D02 Appendix D - TOPMET Performance Synthesis Report

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Abstract

The TOPMET project addresses the key objective of better serving Ground and Air Airspace Users with consistent, relevant and up-to-date Meteorological information. This results in improved resilience of ATM operations to weather hazards, leading to an improved flight safety; and more accurate information to inform flight planning, leading to improved flight efficiency and improved airspace capacity. This report details the execution of the flight trials, performed respectively with Brussels Airlines in July-August 2014, and with DSNA, between May and August 2014, and provides the results of the post-analyses conducted on the collected data.

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This deliverable consists of SJU foreground.

Table of Contents

List of tables

List of figures

Executive summary

The TOPMET project addresses the key objective of better serving Ground and Air Airspace Users with consistent, relevant and up-to-date Meteorological information. This results in improved resilience of ATM operations to weather hazards, leading to an **improved flight safety**; and more accurate information to inform flight planning, leading to **improved flight efficiency** and **improved airspace capacity.**

This project has offered an **integrated pre-operational demonstration** using the combination of:

- some of the most advanced Meteorological products worldwide offered by EUMETNET members,
- early versions of development prototypes designed in the core of the SESAR program, such as the MISC (4DWxCube), the enabling SWIM infrastructure, and various impact-assessment and decision-aid prototypes targeted for dedicated end-user profiles .

The exposure of the considered new technologies and the associated new procedures to live trials during **more than two months** has clearly demonstrated the potential to increase ATM and Airspace Users operational performance, especially regarding:

- **flight efficiency**, based on an optimization of flight routes, in order to reduce the MET-induced extra fuel consumption (by more than 20%) , to reduce the cost impact of MET hazards (by more than 15%), and to reduce the MET-induced delays (by more than 15%)
- **flight safety,** through a better monitoring of weather, enabling the avoidance of MET hazards with potential impact on the crew / passengers or on the aircraft itself,
- **capacity,** through a better anticipation of the impact of the MET hazards on the flights, enabling earlier implementation of measures to avoid sector overload, or unnecessary regulation measures .

Furthermore, the project has widely contributed to **raising the awareness regarding SESAR activities** and objectives, by an intensive communication campaign executed around this project.

The following main recommendations can be derived from the projects results

- To introduce a number of **evolutions on the MET products** & supporting tools based on operational feedback from BEL and DSNA
- To improve the operational procedure on how to use the tools and how they can be inserted in the daily operational processes of BEL and DSNA
- To implement the above described changes in the TOPLINK LSDA trials (in the relevant use cases involving BEL and /or DSNA) and to take the lessons learned into account in the other TOPLINK LSDA use cases, with other Airline partners (Air France, Air Corsica, ENAC for GA) or ANSP partners (Croatia Control, Austrocontrol)
- To refine the targeted KPI figures, and assessment of the KPI gains over a broader scope (more flights, more Airlines, more ATC centers, more ANSPs)
- To provide the right inputs in view of standardization, and prepare for deployment

1 Introduction

1.1 Purpose of the document

This document provides the Performance Synthesis report for the TOPMET project. It describes the results of demonstration exercises defined in the "TOPMET Demonstration Plan", version 00.01.01, issued on 18/12/2012, and refined in the "TOPMET Demonstration Objectives", version 00.01.01, issued on 26/07/2013, how they have been conducted, and how the collected data have been analysed.

1.2 Intended readership

The **TOPMET** Final Demonstration Report is primarily intended for:

- The SESAR Joint Undertaking, since this document describes the details of the results obtained from the demonstration trials;
- The consortium members participating in the project (Thales, Eumetnet, Brussels Airlines, DSNA), since this document constitutes the report of the activities performed during the execution phase.

1.3 Structure of the document

The document is organized as follow:

- Section 1 introduces the document.
- Section 2 provides the context and scope of the demonstrations with reference to the overall SESAR programme and stakeholders involved.
- Section 3 details the execution of the demonstration exercises.
- Section 4 presents the exercise reports for each demonstration exercise.

1.4 Glossary of terms

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1.5 Acronyms and Terminology

Term	Definition
ATM	Air Traffic Management
DOD	Detailed Operational Description
E-ATMS	European Air Traffic Management System
E-OCVM	European Operational Concept Validation Methodology

Term	Definition
OFA	Operational Focus Areas
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency.
4DWxCube	4 Dimensional Weather Cube
A-CDM	Airport Collaborative Decision Making
ACC	Area Control Centre
ADD	Architecture Definition Document
AIRMET	Significant low-level en-route Meteorological Information
ANSP	Air Navigation Service provider
AOP	Airport Operations Plan
APOC	Airport Operations Centre
APP	Approach Control Service
ATCO	Air Traffic Controller
ATM	Air Traffic Management
CAT	Category
CONOPS	Concept of Operations
DCB	Demand and Capacity Balancing
DOD	Detailed Operational Description
E-ATMS	European Air Traffic Management System
E-OCVM	European Operational Concept Validation Methodology
EOBD	Estimated Off-Block Date
EOBT	Estimated Off-Block Time
ETA	Estimated Time of Arrival
FIC	Flight Information Centre

Term	Definition
FOC	Flight Operations Centre
ICAO	International Civil Aviation Organisation
iCWP	Integrated Controller Working Position
IP	Implementation Package
INTEROP	Interoperability Requirements
IRS	Interface Requirements Specification
KPA	Key Performance Area
LVC	Low Visibility Conditions
LVP	Low Visibility Procedures
MET	Meteorological or Meteorology
METAR	Meteorological Aerodrome Report
METSP	MET Service Provider
NMSP	National MET Service Providers
NOP	Network Operations Plan
OFA	Operational Focus Areas
OI	Operational Improvement
OPS	Operational
OSED	Operational Service and Environment Definition
PAC	Operational Package
QFE	Atmospheric pressure at aerodrome elevation
QNH	Aviation Q-code for barometric pressure adjusted to sea level (in the ICAO Standard Atmosphere)
RVT	Remote and Virtual Tower
SARPS	Standards and Recommended Practices
SESAR	Single European Sky ATM Research Program
SESAR Program	The program which defines the Research and Development activities and Projects for the SJU.
SIGMET	Significant en-route Meteorological Information

Term	Definition
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Program	The program which addresses all activities of the SESAR Joint Undertaking Agency.
SPC	Operational Sub Package
SPR	Safety and Performance Requirements
SUT	System Under Test
SWIM	System Wide Information Management
TAD	Technical Architecture Description
TAF	Terminal Aerodrome Forecast
TBS	Time Based Separation
TREND	Landing forecast
TS	Technical Specification
TWR	Aerodrome Control Tower
UDPP	User Driven Prioritization Process
VALP	Validation Plan
VALR	Validation Report
VALS	Validation Strategy
VP	Verification Plan
VR	Verification Report
VS	Verification Strategy
WDS	Weather Dependant Separation
WMO	World Meteorological Organisation
WOC	Wing Operations Centre
WP	Work Package
WV	Wake Vortex
Wx	Weather

2 Context of the Demonstrations

2.1 Scope of the demonstration and complementarity with the SESAR Programme

The TOPMET project addresses the key objective of better serving Ground and Air Airspace Users with consistent, relevant and up-to-date Meteorological information. This results in improved resilience of ATM operations to weather hazards, resulting in an **improved flight safety**; and more accurate information to inform flight planning, leading to **improved flight efficiency** and **improved airspace capacity.**

2.1.1 Project operational and geographical dimensions

The project encompasses multiple operational and geographical dimensions.

First, it supports a global operational interoperability by enabling the consistent distribution of advanced MET information services, among various profiles of Aeronautical Users, such as:

- Flow Management Position staff in En Route ATC centers (in charge of exchanging information from their ATC Unit to the DNM and contributing to manage the demand-capacity balance),
- Commercial Airlines Flight Dispatchers and Network Managers,
- Commercial Airlines Pilots.

The project has also demonstrated a global geographical interoperability – through a unique infrastructure supporting multiple geographical scales such as:

- a “national” / sub-regional scale, typically over the French controlled Airspace,
- an international scale, offering a global coverage over the Europe, Atlantic, and Africa regions.

MET products have been made available in order to allow the airspace user and ATM communities to plan safe and efficient routes based on consistent and accurate weather observations and forecast services across all these geographical regions.

The considered enabling infrastructure, namely an early prototype of the MISC (4DWxCube), is planned to be later used in a similar approach to support the validation of MET services as part of the SESAR WP11.2 and SESAR core program (e.g. in VP700) , therefore demonstrating its capability to ensure a geographical interoperability.

2.1.2 Project background and context

Meteorology is currently taken into account in Aviation and ATM operations, through the use of standardized MET products and services delivered in accordance with ICAO Annex 3 regulations. Those services have been established on the prevailing state-of-the-art available in the 1960’s, and consist mainly in coded text messages (TAF, METAR, SIGMET,…) and low-resolution grids (Wind, Temperature,…).

In addition, most commercial aircraft are equipped with on-board weather radar delivering a real-time image of the weather present in the front sector of the aircraft.

In recent years, technological developments have been the cornerstone for NMS to advance the scientific understanding of meteorology and thereby to enhance the operational capability to deliver tailored observational and forecast products designed to the specific requirements of individual users. While such new products are currently used in a research capacity or in the forecast production process, they are not usually directly accessible to industry, since they are not viewed as "standardized" or "regulated" MET services.

Over the past decade, awareness has been rising within the aviation community, of the benefits which could be derived from a better use and integration of those new products in operational processes, and of the positive impact this usage could create on flight safety and efficiency.

The TOPMET project aimed at demonstrating and promoting the principle of stakeholder-wide integration of new MET products, fully consistent and compatible with ongoing initiatives in SESAR and beyond.

