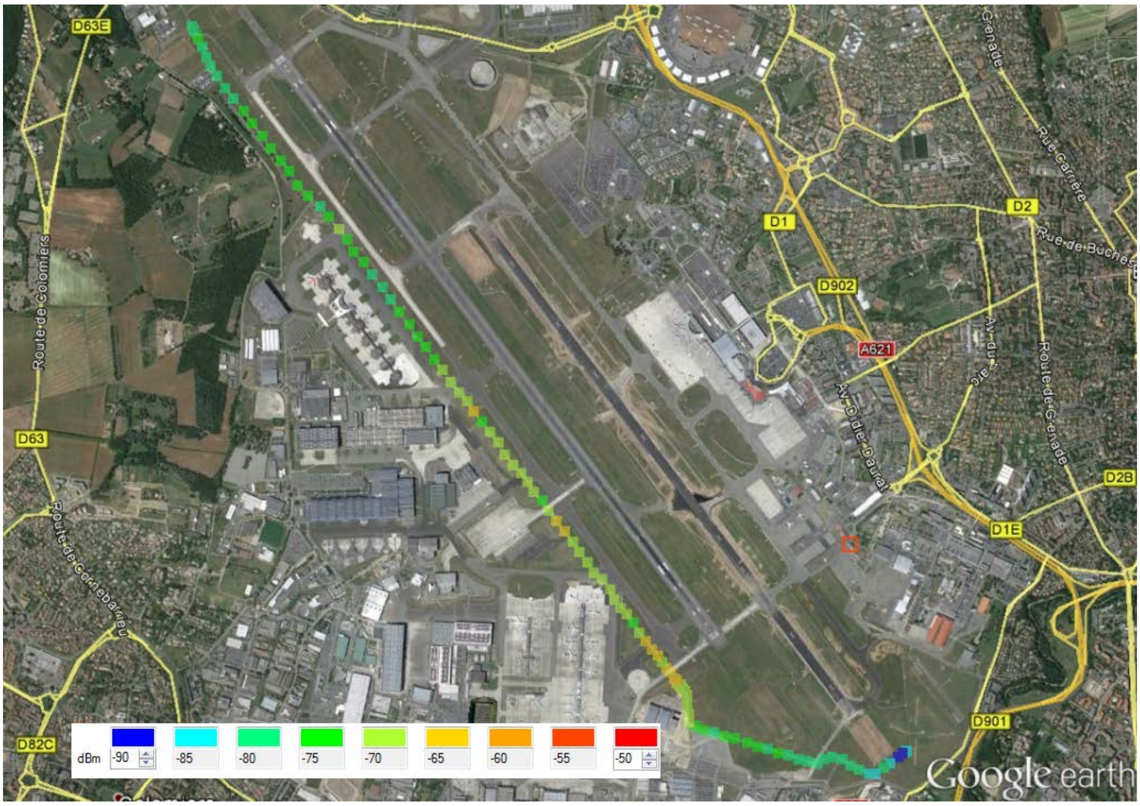


Figure 7-67: Adjacent channels - BS1 measurements

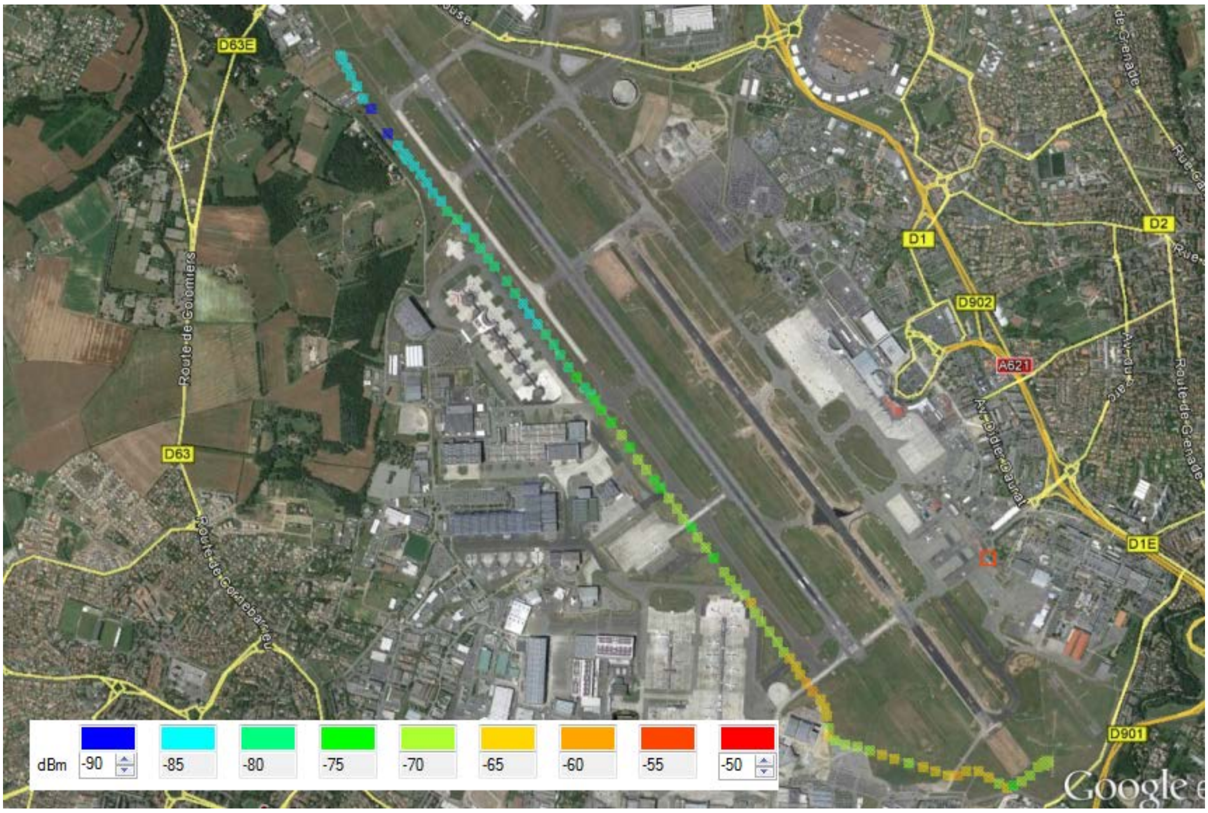


Figure 7-68: Alternate channels - BS2 measurements

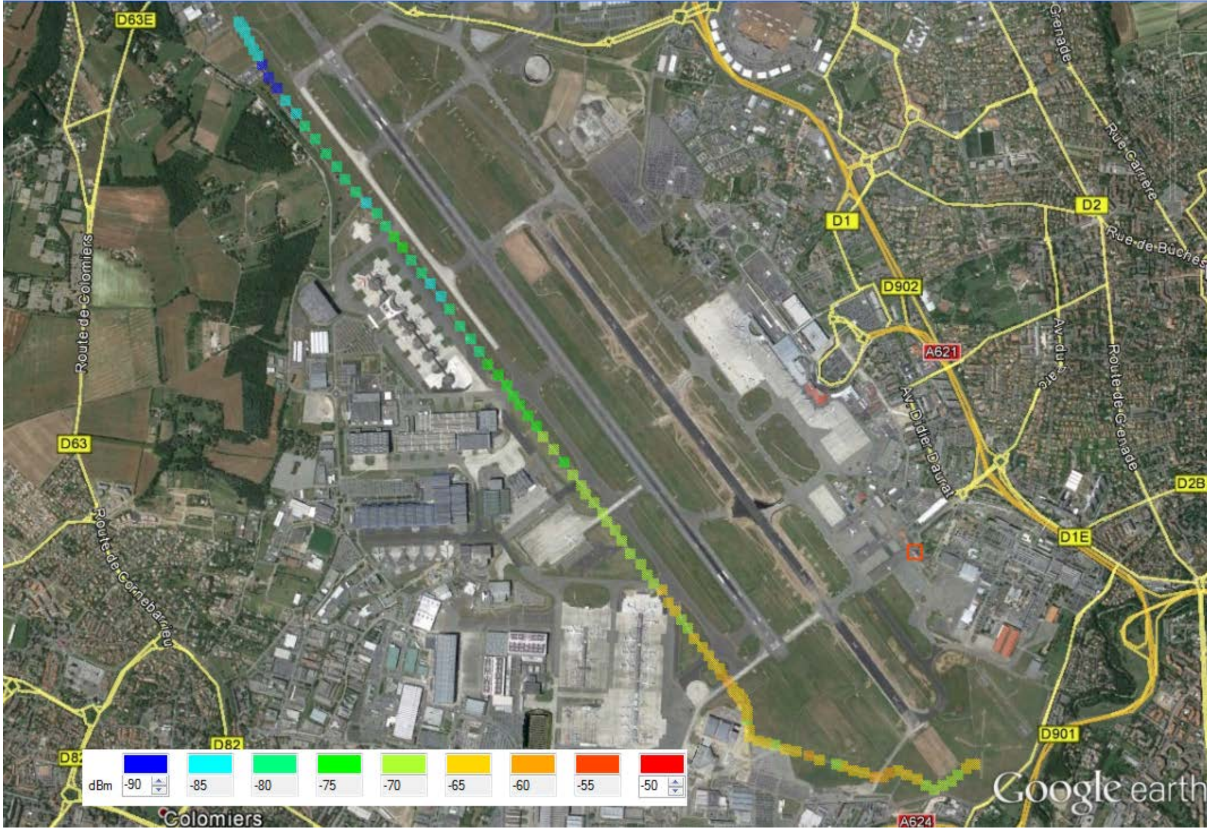


Figure 7-69: Adjacent channels - BS2 measurements

From previous recordings, one can see that operating on adjacent or alternate channels seems not to have a noticeable difference.

For instance measures of RSSI and CINR at point 1 for BS2, using alternate (5103,5 MHz) or adjacent channel (5098,5 MHz) to BS1 (5093,5 MHz, DL RSSI = -74 dBm) are similar: around -83 dBm and 10 dB. Besides, the communication is established with: DL throughput of 3,10 Mbps and UL throughput 470 kbps similar to what was obtained in TAIR_20_point#5, where BS1 was off.

The same applies for BS1 at point 7: RSSI = -85 dBm and CINR = 4 dB in both cases, BS2 being on alternate channels or BS2 being on adjacent channels (with a DL RSSI level of -66 dBm).

Additional results:

Test with 3 MS (DL RSSI fix MS ~ -62 dBm and DL RSSI Mobile MS ~ -70 dBm) localised at PB and connected to BS1:

- UL throughput shared between the MS: 450 to 500 kbps per MS
- DL throughput shared between the MS: around 2 Mbps per MS