2.1.3 Project outcomes

This project has offered an **integrated pre-operational demonstration** using the combination of:

- some of the most advanced Meteorological products worldwide offered by EUMETNET members,
- early versions of development prototypes designed in the core of the SESAR program, such as the MISC (4DWxCube), the enabling SWIM infrastructure, and various impact assessment and decision-aid prototypes targeted for dedicated end-user profiles .

The exposure to live trials of the considered new technologies and the associated new procedures has clearly demonstrated the potential to increase ATM and Airspace Users operational performance, especially regarding:

- **flight efficiency**, based on an optimization of flight routes, in order to reduce the MET-induced extra fuel consumption (by more than 20%) , to reduce the cost impact of MET hazards (by more than 15%), and to reduce the MET-induced delays (by more than 15%)
- **flight safety,** through a better monitoring of weather, enabling the avoidance of MET hazards with potential impact on the crew / passengers or on the aircraft itself,
- **capacity,** through a better anticipation of the impact of the MET hazards on the flights, enabling earlier implementation of measures to avoid sector overload, or unnecessary regulation measures .

Furthermore, the project has widely contributed to **raising the awareness regarding SESAR activities** and objectives, by an intensive communication campaign executed around this project.

In summary; the achieved benefits of the project have been:

- to improve the awareness of Aeronautical Users regarding new MET services, and collect their operational feedback in order to better focus the development of these services along their actual needs and priorities. This feedback will be re-introduced in related SESAR projects whenever relevant (e.g. WP11.2, WP9.48, WP 7.6.2,…),
- to demonstrate the interoperability of the MISC (4DWxCube) between multiple MET providers (NMS) and multiple ATM and Aviation clients (Airlines Ground and Air segments, ANSPs), and to demonstrate Air-Ground pre-SWIM operations in a non-safety-critical environment

Finally, the TOPMET project has enabled for many lessons learned, especially regarding the need for more (better) tailoring of MET information to end users requirements.

2.1.4 Project scope

The TOPMET system architecture is depicted in the figure 1 below. In this diagram:

- The yellow boxes correspond to already existing applications, that are used “as is” in the TOPMET trials
- The blue boxes have been specifically developed or adapted and deployed for TOPMET.

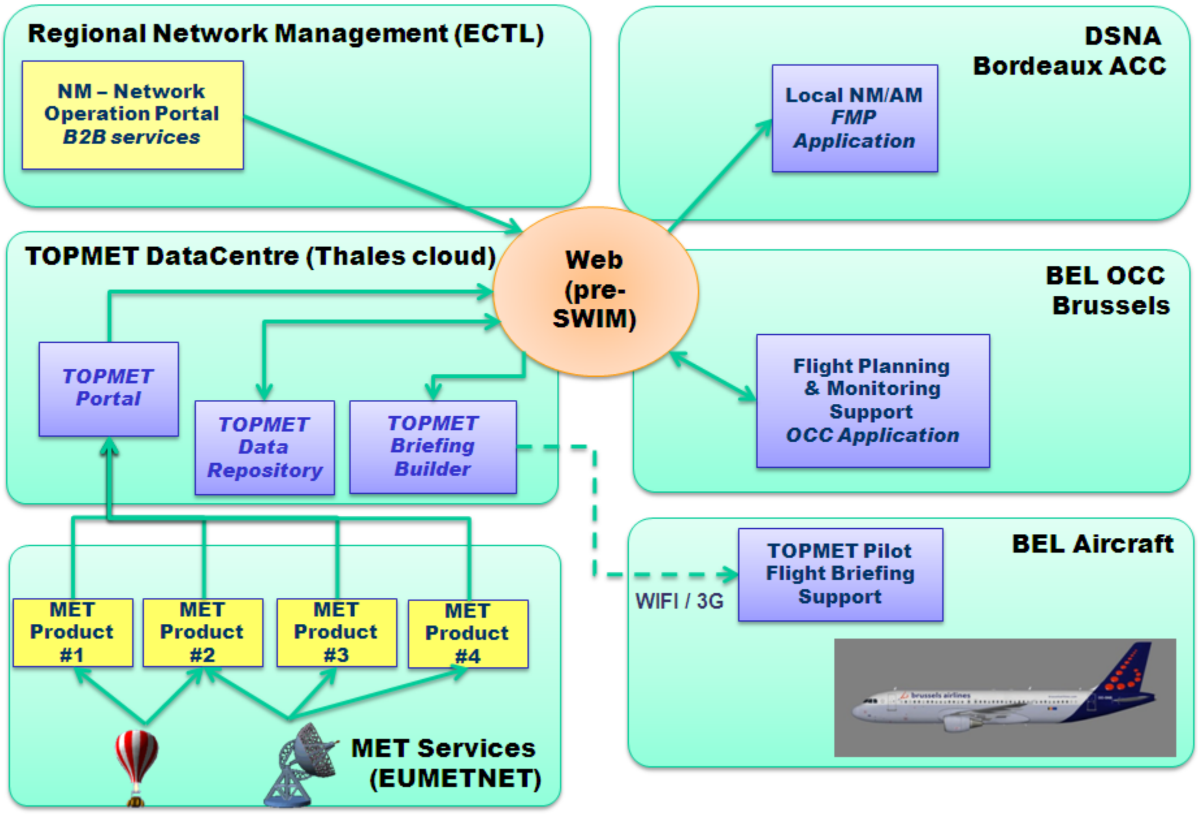


Figure 1: TOPMET System Architecture overview

2.1.5 Demonstration exercises overview

The TOPMET project had planned to perform a set of 4 demonstration exercises:

- 2 exercises involving the Airline only,
  - either for domestic flights over Europe (exercise 100)
  - or for long-haul flights from Europe to Africa or North America (exercise 200)
- 1 exercise involved the ANSP only, over the FIR LFBB (exercise 300)
- 1 joint exercise involving jointly the ANSP and the Airline over the FIR LFBB (exercise 400),

In practice, the following adjustments have been brought during the course of the demonstration campaign, and agreed by the SJU during the Final review held on September 22, 2014:

- Exercises 100 and 200 conducted by Brussels Airlines have been merged, due to the similarity of the processes for European and long haul flights
- A new Exercise 200 has been defined with Brussels Airlines, focused on an alternative mode of operations, enabling and end-to-end process triggered from the ground, instead of being purely “pilot-driven”
- Exercise 300 has been conducted as initially planned, however in “shadow mode”, rather than as a “live trial” interacting with the actual traffic.
- Exercise 400 has not been implemented, mainly due to its legal and regulatory implications, finally not compatible with the schedule of the project.

The exercises have been conducted in parallel over the period of the trials between June 30 and August 29, 2014.

KPIs and associated metrics have also been slightly adjusted during the course of the trials, in order to better reflect the operational expectations of both the Airline and the ANSP.

Demonstration Exercise ID and Title	***EXE-0206-100 – Airline improvement (pilot-driven assessment)***
Leading organization	Brussels Airlines
Demonstration exercise objectives	Demonstrate the benefits of using advanced new MET products on Brussels Airlines flights, in order to: • Reduce fuel consumption • Reduce flight cost • Improve flight predictability • Improve passenger comfort and flight safety • Reduce Environmental impact
OFA addressed	• OFA03.01.04: Business and Mission Trajectory • OFA03.01.08: System Interoperability with air and ground data sharing
Applicable Operational Context	The operational context applicable to TOPMET scenarios in EXE-0206-100 includes: • Optimized preparation of the SBT/RBT by the FOC. • Optimized flight execution & possible revisions to the RBT by the Pilot in coordination with the FOC
Demonstration Technique	Principally offline analysis of data recorded during conduct of the Live Flight Trial
Number of flight trials	93 commercial flights (where the pilot has used the TOPMET flight application, and provided some feedback)

Table 1 – Overview EXE-0206-100

Demonstration Exercise ID and Title	*EXE-0206-200 – Airline improvement (end-to-end assessment)*
Leading organization	Brussels Airlines
Demonstration exercise objectives	Demonstrate the benefits of using advanced new MET products on Brussels Airlines flights, in order to: • Reduce fuel consumption • Reduce flight cost • Improve flight predictability • Improve passenger comfort and flight safety • Reduce Environmental impact
OFA addressed	• OFA03.01.04: Business and Mission Trajectory • OFA03.01.08: System Interoperability with air and ground data sharing
Applicable Operational Context	The operational context applicable to TOPMET scenarios in EXE-0206-200 includes: • Optimized preparation of the SBT/RBT by the FOC • Optimized flight execution & possible revisions to the RBT by the Pilot in coordination with the FOC
Demonstration Technique	Principally offline analysis of data recorded during conduct of the Live Flight Trial
Number of flight trials	21 commercial flights (impacted by MET, subject to specific analyses)

Table 2 – Overview EXE-0206-200

Demonstration Exercise ID and Title	***EXE-0206-300 – FMP improvement***
Leading organization	DSNA
Demonstration exercise objectives	Demonstrate the benefits of using advanced new MET products on flights overflying the LFBB FIR, in order to: • Increase Airspace capacity • Increase IFR flights predictability • Reduce cost flights for Airlines • Reduce Environmental impact
OFA addressed	• OFA05.03.04: Enhanced ATFCM processes
Applicable Operational Context	The operational context applicable to TOPMET scenarios in EXE-0206-300 includes: • Preparation of possible Mid & Short Term ATFM measures by the ACC/FMP in coordination with the DNM.
Demonstration Technique	Principally offline analysis of data recorded during conduct of the Live Flight Trial
Number of flight trials	848 commercial flights (reported as delayed due to MET during the trials period, taken into account in the KPI assessment)

Table 3 – Overview EXE-0206-300

3 Execution of Demonstration Exercises

3.1 Exercises Preparation

The preparation of the TOPMET demonstration trials has involved a number of dedicated activities, and required the set-up of dedicated operational procedures, as well of a dedicated supporting platform.

3.1.1 Preparatory activities

The following preparatory activities have been conducted in the project:

- **Activity 1.1:**

  The refined definition of common ***objectives, metrics, and tools***, completing the initial definition provided in the Demonstration Plan, has been conducted in Task T002 (Operational validation objectives). Metrics have later been refined again during the course of Task T004 (System deployment & verification), taking into account the feedback of operational users when starting the deployment of the platform.

- **Activity 1.2:**

  The definition, deployment and verification of an ***experimental platform*** supporting the demonstrations, has been conducted mainly in Task T003 (System architecture definition), associated to deliverable D003 (System definition report) and Task T004 (System deployment & verification), associated to deliverable D004 (Overall system verification report). This system was supporting the provision of the new MET information services to respectively the FMP controllers, the Airline Network Managers, and the pilots in the cockpit. For more details, refer to references

- **Activity 1.3:**

  The ***training*** of individual staff (pilots, network managers, FMP controllers) on the TOPMET tools and processes

- **Activity 1.4:**

  The ***final selection of scenarios, routes and flights*** considered for the reference and solution trials (depending on the aircraft equipped with the TOPMET applications, and the trained staff)

3.1.2 Adaptation of the supporting platform

The TOPMET supporting platform has been described on figure 1 above. The following section summarizes the main adaptations performed on this platform for the purpose of the TOPMET demonstrations. Details on the platform have been provided in the Technical Specification (deliverable D003, reference [4]) and in the Overall system verification report deliverable D004, reference [5]).

3.1.2.1 MET Services

Overview: This segment consists of a set of new MET products addressing mainly the observation and forecast of convection, lightning, thunderstorms, icing and turbulence - on geographical coverage depending on the products. In addition, the provision of high resolution Wind & Temperature data has been offered. However, due to the impossibility to use this information in the ATM & Aviation systems in their current status (aircraft FMS, ATM & AOC decision aids), no further exploitation of these data has been performed in the project. The possible benefits to be envisaged in their use are summarized in the "recommendations" section 8.2.

Performed adaptations in TOPMET: The considered services were readily available at individual MET Offices and under evolutions as per WP 11.2, in order to ensure their standardization over Europe under the banner of the EUMETNET EIG. They have been used in TOPMET in their current status – keeping in mind that as an outcome of WP11.2, those products will become available in a standardized and homogeneous format over Europe.

3.1.2.2 European ATM Network Management

The Network Management portal of Eurocontrol has been used during the course of the project, and a permanent access to the information flow has been made available through the NM B2B interface.

No dedicated changes have been implemented by Eurocontrol for the purpose of TOPMET project.

3.1.2.3 TOPMET Data Center

Overview: This segment consists of a preliminary prototype of the MISC (4DWxCube), and aims at performing the interface between the various MET Services providers, and the various ATM clients (ANSP, Airline). It has been derived from the Step 1 Quick Win developments in WP11.2.

Performed adaptations in TOPMET: The prototype developed for WP 11.2 Step 1 has been replicated (to avoid any contractual or technical interference between the two projects). Both interfaces of the MISC (4DWxCube, on the "MET side" and on the "SWIM side") have been customized to the specific needs of the TOPMET project, based on the means developed in WP11.2 and in WP 14 "SWIM Technical Architecture".

In addition, a "TOPMET Data Repository" capability has been implemented, to store all relevant information during the course of the trials,

These adaptations have been conducted by Thales Air Systems with the support of the relevant EUMETNET members involved in its development within WP11.2.

Finally a "TOPMET Briefing Builder" capability has been developed by Thales Avionics, in order to prepare the information required by the "TOPMET Flight Support" function.

3.1.2.4 ANSP segment

Overview: This segment consists in a dedicated application which has been deployed at the Flow Management Position offices, in the Bordeaux (LFBB) En Route control centre of DSNA. This application was operated on a dedicated terminal (PC + high resolution display) deployed in a technical room, contiguous to the main control room of Bordeaux ACC.

Performed adaptations in TOPMET: The considered TOPMET application has been developed by Thales Air Systems and derived (replicated, extended, and customized) from the AWIDSS (Airport

Weather Information & Decision Support System) prototype deployed since October 2012 at Paris, Charles de Gaulle Airport Tower as per WP 11.2 Quick Win.

3.1.2.5 Airline FOC segment

Overview: This segment consists in a dedicated application which has been deployed in the Brussels Airlines Operational Control Centre (OCC), in BEL headquarters in Brussels. This application was operated on two dedicated terminals (PC + high resolution display) deployed in the OCC, and enabling the involvement of two Network Officers in parallel.

Performed adaptations in TOPMET: The considered TOPMET application has been developed by Thales Air System, as directly derived from the ANSP supporting application deployed in Bordeaux ACC.

3.1.2.6 Aircraft segment

Overview: This segment consists in a dedicated application running on a ground connected Personal Electronic Device (tablet) delivered to Brussels Airlines Pilots, and fit for use by Pilots, either on the ground (BEL premises, home, hotel,…), or on-board commercial aircraft of Brussels Airlines (when on the ground), connected through Wi-Fi or 3G mobile communication networks.

10 devices have been delivered to Brussels Airlines pilots; one device being allocated to a given, trained, pilot.

Performed adaptations in TOPMET: The considered TOPMET application has been developed by Thales Avionics, and deployed on COTS tablet devices.

3.1.3 Operational demonstration procedures

Operational procedures have been tuned for each of the three demonstration scenarios, in order to fit into local constraints, and to take into account the actual capabilities of the supporting platform.

The resulting procedures, as performed during the execution of the demonstrations, are summarized in the following sections.

3.1.3.1 Scenario EXE-0206-100 *(Airline improvement, pilot-driven assessment)*

Time	Roles			
	TOPMET coordinator	BEL TOPMET Ground PoC	BEL TOPMET Pilot	BEL fuel efficiency Manager
Day N (Preflight)			- Connect TOPMET Tablet tool & upload relevant information for the coming flight - Assess MET situation based on TOPMET pre-flight information - Initialize Pilot's Flight Report in TOPMET Tablet	
Day N (Execution)			- Depending on MET evolutions during flight, re-assess the MET situation in flight based on TOPMET pre-flight information	
			If severe situation confirmed: - identify MET-impact scenario type; - report actual decision taken - Update Pilot's Flight Report in TOPMET Tablet	
Day N (Post-flight)		When tablet is back in BEL OCC: - consolidate Pilot feedback reports - upload reports in TOPMET Data Center		

Post-flight daily consolidation (D+1)	- download & check all new pilots reports in Data Center - trigger TOPMET local contact to get any missing post-analysis information			
		- recover missing paper info, scan & download into Data Center		
	Check all information is complete			
Post-flight weekly consolidation	Consolidate all information & compute estimated KPIs			
				Check validity of estimated KPIs

3.1.3.2 Scenario EXE-0206-200 *(Airline improvement, end-to-end assessment)*

Time	Roles			
	TOPMET coordinator	BEL TOPMET Ground PoC	BEL Pilot	BEL fuel efficiency Manager
Execution Day N	- Monitor alerts in TOPMET OCC tool - If impacting MET event detected, prepare "trigger" report including Flight ID, description of suspected MET-impact scenario, and proposed decision - Send trigger report to BEL PoC on duty by email	- Monitor alerts in TOPMET OCC tool		
		- assess the actual severity of the MET situation using TOPMET OCC Tool, and other available means in OCC - if severe situation confirmed, contact Pilot via ACARS - identify MET-impact scenario type (S1-S13); - report recommended decision, and actual decision taken by pilot		
			If contacted by BEL PoC: - check MET situation based on visual & WXR - feedback BEL PoC by ACARS on actual status & decision taken	
		- consolidate Trigger report and Pilot feedback - upload consolidated event report in TOPMET Data Center		

Post-flight daily consolidation (D+1)	- check all actions performed -download & check all data reports - trigger TOPMET local contact to get any missing post-analysis information			
		- recover missing paper info, scan & download into Data Center		
	Check all information are complete			
Post-flight weekly consolidation	Consolidate all information & compute estimated KPIs			
				Check validity of estimated KPIs

3.1.3.3 Scenario EXE-0206-300 *(ATC/FMP improvement)*

The operational process used at DSNA for the trials period is summarized below:

- The TOPMET DSNA coordinator monitors the FMP application
- When a MET hazard warning is occurring, he analyses in detail the situation
- When relevant he contacts the Deputy Control Room Supervisor on duty to assess his current perception of the situation (based on the currently available tools)
- The TOPMET DSNA coordinator collects all relevant data related to the Flow Management decisions (regulations) related to MET, and associated information (concerned flights, resulting delays,…)
- The TOPMET DSNA coordinator validates the computation of KPIs and metrics, based on the consolidation and analysis of the collected data.

3.1.4 KPI & metrics definition

KPIs and associated metrics have been refined and tuned for each of the three demonstration scenarios, in order to ensure the representativeness of the selected metrics, and the feasibility of their assessment.

3.1.4.1 Scenarios EXE-0206-100 & -200 *(Airline improvement)*

The same KPIs have been defined for both "pilot-driven assessment" scenario (100) and "end-to-end assessment" scenario (200).

The rationale for revising is a refined analysis of KPIs targets by BEL « fuel management officer », which has raised some concerns on their operational relevance, and their ability to demonstrate positive benefits.

The approach taken has been to reduce the number of KPIs, and to keep focused on what will represent value to BEL and will be aligned with the latest recommendations from the SJU.