Two MS on one BS with good reception level (point #4, RSSI = -66 dBm) were able to establish simultaneous communications of 1 Mbps in UL (per MS) and around 3 Mbps in DL (per MS).

7.3.6.3.1 Unexpected behaviors/Results

None

7.3.6.4 Conclusions and recommendations

The test case allowed checking multi-channel influence. No influence was noticeable during the tests.

Appendix A IOT

A.1 Purpose of the IOT Appendix

P15.02.07-D10 document includes the Verification Plan and Verification Report of the P15.02.07 phase 2 verification activities.

The P15.02.07 Phase 2 verification activities included:

- Laboratory tests: performances measurement related to the new AeroMACS profile and interoperability between different vendors pieces of equipment,
- Field tests: tests in real airport environment focussed on the ground segment datalink.

The results of the different Verification test cases analysed in D10 are summarized in the following table:

Test Case nr.	Test Case Name	VO's addressed	Result
TLAB2_010	Service flows control	AeroMACS_VO_Interop_05 B/C	OK
TLAB2_020	channel selectivity and transmit power measurements	AeroMACS_VO_RF_04 B/C AeroMACS_VO_RF_05 A/B AeroMACS_VO_RF_08 E	OK
TLAB2_030	MS channel quality report and MS transmit synchronisation	AeroMACS_VO_Interop_06 A/B AeroMACS_VO_RF_11 A	OK