3.1.4.1.1 INITIAL KPIs definition

The following KPIs had been defined in the TOPMET Demonstration plan:

OBJ-0206-100: Reduce fuel consumption

Related SESAR KPI:	*Efficiency (fuel)*
Performance Index:	*Average kg Fuel Burn per Flight*
Target:	*2% reduction over "hazardous MET periods" (tbc)*

OBJ-0206-200: Reduce extra fuel take-off

Related SESAR KPI:	*Efficiency (fuel)*
Performance Index:	*Remaining extra fuel at gate*
Target:	*2% reduction over "hazardous MET periods" (tbc)*

OBJ-0206-300: Improve flight punctuality

Related SESAR KPI:	*Predictability*
Performance Index:	*number of delayed flights, average delay of delayed flights*
Target:	*3% reduction over "hazardous MET periods" (tbc)*

OBJ-0206-400: Improve passenger comfort & aircraft flyability

Related SESAR KPI: *Safety*

Performance Index: *Average period of flight with vertical/horizontal acceleration above threshold*

Target: *10 % reduction over "hazardous MET periods" (tbc)*

3.1.4.1.2 Revised KPIs definition

They have been revised and refined as follows:

OBJ-0206-100: Reduce fuel consumption

Related SESAR KPI: *Efficiency (fuel)*

Performance Index: *Cumulated additional fuel consumption due to MET*

Target: *20% reduction*

OBJ-0206-200: Reduce flight cost

Related SESAR KPI: *Efficiency (cost)*

Performance Index: *Additional flight cost due to MET*

Target: *10% reduction*

OBJ-0206-300: Improve flight predictability

Related SESAR KPI: *Predictability*

Performance Index: *cumulated additional (unexpected) flight delay due to MET compared to plan*

Target: *20% reduction*

OBJ-0206-400: Improve passenger comfort & aircraft flyability

Related SESAR KPI: *Safety*

Performance Index: *Cumulated period of flight with vertical/horizontal acceleration above threshold*

Target: *10 % reduction*

3.1.4.2 Scenario EXE-0206-300 *(ATC/FMP improvement)*

3.1.4.2.1 INITIAL KPIs definition

The following KPIs had been defined in the TOPMET Demonstration plan:

OBJ-0206-500: Improve Airspace capacity

Related SESAR KPI: *Capacity (Airspace)*

Performance Index: *IFR movements per airspace volume / unit time based on NM Entry/Occupancy count*

Target: *3% gain (tbc)*

OBJ-0206-600: reduce ATCO workload

Related SESAR KPI: -

Performance Index: *Perceived reduced stress in degraded conditions reported in questionnaires (no quantitative target measurable)*

Target: *(no quantified index)*

OBJ-0206-700: improve flight predictability

Related SESAR KPI: *Predictability*

Performance Index: *number of flights with deviation of flight duration over FIR compared to initial FPL – above a given threshold*

Target: *3% reduction (tbc)*

3.1.4.2.2 Revised KPIs definition

OBJ-0206-500: Improve Airspace capacity

(Unchanged)

Related SESAR KPI: *Capacity (Airspace)*

Performance Index: *IFR movements per airspace volume / unit time based on NM Entry/Occupancy count*

Target: *3% gain*

OBJ-0206-600: reduce ATCO workload

(not measurable for TOPMET)

OBJ-0206-700: improve flight predictability

Related SESAR KPI: *Predictability*

Performance Index: *cumulated unexpected delays induced by MET over FIR (vs initial flight plans)*

Target: *20 % reduction*

OBJ-0206-800: Reduce cost-impact of MET related network delays

Related SESAR KPI: *Cost efficiency*

Performance Index: *cost impact of cumulated unexpected delays induced by MET over FIR (vs initial flight plans)*

Target: *10 % reduction*

3.1.5 Post-analysis procedures

3.1.5.1 Scenario EXE-0206-100 & -200 *(Airline improvement)*

3.1.5.1.1 Definition of "MET-impact scenarios"

A number of "MET-impact scenarios" have been defined, which characterize different operational situations where the flight may be impacted by MET phenomena. They are summarized below:

- Typical situations where « inefficient » fuel consumption could be avoided: (« potential to reduce loss »):
    - **S01: Diversion** due to MET hazards at arrival (fog, snow, severe thunderstorm…)

      Could be avoided e.g. by waiting on ground before taking-off, or slowing down while en-route

    - **S02: Holding patterns** due to MET hazards at arrival (fog, thunderstorm,…)

      Could be avoided e.g. by waiting on ground before taking-off, or slowing down while en-route

    - **S03: Extra track miles** due to route deviation around severe thunderstorms / Cbs

      Could be reduced by anticipated / optimized in flight re-routing (horizontal or vertical)

    - **S04: Extra-fuel i**nduced by switching-on **de-icing** devices when entering severe icing areas en route

      Could be reduced e.g. by anticipated / optimized FL change

- Typical situations where fuel consumption could be more efficient (« potential to improve gain »)
    - **S05: Suboptimal horizontal routes** (jet streams…) or FLs due to low accuracy of MET parameters (wind/temp, …)

      Could be improved by higher accuracy MET parameters

    - **S06: Suboptimal climb or descent profiles** due to low accuracy of MET parameters (wind/temp, …)

      Could be improved by higher accuracy MET parameters

- Typical situations where significant variance on Flight Duration is induced by MET causes :

- **S07:** « **Last minute change » on Take Off Time** due to MET hazards at **departure** (fog, snow, severe thunderstorm,…) requiring to postpone TOT and keep aircraft grounded

  Could be reduced by better MET forecast , enabling to anticipate an effective TOT

  - ***S07a:*** *Situation where a TOT change is induced by an un-anticipated need for aircraft de-icing*
  - ***S07b:*** *Situation where a TOT change is induced by an un-anticipated need for re-tank after initial tanking completion, due to an un-anticipated need for aircraft de-icing*

- **S08: Change on flight duration ,** due to MET hazards on the **planned route**, requiring to make tactical decisions and change route during the flight

  Could be reduced by better MET forecast , enabling to anticipate an effective not « weather-dependent » route

- **S09: Change on Time of Arrival,** due to MET hazards at **arrival** (fog, snow, severe thunderstorm,…), requiring to postpone TA by holding patterns or diversion

  Could be reduced by better MET forecast, enabling to anticipate an effective TA

- Typical situations where flight safety is impacted due to MET hazards :
  - **S10: passenger or crew incidents** due to severe turbulence, high winds, wind shear…
  - **S11: airframe damages** due to severe hail impact on front glass, severe icing…
- Typical situations where flight comfort is impacted by MET hazards:
  - **S12: passenger or crew discomfort** due to moderate/severe **turbulence** En Route, high winds…
  - **S13: intense pilot stress** due to severe turbulence, high winds, wind shear…

3.1.5.1.2 Definition of “MET-impact reduction decisions”

In order to reduce the impact of MET on those scenarios, a number of potential operational decisions have been identified:

- **D01:** Decision for **delaying take-off** to avoid diversion or holding patterns at arrival
  - Conditions for success: severe MET@ ADES, reliable forecast (horizon > 1 -2 h ?, short-haul only) , automated warning & proposed TOT change to dispatcher & pilot
- **D02:** Decision for **slowing-down en-route** to avoid diversion or holding patterns at arrival

- Conditions for success: severe MET@ ADES, reliable forecast (horizon > 30 mn - 1 h ?) , automated warning & proposed TTA change to dispatcher & pilot

- **D03a:** Decision for an **anticipated (before take-off) horizontal re-routing** to « more efficiently » avoid a severe Cb / thunderstorm
  - Conditions for success: wide horizontal & vertical extension of Cb, reliable forecast (horizon > 1 -2 h ?, short-haul only), automated warning & proposed rerouting to dispatcher & pilot
- **D03b:** Decision for an **anticipated (during flight) horizontal re-routing** to « more efficiently » avoid a severe Cb / thunderstorm
  - Conditions for success: wide horizontal & vertical extension of Cb, reliable forecast (horizon > 30 mn - 1 h ?) automated warning & proposed rerouting to dispatcher & pilot
- **D04a**: Decision for an **anticipated (before take-off) FL change** to « more efficiently » avoid a severe Turbulence or Icing area
  - Conditions for success: limited vertical extension of hazard, reliable forecast (horizon > 1 - 2 h ?, short-haul only), automated warning & proposed FL change to dispatcher & pilot
- **D04b**: Decision for an **anticipated (during flight) FL change** to « more efficiently » avoid a severe Turbulence or Icing area
  - Conditions for success: limited vertical extension of Cb, reliable Cb forecast (horizon > 15 mn ?) , automated warning & proposed FL change to dispatcher
- **D05**: Decision to **uplink more up-to-date / accurate GRIBs to FMS** while en route:
  - Conditions for success: higher time & space resolution gridded MET information, automatic what-if during flight, automatic warning of dispatcher if a gain is identified, GRIB update during flight is feasible
- **D06:** Decision for **delaying take-off at Flight planning phase**, to avoid unexpected last minute delay of TOT due to MET
  - Conditions for success: severe MET@ ADES, reliable forecast (horizon > 1 -3 h ?) , automated warning & proposed TOT change to dispatcher
- **D07:** Decision for **including de-icing time at Flight planning phase**, to avoid unexpected delay of TOT due to de-icing
  - Conditions for success: severe MET@ ADES, reliable forecast (horizon > 1 -3 h ?) , automated warning & proposed TOT change to dispatcher

The applicability matrix from the Decisions Dxx to the MET-impact scenarios Sxx is summarized in the table below:

Decisions \ Scenarios	S01 Divertion / MET @ ARR	S02 Holding / MET @ ARR	S03 Fl. Length extension / MET En Route	S04 De-icing in-flight	S05 Sub-optimal ER profile	S06 Sub-optimal climb / descent profile	S07 TOT change / MET @ DEP	S07a TOT change / aircraft de-icing	S07b TOT change / re-tanking	S08 Fl. Duration Change / MET En Route	S09 TOA change / MET @ ARR	S10 PAX / crew MET-related incidents	S11 Airframe MET-related damages	S12 MET-related PAX / crew discomfort	S13 MET-related Pilot stress
D01: delay take-off when MET @ ARR	X	X									X	X	X	X	X
D02: slow down when MET @ ARR	X	X									X	X	X	X	X
D03a: anticipated re-routing (before DEP) when MET ER			X							X		X	X	X	X
D03b: anticipated re-routing (in-flight) when MET ER			X							X		X	X	X	X
D04a: anticipated FL change (before DEP) when MET ER			X	X						X		X	X	X	X
D04b: anticipated FL change (in-flight) when MET ER			X	X						X		X	X	X	X
D05: uplink improved GR Bs to FMS (in-flight)					X	X									
D06: delay take-off at Fl Planning stage when MET @ DEP							X								
D07: include de-icing & full tanking at Fl Planning stage								X	X						