TLAB2_040	IOT between Thales GS and Selex MS	AeroMACS_VO_Limited_ Interop A/B/C/D/E	pOK
P2_LAB1_1	Connection Re-establishment	AeroMACS_VO_Interop_03_B	OK
P2_LAB1_2	Power Control	AeroMACS_VO_Interop_06_A/B AeroMACS_VO_Interop_10_ C/D	OK
P2_LAB1_3	Quality of Service	AeroMACS_VO_Interop_07_ B/C	OK
P2_LAB1_4	Security	AeroMACS_VO_Interop_11_C/D/F	OK
P2_LAB1_5	Radio Performance	AeroMACS_VO_RF_04_A AeroMACS_VO_RFReal_01_B	OK
P2_LAB_6	IOT between Selex Ground System and Thales MS	AeroMACS_VO_Limited Interop A/B/C/D/E	pOK
TAIR_010	Installation and main performances verification (modulations, data rate, QOS, MS channel quality report, transmit power, MS scanning & ranging performances)	AeroMACS_VO_Interop_02 C AeroMACS_VO_Interop_04 B AeroMACS_VO_Interop_06 C/D AeroMACS_VO_RF_08 B AeroMACS_VO_RF_09 A/B/C AeroMACS_VO_RF_10 A	OK
TAIR_020	Cell coverage in LOS, Modulation performances, link adaptation, and MS channel quality reporting	AeroMACS_VO_RF_01 A/D AeroMACS_VO_Interop_06 C/D AeroMACS_VO_Interop_02 C/D/E AeroMACS_VO_RFReal_03 A/B/C/D/E/F/G/H/I AeroMACS_VO_RFReal_02 A/B/C/D	OK
TAIR_030	Real deployment and NLOS performances	AeroMACS_VO_RFReal_04 B AeroMACS_VO_RFReal_02 A/B/C/D	OK
TAIR_050	Mobility tests	AeroMACS_VO_RFReal_08 B AeroMACS_VO_RF_04 D	OK
TAIR_060	Multi-channel tests	AeroMACS_VO_RFReal_07 A/B/C/D	OK