Table 4: Scenarios / Decisions matrix

3.1.5.1.3 Principles of the KPI assessment

For each flight performed during the demonstration:

- A first analysis identifies if the flight has been impacted by MET or not
- For each MET-impacted flight, the corresponding MET-impact scenario is identified (S01 to S13)
  - The effect on KPIs due to this MET-impact is computed, with reference to the original flight plan (i.e. without MET-impact)
- For each identified MET-impacted flight, the potential decisions (D01 to D07) available to the Airline are identified
  - The effect on KPIs (i.e. reduced MET impact) which would have resulted if the decision is computed, with reference to both the original situation (no MET impact), and the actual situation (MET impact)

The principle is depicted in the figure below:

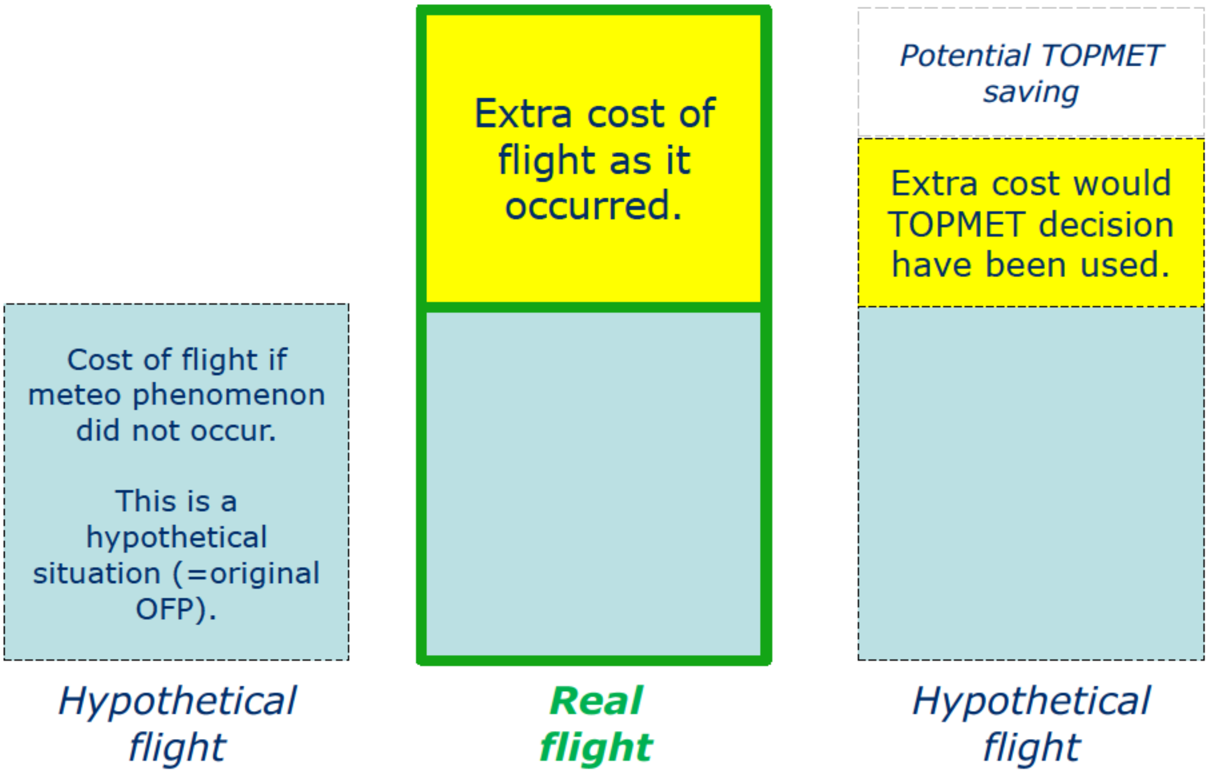


Figure 2: TOPMET KPI assessment principle

Based on this analysis,

- the required post-flight data necessary to assess the KPIs have been identified for each scenario / decision,
- a computation sheet has been created for each scenario / decision, in order to assess the KPI metrics, based on the relevant post-flight data.

3.1.5.1.4 Data gathering

This paragraph summarizes the post-flight data which have been collected for each MET-impacted flight:

- Situation report:

  Which scenario is observed during the flight (S01 to S13)

  Which potential decision could be made or have been made (D01 to D07)

- MET situations:

  (to store MET products during identified events S01 to S13)

- Flight Plans

FTFM, CTFM (successive changes if any) related to considered flight (from the NOP)

- Flight Tracks

Actual flight profile (from tablet GPS, FlightRadar24)

- BEL Flight Data Recorder

Initial fuel at take-off, Residual fuel at landing

Detailed flight profile (position, altitude, speed, vertical acceleration)

3.1.5.2 Scenario EXE-0206-300 *(ANSP improvement)*

3.1.5.2.1 Definition of "MET-impact scenarios"

A similar approach as for the Airline has been conducted with the ANSP.

Essentially one scenario has been documented, i.e. a hazardous MET area forecasted to enter a control sector, and requiring moving away the traffic, and reducing the sector capacity, through a regulation, i.e. assigning departure slots to scheduled flights.

The decision for setting up a regulation is often made once one or a few flights have requested for an horizontal re-routing, in order to avoid dangerous MET areas.

In a number of cases, the decision can also be anticipated, and made typically up to 3h ahead of the time where the actual MET hazard will impact the considered sector.

3.1.5.2.2 Definition of "MET-impact reduction decisions"

The TOPMET supporting tools will help reducing the impact of a MET regulation, by a more accurate and timely forecast of MET hazards, enabling to:

- reduce the "false alerts", i.e. setting a regulation for a MET hazard that finally does not occur in the considered sector
- improving the timeliness of the regulation, i.e. matching the start and end time of the regulation to the actual entry and exit time of the MET hazard in the considered sector

3.1.5.2.3 Principles of the KPI assessment

The principle finally applied for the KPI assessment are the same in this exercise, as compared with the Airline Case, as no real-time actual operational decision can be made- based on the TOPMET tools.

The relevant data are collected, and a "what if" scenario is reconstructed based on the recorded data, taking into account the decision that could have been made based on TOPMET tools, and re-assessing the KPI in this alternative case.

3.1.5.2.4 Data gathering

The data gathered to support the analysis include:

- MET situations : storage of MET products during the trial period (from the MET Offices)
- Flight Plans: FTFM, CTFM (with successive changes if any) related to all flights overflying the LFBB FIR (from the NOP)
- Sector load: occupancy & entry counts related to all flights overflying the LFBB FIR (from the NOP)
- Historical track of TFM decisions : all features (start, update and end time of regulations, with associated features
- List of flights having received a regulation slot, and resulting ground delay at departure.

3.2 Exercises Execution

The trials have finally been executed over the following periods of time:

Exercise ID	Exercise Title	Actual Exercise execution start date	Actual Exercise execution end date	Actual Exercise start analysis date	Actual Exercise end date
EXE-0206-100	*Airline improvement (pilots-driven assessment)*	1/07/2014	1/09/2014	1/07/2014	19/09/2014
EXE-0206-200	*Airline improvement (end-to-end assessment)*	7/07/2014	29/08/2014	7/07/2014	19/09/2014
EXE-0206-300	*FMP improvement*	1/05/2014	31/08/2014	1/07/2014	19/09/2014

Table 5: Exercises execution/analysis dates

The table below summarizes the list of the flights executed as per EXE-0206-100, i.e. the flights executed with the pilot using the TOPMET tablet (in total 79 flights):

Date	From/To	City
01/07/14	BRU-RAK	Marrakech
01/07/14	RAK-BRU	Marrakech
02/07/14	BRU-CPH	Copenhagen
02/07/14	BRU-GOT	Goteborg
02/07/14	GOT-BRU	Goteborg
04/07/14	FCO-BRU	Roma
07/07/14	BRU-MAN	Manchester
07/07/14	BRU-GVA	Geneva
07/07/14	GVA-BRU	Geneva
07/07/14	BRU-GVA	Geneva
07/07/14	GVA-BRU	Geneva
08/07/14	MAN-BRU	Manchester
08/07/14	BRU-MXP	Milano
08/07/14	MXP-BRU	Milano
09/07/14	BRU-MXP	Milano
09/07/14	MXP-BRU	Milano
10/07/14	BRU-BIO	Bilbao
10/07/14	BIO-BRU	Bilbao
16/07/14	BRU-BMA	Stockholm
16/07/14	BRU-FSC	Figari
16/07/14	FSC-BRU	Figari
17/07/14	BMA-BRU	Stockholm
17/07/14	BRU-SXB	Strasbourg
17/07/14	SXB-BRU	Strasbourg
18/07/14	BRU-LYS	Lyon
18/07/14	LYS-BRU	Lyon
18/07/14	BRU-MAD	Madrid
18/07/14	MAD-BRU	Madrid
24/07/14	BRU-SVQ	Seville
29/07/14	BRU-OSL	Oslo
29/07/14	BRU-GOT	Goteborg
29/07/14	GOT-BRU	Goteborg
30/07/14	BRU-EDI	Edinburgh
30/07/14	OSL-BRU	Oslo
31/07/14	EDI-BRU	Edinburgh
04/08/14	BRU-BSL	Basel
04/08/14	BSL-BRU	Basel
04/08/14	BRU-LIN	Milano
07/08/14	BRU-BMA	Stockholm
07/08/14	BMA-BRU	Stockholm
08/08/14	BRU-FLR	Florence

08/08/14	FLR-BRU	Florence
11/08/14	BRU-LYS	Lyon
11/08/14	LYS-BRU	Lyon
12/08/14	BRU-LYS	Lyon
21/08/14	BRU-GOT	Goteborg
21/08/14	BRU-LYS	Lyon
21/08/14	LYS-BRU	Lyon
22/08/14	GOT-BRU	Goteborg
22/08/14	BRU-VCE	Venice
22/08/14	VCE-BRU	Venice
22/08/14	BRU-LYS	Lyon
23/08/14	LYS-BRU	Lyon
24/08/14	BRU-LYS	Lyon
25/08/14	BRU-GVA	Geneva
25/08/14	GVA-BRU	Geneva
27/08/14	BRU-BIO	Bilbao
27/08/14	BIO-BRU	Bilbao
28/08/14	BRU-FCO	Roma
28/08/14	FCO-BRU	Roma
28/08/14	BRU-BLQ	Bologna
28/08/14	BLQ-BRU	Bologna
28/08/14	BRU-SVQ	Seville
28/08/14	SVQ-BRU	Seville
28/08/14	BRU-BIO	Bilbao
29/08/14	BRU-MLA	Malta
29/08/14	MLA-BRU	Malta
30/08/14	BIO-BRU	Bilbao
30/08/14	BRU-CDG	Paris
30/08/14	CDG-BRU	Paris
31/08/14	BRU-MRS	Marseille
31/08/14	MRS-BRU	Marseille
31/08/14	BRU-OSL	Oslo
31/08/14	BRU-BCN	Barcelona
31/08/14	BCN-BRU	Barcelona
01/09/14	BRU-FLR	Florence
01/09/14	FLR-BRU	Florence
01/09/14	OSL-BRU	Oslo
01/09/14	BRU-GOT	Goteborg

Table 6: Exercise EXE-0206-100 summary

The table below summarizes the list of the flights executed as per EXE-0206-200, i.e. the flights executed with the end-to-end airline process, triggered from the ground when MET hazards warnings have been issued (in total 21 flights):

Date	From/To	City
04/07/14	NAP-BRU	Naples
04/07/14	BRU-BIO	Bilbao
04/07/14	LIS-BRU	Lisbon
23/07/14	BRU-FSC	Figari
24/07/14	BRU-GVA	Geneva
24/07/14	EBBR-LEMD	Madrid
25/07/14	EBBR-GMAD	Agadir
29/07/14	EDI-BRU	Edinburgh
29/07/14	LIRF-EBBR	Roma
29/07/14	BIO-BRU	Bilbao
30/07/14	LTBJ-EBBR	Izmir
31/07/14	TLV-BRU	Tel-Aviv
01/08/14	BRU-DLA	Douala
01/08/14	BRU-BJM	Bujumbura
01/08/14	BCN-BRU	Barcelona
01/08/14	BCN-BRU	Barcelona
01/08/14	BRU-MAD	Madrid
01/08/14	MLG-BRU	Malaga
22/08/14	EBBR-UUDD	Moscow
22/08/14	BCN-BRU	Barcelona
22/08/14	MLG-BRU	Malaga

Table 7: Exercise EXE-0206-200 summary

The table below summarizes the list of the control days executed as per EXE-0206-300, when MET hazards regulations have been issued (in total 12 days):

DATE	Sectors		Duration	Delay
21-05	P123 15h/18h	Tact posée à 14h29 Taux 42/47/53 MTO"CB"	3:00	659'
23-06	L4 06h00/06h17	Tact posée à 04h10 Taux 36 MTO	0:17	102'
	X4 06h/07h40	Tact posée à 04h09 Taux 43/40 MTO	1:40	195'
	X4 09h00/11h00	Tact CNL à 08h40 Taux 43 MTO	0:00	47'
	X4 19h20/20h40	Tact posée à 18h17 Taux 41 MTO	1:20	219'
28-06	R4 16h00/17h15	Tact posée à 14h28 Taux 35 MTO	1:15	464'
	R3 16h00/17h15	Tact posée à 14h34 Taux 35 MTO	1:15	288'
	X4 16h31/19h00	Tact posée à 16h07 Cnl 19h00 Taux 35/39/43 MTO	2:29	1 199'
01-07	ZX414h30/15h06	Tact posée à 13h24 Taux 55/59 MTO	0:36	907'
03-07	ZX1 15h00/16h05	Tact posée à 13h31 Taux 39 MTO	1:05	190'
	X4 15h40/16h44	Tact posée à 13h45 Taux 41 MTO	1:04	267'
	X4 19h00/21h20	Tact posée à 16h00 Taux 41 CNL à 18h41 MTO	0:00	171'
07-07	X4 06h00/08h00	Tact CNL à 06h10 Taux 43 MTO	0:10	92'
19-07	R4 08h20/15h00	Tact CNL à 10h10 Taux 40/44 MTO	1:50	524'
20-07	P3 15h50/18h00	Tact posée à 13h50 Taux 50 MTO	2:10	843'
25-07	RL1 12h40/16h20	Tact posée à 12h31 Taux 39 MTO	3:40	466'
	RL2 12h40/16h40	Tact posée à 12h31 Taux 41 MTO	4:00	1050'
	RL3 12h40/17h15	Tact posée à 12h31 Taux 41/43 MTO	4:35	619'
	RL4 12h40/19h20	Tact posée à 12h31 Taux 48/50 MTO	6:40	1933'
02 08	X4 18h20/20h00	Tact posée à 16h27 Taux 43 46 MTO	1:40	611'
	NH4 16h00/18h40	Tact posée à 15h47 Taux 49/51/53 MTO	2:40	1106'
03 08	R4 10h20/12h00	Tact posée à 09h10 Cnl à 10h18 Taux 44 MTO	0:00	275'
	X4 08h40/12h40	Tact posée à 04h55 Cnl à 09h20 Taux 43 47 MTO	0:40	311'
08 08	P123 16h20/16h40	Tact posée à 14h30 Taux 51 Weather	0:20	215'

	ZX4 18h20/21h00	Tact posée à 16h07 Taux 53 Cnl à 20h17 Weather	1:57	1623'

Table 8: Exercise EXE-0206-300 summary

3.3 Deviations from the planned activities

The detailed activities and procedures have been documented in the section 4.1 above. The following sections summarize the main deviations introduced during the course of the project, with reference to the Demonstration Plan.

3.3.1 Airline scenarios EXE-0206-100 & -200

In summary, the following deviations have been introduced with reference to the Demonstration Plan:

- The decomposition in two exercises has been reshaped, with 2 exercises running in parallel :
  - 1 exercise involving pilots, supported by the TOPMET tablet
  - 1 exercise involving the whole decision chain (a trial coordinator, a local point of contact in BEL OCC, and the concerned pilots)

  The distinction between medium and long haul appeared to be not relevant, as tools and process were applied in exactly the same way for both categories of flights
- The operational procedures have been adjusted, based on a more accurate analysis of their insertion in the current organisation of BEL, and to take into account a number of local constraints, not yet identified at the stage of the Demonstration Plan.
- The KPI objectives and associated metrics have been revised as follows:
  - The metrics for assessing the improvement of fuel consumption has been revised to be more representative of the approach in use within the Airline
  - The KPI "reduction of extra fuel take-off" has been removed, as not measurable and with poor relevance at this stage of maturity of the concept
  - A new KPI has been introduced on "flight cost improvement", directly related to the improvement of fuel consumption, but taking also into account additional effects, e.g. in the case of a diversion.
  - The KPI "flight punctuality" has been replaced by "flight predictability" in order to better isolate the effect of MET
- The duration of the "operational trials" (i.e. on which the KPI can be assessed) has been reduced to a period of 2 months, in order to meet the project final milestone
  - A period of approximately 6 months (from Jan to June 2014) has included more than 50 "TOPMET pre-operational" commercial regular flights, and has been used for

multiple iteration cycles, in order to refine the end –to –end process, and improve the suitability of supporting tools for pilots and OCC. This "pre-trials" period has enabled many "lessons learned" and has been extremely beneficial to improve the maturity of the concept.

- The operating process has been limited to "Shadow Mode" operations
  - The MET false alarm rate (probability to warn against a hazard not actually present, or not to warn against a hazard actually present), and the level of calibration of MET information (i.e. unified inter-calibration of the MET information from various sources, and unified settings of appropriate impact thresholds), as well as the level of maturity of the operational concept, were not sufficient to enable implementing operational decisions on commercial flights, purely relying on the TOPMET infrastructure
  - However the real-time- and post-analysis of the information provided by the TOPMET infrastructure was sufficient to predict, in a number of situations, the hypothetical results which would have been reached when implementing the recommended decisions
- The usage of High Resolution Wind & Temperature gridded data, offered by the MET services, has finally not been evaluated as not feasible in the current status of the aircraft or ground support decision aids; as a consequence, no scenario of the type "S05' or "S06" (sub-optimal routes or climb /.descent profiles) has been assessed; the issue is related below in the "recommendations" in section 8.2.

3.3.2 ANSP scenario EXE-0206-300

In summary, the following deviations have been introduced with reference to the Demonstration Plan:

- The operational procedures have been adjusted, based on a more accurate analysis of their insertion in the current organization of DSNA, and to take into account a number of local constraints, not yet identified at the stage of the Demonstration Plan.
- Revision of KPI objectives and associated metrics:
  - The KPI "reduction of ATCO workload" has been removed, as not measurable and with poor relevance at this stage of maturity of the concept
  - The metrics for the KPI "flight predictability" have been refined in order to better isolate the effect of MET, and measure its contribution to network delays
  - A new KPI has been introduced on the "cost impact of MET-related network delays",
- The duration of the "operational trials" (i.e. on which the KPI can be assessed) has been reduced to a period of 4 months, in order to meet the project final milestone

  - The period of from October 2013. to April 2014 has been used for multiple iteration cycles, in order to refine the end –to –end process, and improve the suitability of supporting tools for FMPs. This “pre-trials” period has enabled many “lessons learned” and has been extremely beneficial to improve the maturity of the concept.