Table 12: Summary of P.15.02.07 Laboratory and Airport tests phase 2 results

- OK: Verification test achieves the verification objective expectations
- NOK (Non OK): Verification test does not achieve the verification objective expectations
- POK (Partially OK): Verification test achieves partially the verification objective expectations
- NT (Not Tested): Verification test not performed

While the overall P.15.02.07 results including Lab and Airport testing were satisfactory, the InterOperability Tests (IOT) finalized with some unresolved issues.

Under the situation that additional IOT tests could not be executed within the project, the scope of this appendix is focused in the Interoperability Tests status: summarizing the IOT tests performed and the related issues, and providing recommendations for future activities. Detailed description of the interoperability tests results are contained in D10 Sections 7.1.6 and 7.2.4.

A.2 P.15.02.07 IOT Context

The P.15.02.07interoperability tests perimeter, as defined in D05, consists of the testing of interoperability limited to air interface with the verification objectives presented in following table:

General VO Id	Title	Purpose
AeroMACS_VO_Limited Interop_A	Scanning and synchronization	When switched on, MS starts off with the scanning of the spectrum. Verify that the correct expected broadcast messages are exchanged, the preamble is correctly decoded by the MS.
AeroMACS_VO_Limited Interop_B	Initial Ranging	Verify that, after successful DL Synchronization, MS and BS exchanges the proper RNG-REQ/RNG-RSP messages, completing the Initial Ranging
AeroMACS_VO_Limited Interop_C	Basic Capabilities Negotiation	Verify the correct exchange of Service Basic Capability informations.
AeroMACS_VO_Limited Interop_D	Admission control	Security associations and key exchange that concern only to the "air interface" as part of the MS Authentication and Authorization procedures.
AeroMACS_VO_Limited Interop_E	Registration	Verify that BS and MS successfully conclude the registration procedure

Table 13: AeroMACS Limited Interoperability Verification Objectives

The IOT tests were performed with same testbed as described in D10 § 3.5.2.1, where the mobile stations are exchanged between manufacturers. The following pictures represent the Thales and Selex ES IOT testbeds:

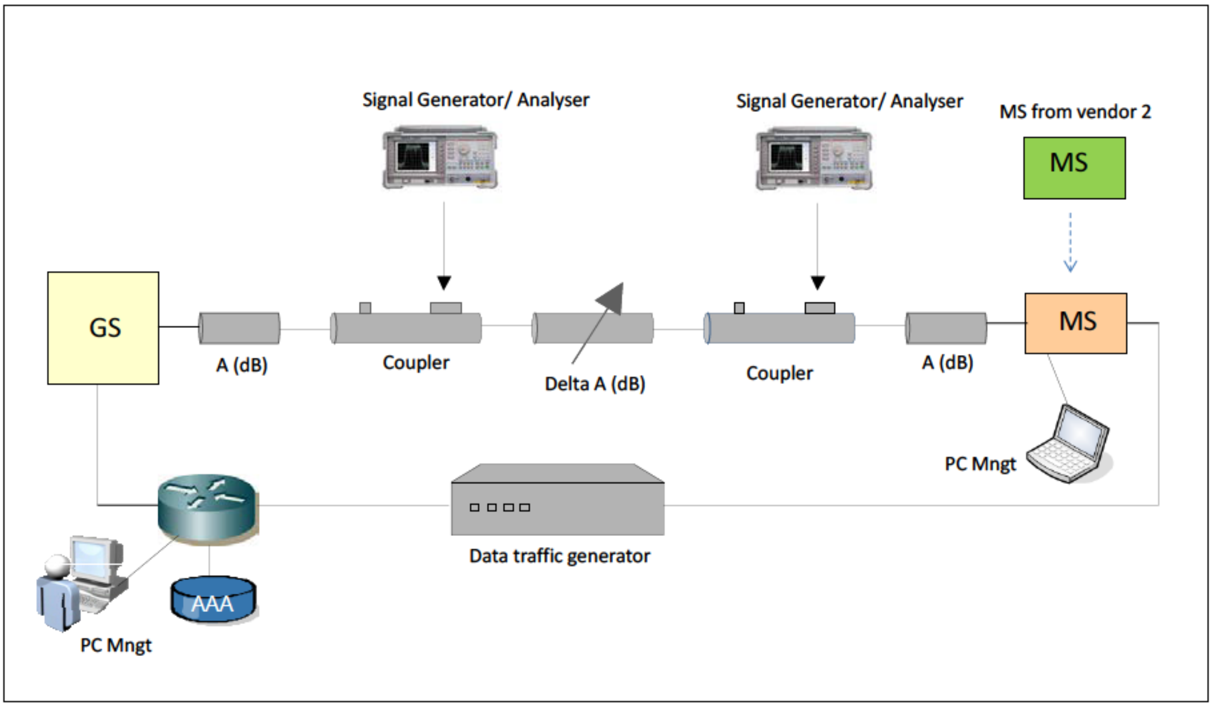


Figure 7-70: IOT Thales testbed

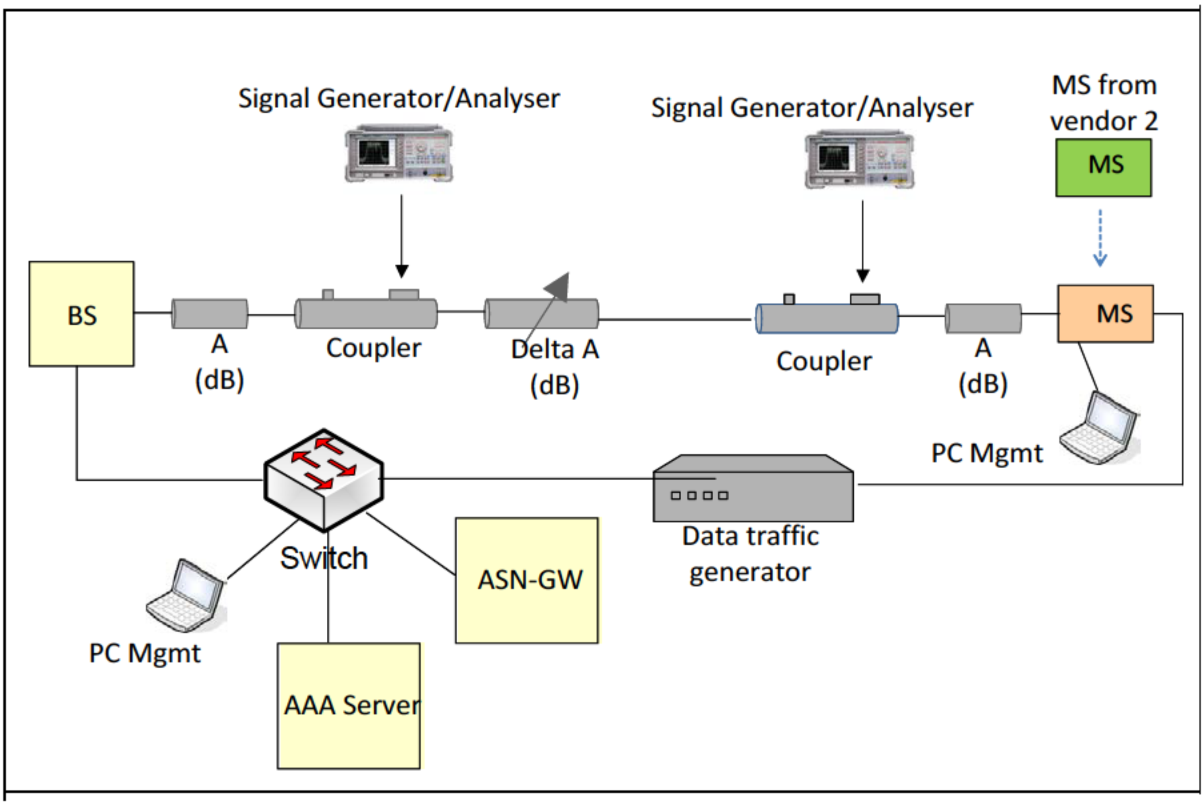


Figure 7-71: IOT Selex ES testbed

The summary of IOT test cases for both Selex ES and Thales is shown below:

Test Case nr.	Test Case Name	Lab. Environment	VO’s addressed
TLAB2_040	IOT test between Thales GS and Selex MS	Lab_test_bed_01 with Selex MS	AeroMACS_VO_Limited Interop A/B/C/D/E
P2_LAB_6	IOT between Selex Ground System and Thales MS	Lab_test_bed_02 with Thales MS	AeroMACS_VO_Limited Interop A/B/C/D/E

Table 14: Identification of Phase 2 IOT test cases

Each test case is divided in several steps to address the VOs described in Table 13.
More information can be found in D10, Chapter 7 and in § A.3 below.

The following picture gives a summary of the status of the IOT.