- The operating process has been limited to “Shadow Mode” operations

  - The level of maturity of the operational concept, and the performance of the MET forecasts (see section 4.3.1) was not sufficient to enable implementing operational ATC decisions on, purely relying on the TOPMET infrastructure

  - However the real-time- and post-analysis of the information provided by the TOPMET infrastructure was sufficient to predict, in a number of situations, the hypothetical results which would have been reached when implementing the recommended decisions

4 Exercises Results

4.1 Summary of Exercises Results

The table below summarizes the results obtained against each of the success criteria identified above.

4.1.1 EXE-0206-100 (airline benefits, pilot-driven assessment)

Exercise ID	Demonstration Objective ID	Demonstration Objective Description	Success Criterion	Exercise Results	Demonstration Objective Status
EXE-0206-100 Airline improvement (pilot-driven assessment)	**OBJ-0206-100**	Reduce fuel consumption	Cumulated additional fuel consumption due to MET: 20% reduction	*Not measurable, No significant MET-impact scenario observed on the flights where the TOPMET tablet was on-board*	*Not measured*
	OBJ-0206-200	Reduce flight cost.	Additional flight cost due to MET: 10% reduction	*Not measurable, No significant MET-impact scenario observed on the flights where the TOPMET tablet was on-board*	*Not measured*
	OBJ-0206-300	Improve flight predictability.	Cumulated additional (unexpected) flight delay due to MET compared to flight plan: 20% reduction	*Not measurable, No significant MET-impact scenario observed on the flights where the TOPMET tablet was on-board*	*Not measured*
	OBJ-0206-400	Improve passenger comfort & aircraft flyability	Cumulated period of flight with vertical/horizontal acceleration above threshold: 10 % reduction	*Not measurable, No significant MET-impact scenario observed on the flights where the TOPMET tablet was on-board*	*Not measured*

Table 9: Scenario EXE-0206-100: Summary of Demonstration Exercises Results

4.1.2 EXE-0206-200 (airline benefits, end-to-end assessment)

Exercise ID	Demonstration Objective ID	Demonstration Objective Description	Success Criterion	Exercise Results	Demonstration Objective Status
EXE-0206-200 ***Airline improvement (end-to-end assessment)***	**OBJ-0206-100**	Reduce fuel consumption	Cumulated additional fuel consumption due to MET: 20% reduction	S03 MET-impact scenario (in-flight re-routing): **26%** reduction	OK
				S01 MET-impact scenario (diversion to alternate airport): **79%** reduction	OK
	OBJ-0206-200	Reduce flight cost.	Additional flight cost due to MET 10% reduction	S03 MET-impact scenario (in-flight re-routing): **19%** reduction (MET-induced extra cost reduced from 1937 € to 1561 €, over 4 flights)	OK
				S01 MET-impact scenario (diversion to alternate airport): **73%** reduction (MET-related fuel consumption reduced from 3748 € to 1020 €, over 1 flight – not taking into account the indirect cost – related to PAX)	OK
	OBJ-0206-300	Improve flight predictability.	Cumulated additional (unexpected) flight delay due to MET compared to plan: 20% reduction	S03 MET-impact scenario (in-flight re-routing): **33%** reduction (MET-induced extra flight duration reduced from 9 mn to 6 mn, over 4 flights)	OK
	OBJ-0206-400	Improve passenger comfort & aircraft flyability	Cumulated period of flight with vertical/horizontal acceleration above threshold 10 % reduction	*Not measurable during the trials, No relevant "S12" MET-impact scenario observed during the period of the trials*	*Not measured*

Exercise ID	Demonstration Objective ID	Demonstration Objective Description	Success Criterion	Exercise Results	Demonstration Objective Status
		Improve safety of flight	(Avoid any MET-related event impacting the safety of flight)	*Was not expected to be encountered during the trials period. The post-analysis of an incident due to strong turbulences occurred on April 27, 2014 in Luanda on SN359 (8 injured, significant airframe damages) provides some indications showing that the TOPMET tools might have allowed to avoid the incident. No more details can be provided at this stage considering the on-going investigation report.*	*OK (to be confirmed)*

Table 10: Scenario EXE-0206-200: Summary of Demonstration Exercises Results

4.1.3 EXE-0206-300 (ANSP benefits, FMP-driven assessment)

Exercise ID	Demonstration Objective ID	Demonstration Objective Description	Success Criterion	Exercise Results	Demonstration Objective Status
EXE-0206-300 ***FMP improvement***	**OBJ-0206-500**	Improve Airspace capacity	IFR movements per airspace volume / unit time based on NM Entry/Occupancy count: 3% gain	*Gain not measurable during the trials,*	*Not measured*
	OBJ-0206-600	reduce ATCO workload	(not measurable for TOPMET)	N/A	N/A
	OBJ-0206-700	Improve flight predictability.	Cumulated unexpected delays induced by MET over FIR (vs initial flight plans): 20 % reduction	Achieved: **18 %** reduction	OK (objective nearly achieved)
	OBJ-0206-800	Reduce cost-impact of MET-related network delays	Cumulated cost-impact on Airlines of unexpected delays induced by MET over FIR (vs initial flight plans): 10 % reduction	Achieved: **18 %** reduction	OK

Table 11: Scenario EXE-0206-300: Summary of Demonstration Exercises Results

4.2 Metrics and Indicators per KPA

The final indicators, metrics and the results obtained from the analysis are summarized in the table below, synthetized per KPA.

The KPA for which no measurements have finally been provided are not reminded here (capacity).

KPA	Objective ID	KPI	Metric	Measuring Process and Criteria	Expected Benefit	TOPMET Results
EFFI-CIENCY (FUEL)	OBJ-0206-100	Extra fuel consumption due to MET	Cumulated additional fuel consumption due to MET, based on EXE-0206-200, **S03** MET-impact scenario (in-flight rerouting)	Comparison between actual and hypothetical flight data	Reduce by 20% the additional fuel consumption due to MET	**26%** reduction (MET-related fuel consumption reduced from 2356 kg to 1751 kg, over 4 flights) .
			Cumulated additional fuel consumption due to MET, based on EXE-0206-200, **S01** MET-impact scenario (diversion)	Comparison between actual and hypothetical flight data	Reduce by 20% the additional fuel consumption due to MET	**79%** reduction (MET-related fuel consumption reduced from 4700 kg to 1000 kg, over 1 flight).
EFFI-CIENCY (COST)	OBJ-0206-200	Extra flight cost due to MET	Cumulated additional flight cost due to MET, based on EXE-0206-200, **S03** MET-impact scenario (in-flight rerouting)	Comparison between actual and hypothetical flight data	Reduce by 10% the additional flight cost due to MET	**19%** reduction (MET-induced extra cost reduced from 1937 € to 1561 €, over 4 flights) .
			Cumulated additional flight cost due to MET based on EXE-0206-200, **S01** MET-impact scenario (diversion)	Comparison between actual and hypothetical flight data	Reduce by 10% the additional flight cost due to MET	**73%** reduction (MET-related extra cost reduced from 3748 € to 1020 €, over 1 flight – not taking into account the indirect cost –related to PAX).
			Cumulated additional flight cost due to MET based on EXE-0206-300,	Comparison between actual and hypothetical flight data	Reduce by 10% the additional flight cost due to MET	**18 %** reduction (from 488 k€ to 399 k€ cumulated cost, over 12 days, for 848 flights, i.e. in average 104 € gain per flight).
SAFETY	OBJ-0206-400	Severe turbulence impacting PAX comfort	Cumulated period of flight with vertical/horizontal acceleration above threshold, , based on EXE-0206-200, **S12** MET-impact scenario (high turbulence)	Comparison between actual and hypothetical flight data	Reduction of at least 10 %	*No occurrence observed during the trials period*
PREDICTA BILITY	OBJ-0206-300	Extra flight delay due to MET	Cumulated additional (unexpected) flight delay due to MET compared to plan, based on EXE-0206-200, **S03** MET-impact scenario (in-flight rerouting)	Comparison between actual and hypothetical flight data	Reduce by 20% the additional time delay due to MET	**33%** reduction (MET-induced extra flight duration reduced from 9 mn to 6 mn, over 4 flights)

	OBJ-0206-700	Extra flight delay due to MET	Cumulated unexpected delays induced by MET over FIR (vs initial flight plans), based on EXE-0206-300,	Comparison between actual and hypothetical flight data	Reduce by 20% the additional time delay due to MET	**18 %** reduction (from 14376 mn to 11776 mn cumulated delay, over 12 days, for 848 flights, i.e. in average 3 mn gain per flight

Table 12: Table of KPAs addressed

4.3 Summary of Demonstration Conduct Assumptions

4.3.1 Results per KPA

See sections 5.1 and 5.2.

4.3.2 Impact on Safety, Capacity and Human Factors

The following points may be highlighted:

- Safety: Even if a positive impact on safety was expected in the deployment of TOPMET, it was not expected to provide any evidence on safety benefits during the course of the project; and actually, no safety-related event has been observed during the trials period. However, the post-analysis of an incident due to strong turbulences occurred on April 27, 2014 in Luanda on flight SN359 (8 injured, significant airframe damages) provides some indications showing that the TOPMET tools might have allowed to avoid the incident. No more details can be provided at this stage considering the on-going investigation by the Belgian Authorities.

- Capacity: the expected impact on the sectors capacity was expected to be analysed in exercise EXE-0206-300 (FMP). However the considered metrics appeared to be not appropriate and unable to properly reflect the impact of MET on sector capacity, and its possible improvement through the introduction of the TOPMET concept. Other KPIs related to predictability and cost efficiency for Airlines appeared to be more powerful to measure the potential impact of the TOPMET concept on Flow Management performances.

  .