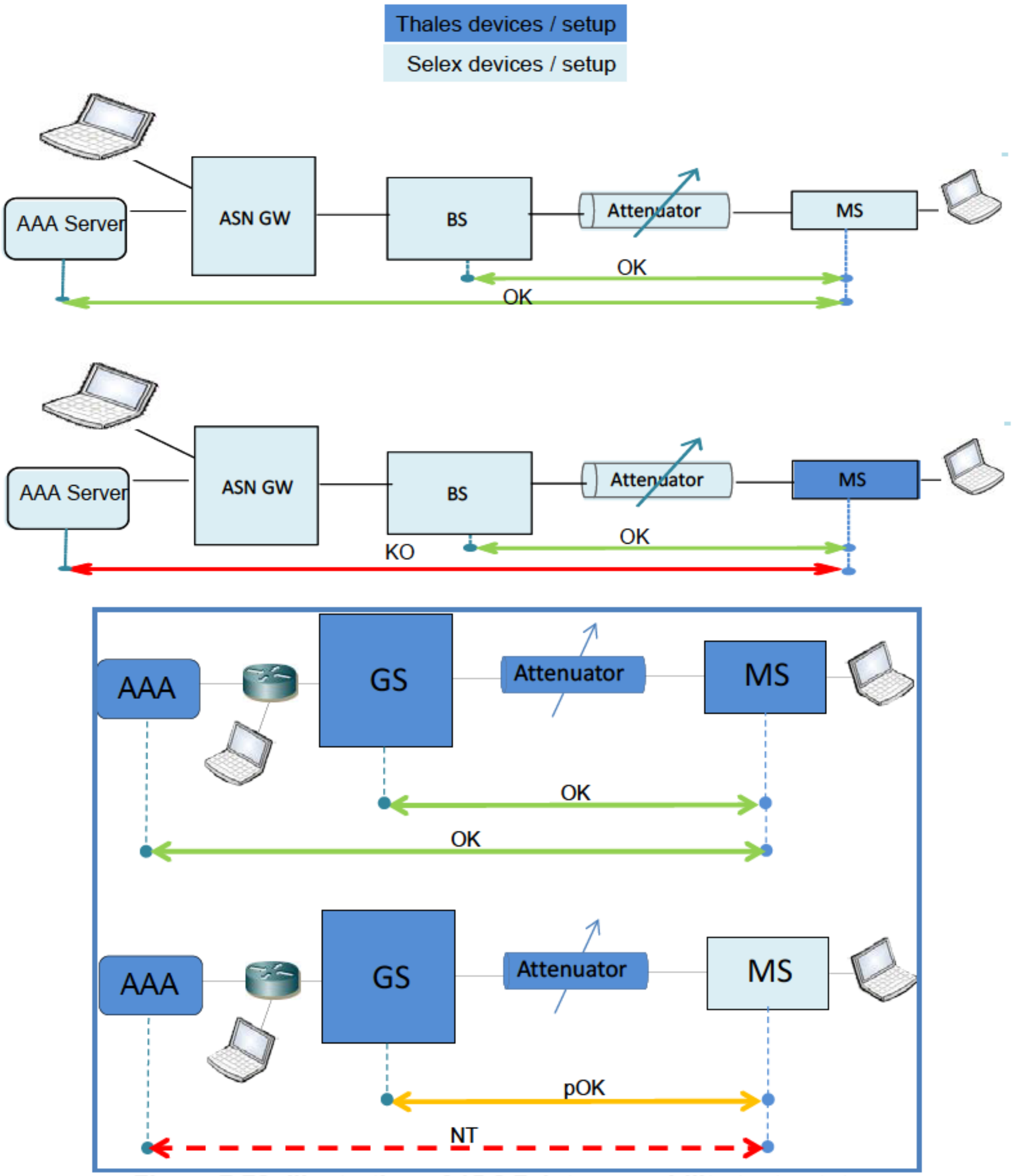


Figure 7-72: Illustration of 15.2.7. interoperability tests status

A.3 IOT incident comments

A.3.1 #P2_LAB1_6

Information on this test case is included in D10, chapter 7.1.6.

The verification test results were the following:

- Scanning / preamble detection (AeroMACS_VO_Limited Interop A) => OK
- Synchronization (AeroMACS_VO_Limited Interop A) => OK
- Initial ranging (AeroMACS_VO_Limited Interop B)=> OK
- Basic capabilities negotiation (AeroMACS_VO_Limited Interop C) => OK
- Admission control (AeroMACS_VO_Limited Interop D) => NOK
- Registration (AeroMACS_VO_Limited Interop E) => NT

Description of issues:

- Authentication/authorization procedure failed
- It was not possible to complete registration

A.3.1.1 Analysis of results

Analysis of this IOT test can be found in D10 Section 7.1.6.3.2.

A.3.1.2 Mitigation actions

It was not possible to finalize authentication/authorization procedure.

An action was identified to perform additional investigation, involving Thales, Selex ES, Indra and Eurocontrol teams.

Wireshark captures, MS certificate files, AAA certificate files, certificate configuration files were analyzed with the objective to obtain additional information. A conclusive result was not reached; hence the recommendations contained in D10 are confirmed. In particular, a clearer definition of the security framework is recommended, in order to define unambiguously the AeroMACS Certification Authority, the rules to generate the certificates, and the protocol versions to be implemented by the various actors.

A.3.1.3 Comments and recommendations

Further work within standardization activities in field of security is recommended, to define properly the certificate deployment infrastructure, a “normalized” authentication, and a clear definition of security framework.

A.3.2 # TLAB2_040

Information on this test case is included in D10, Chapter 7.2.4.

The verification test results were the following:

- Scanning / preamble detection (AeroMACS_VO_Limited Interop A) => OK
- Synchronization (AeroMACS_VO_Limited Interop A) => NOK
- Initial ranging (AeroMACS_VO_Limited Interop B)=> NT
- Basic capabilities negotiation (AeroMACS_VO_Limited Interop C) => NT
- Admission control (AeroMACS_VO_Limited Interop D) => NT
- Registration (AeroMACS_VO_Limited Interop E) => NT

Description of issues:

- Synchronization failed
- Subsequent steps could not be executed

A.3.2.1 Analysis of results

Analysis of this IOT test can be found in D10 Section 7.2.4.3.2.

A.3.2.2 Mitigation actions

An action was proposed to consider repetition of some IOT tests. The teams involved considered the possibility to schedule one IOT session in September, but in the end this additional session could not be arranged due to budget limitations and equipment availability needed for other Sesar projects.

A.3.2.3 Comments and recommendations

It was not possible to draw any definitive conclusion as the test failed in the early stages.

It is suggested to plan ad-hoc activities with the purpose to complete IOT in the near future (SESAR2020/VLD could be suitable opportunities) in coordination with the relevant standardization authorities.

8 References

8.1 Reference Documents

The following documents were used to provide input:

[1] P 15.02.07 D05.2 - AeroMACS Verification Strategy

[2] P 15.02.07 D05.1 - AeroMACS prototypes description

[3] P 15.02.07 D06 - AeroMACS integration & testing – phase 1

[4] http://freeradius.org/

[5] P15.02.07 D04- AeroMACS Deployment & Integration Analysis

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