- Human Factors: this KPA was out of the scope of the project. However a specific effort has been undertaken to take HF into considerations in the design of end-users applications for Pilots, OCC and FMP ground operators. Much feedback has been gained during the project on HF aspects, which will be valued in the preparation of follow-on activities.

4.3.3 Description of assessment methodology

See sections 4.1.3 and 4.1.5 above.

4.3.4 Results impacting regulation and standardisation initiatives

The feedback obtained on the use of MET information in actual operations will provide useful inputs in the perspective of future standardization of MET hazards representation for aviation (reflectivity thresholds, contours, etc,…). Further experiments will however be needed before reaching the required background in defining these standards.

4.4 Analysis of Exercises Results

See section 4.1 and 5.2 for the general analysis of the results for each exercise and objective. See also section 6 for more detail regarding the rationale for the results.

4.4.1 Unexpected Behaviours/Results

The deviations from the initial demonstration plan are listed in section 4.3.

The most significant unexpected behaviours or results encountered during the course of the project are summarized below:

- The difficulty to adapt existing operational processes to take into account additional MET information (considering the current workload of actors, especially in the critical periods when MET hazards generally occur)
- The difficulty to reach an adequate level of acceptance of the new MET information by operational end-users (delivering a relevant and valid information , at the right time, to the right actor)

4.5 Confidence in Results of Demonstration Exercises

4.5.1 Quality of Demonstration Exercises Results

The quality of the Demonstration Exercise Results has been limited by several factors faced during the course of the trials.

In summary:

- In **Exercise EXE-0206-100** (Airline, Pilot-driven assessment):
    - The lack of in-flight connectivity, and the insufficient (or not reliable enough) forecast horizon for MET hazards, strongly reduced the domain where the benefits could be actually derived in this scenario
    - The probability of occurrence of MET hazards during the trials has been overestimated, and the use of even up to 5 tablets in parallel has not allowed to reach a statistically sufficient number of MET hazards occurrences
    - The use of a “shadow mode” process (i.e. the pilot using the tablet for information only, not making any decision to optimize his flight based on the tablet information) has limited the capture of operational feedbacks from the pilot .
    - The consequence is that the flights executed in EXE-0206-100 have finally not been fit for the assessment of KPI gains. They have however generated a high added value in preparation of follow-on activities, where the main limitations listed above will have been removed.

- In **Exercise EXE-0206-200** (Airline, end-to-end assessment):
  - The insufficient levels of calibration, and reliability of the forecast of MET hazards, have induced a number of “false alerts”, or conversely, not allowed to detect in time some actual hazards observed by the pilots
  - The limited duration of the trials (2 months), the capacity to perform the monitoring only part-time (e.g. not over week-ends), or the allocation of higher priorities to the OCC staff during some critical periods, resulted in the fact that only a part of the potential flights of interest have been captured during the trial period.
  - The flights selected for the post-analyses appear however to be representative of the most common situations; they demonstrate potential KPI gains which revealed to be consistent with those measured in EXE-0206-300

- In **Exercise EXE-0206-300** (ATC/FMP):
  - The insufficient levels of calibration, and reliability of the forecast of MET hazards, did not allow FMP operators to make real-time analyses, and limited the approach to a post-analysis demonstration of the expected benefits
  - This approach however allowed capturing a much significant sample of MET-impacted flights (> 800) which provided a good level of confidence on the assessed statistical results.

4.5.2 Significance of Demonstration Exercises Results

The following points may be highlighted:

- <u>Operational significance</u>:
  - In Exercise EXE-0206-100, the pilot has identified a relevant use of the tablet in the flight preparation phase, in collaboration with the OCC staff. He has also confirmed a non relevant use of the tablet during flight execution, due to the absence of in-flight connectivity.
  - In Exercise EXE-0206-200, a detailed analysis has been conducted with BEL operational staff, to identify the most representative MET-impact scenarios expected to be encountered during actual operations. A similar analysis has been conducted as well with DSNA in EXE-0206-300. The trials have allowed to better assess the actual level of impact of those scenarios, and to get an indication on their frequency of occurrence. The flights selected for the post-analysis correspond well to some of the “template scenarios” which have been defined, hence are considered as operationally relevant. A longer trial period, would have allowed capturing further types of scenarios of low or seasonal occurrence. Also some of the considered “template scenarios” have

been proved as having a much lower impact as initially predicted (e.g. the use of in-flight de-icing devices, which has finally a very limited impact on fuel consumption).

- A similar analysis has been conducted as well with DSNA in EXE-0206-300.Similar considerations can be derived.

- Statistical significance:
    - In Exercise EXE-0206-200, the number of statistical samples has been relatively low (less than 5 flights per investigated scenario type). Hence the statistical representativeness has to be considered as low. However, especially for MET-impact scenario S03 (in flight rerouting), the few samples analysed have shown a relative consistency in their statistical distribution.
    - In Exercise EXE-0206-300, the number of statistical samples has been much higher (> 800 flights) hence the statistical representativeness can be considered as much greater.

4.5.3 Conclusions and recommendations

4.5.3.1 Conclusions

See section 8.1

4.5.3.2 Recommendations

See section 8.2

5 Demonstration Exercises reports

5.1 Demonstration Exercise EXE-0206-100

5.1.1 Exercise Scope

See section 2.1.5.

This exercise addresses the improvement of the Airline KPIs, through the use of the supporting tools available on a Tablet for the Pilot.

5.1.2 Conduct of Demonstration Exercise

5.1.2.1 Exercise Preparation

See section 3.1.

The configuration used in this exercise is depicted in figure 1, section 2.1.4 above, and focuses on the operational use of the "BEL aircraft segment" (bottom right of the diagram).

5.1.2.2 Exercise execution

See section 3.2, Table 6.

In total, 79 flights have been executed.

5.1.2.3 Deviation from the planned activities

See section 3.3.1.

5.1.3 Exercise Results

5.1.3.1 Summary of Exercise Results

See section 4.1.1, Table 9.

5.1.3.1.1 Results per KPA

This exercise has not allowed the computation of KPAs which have been assessed in EXE-0206-200, using the end-to-end system including the ground segments.

5.1.3.1.2 Results impacting regulation and standardisation initiatives

See Section 4.3.4.

5.1.3.1.3 Unexpected Behaviours/Results

See Section 4.4.1.

5.1.3.1.4 Quality of Demonstration Results

See Section 4.5.1.

5.1.3.1.5 Significance of Demonstration Results

See Section 4.5.2.

5.1.4 Conclusions and recommendations

5.1.4.1 Conclusions

See section 8.1 of the Final Demonstration Report

5.1.4.2 Recommendations

See section 8.2 of the Final Demonstration Report

5.2 Demonstration Exercise Report EXE-0206-200

5.2.1 Exercise Scope

See section 2.1.5.

This exercise addresses the improvement of the Airline KPIs, through the use and end-to-end process involving both the Ground and the Pilot.

5.2.2 Conduct of Demonstration Exercise EXE-0206-200

5.2.2.1 Exercise Preparation

See section 3.1.

The configuration used in this exercise is depicted in figure 1, section 2.1.4 above, and focuses on the operational use of the "BEL ground and aircraft segments" (center and bottom right of the diagram).

5.2.2.2 Exercise execution

See section 3.2, Table 7.

In total, 21 flights have been executed.

A selection of the most relevant flights has been made to support further post-analysis. The sections below provide more details on the selected flights.

5.2.2.2.1 Flight BEL1FS / SN3581 – 16 July 2014

5.2.2.2.1.1 General information

Flight ID	EOBD	EOBT	ETA
BEL1FS / SN3581	16072014	1130	1340

EBBR – LFKF

```
ATC PLAN
N0408F290 ROUSY UT27 GTQ/N0397F310 UN852 MILPA UM730 MEDAM UM623
VAREK/N0345F210 UM128 AJO/N0342F190
```

5.2.2.2.1.2 Situation description

Airline Phase when issues are identified	Met hazard Location	MET hazards type	Info support means used	Abnormal scenario
In Flight	EN route	ASPOC / CB'S	TOPMET AOC	TBC

The flight could found some ASPOC en route close to departure airport.

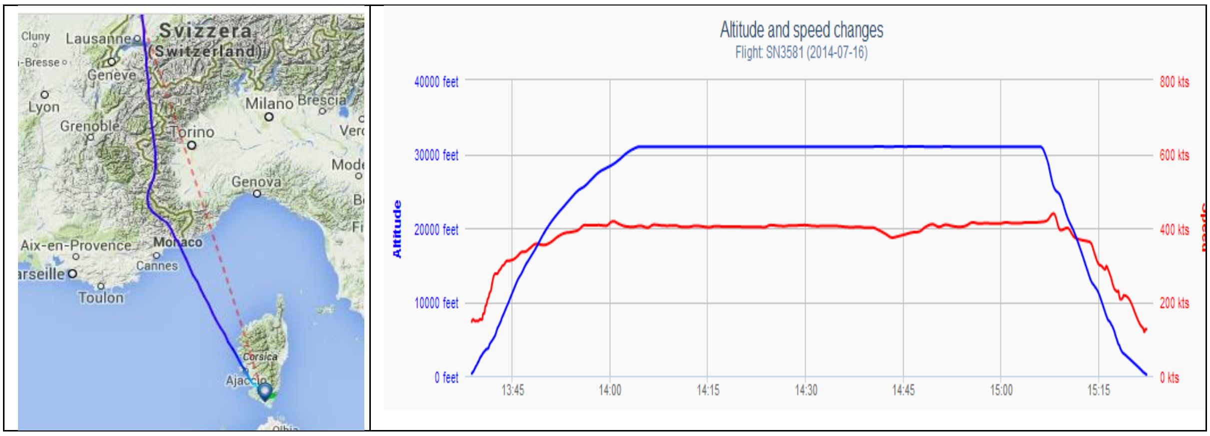
For this flight we received a feedback from the pilot:

"CB and RDT over Southern Alps (near Nice)...

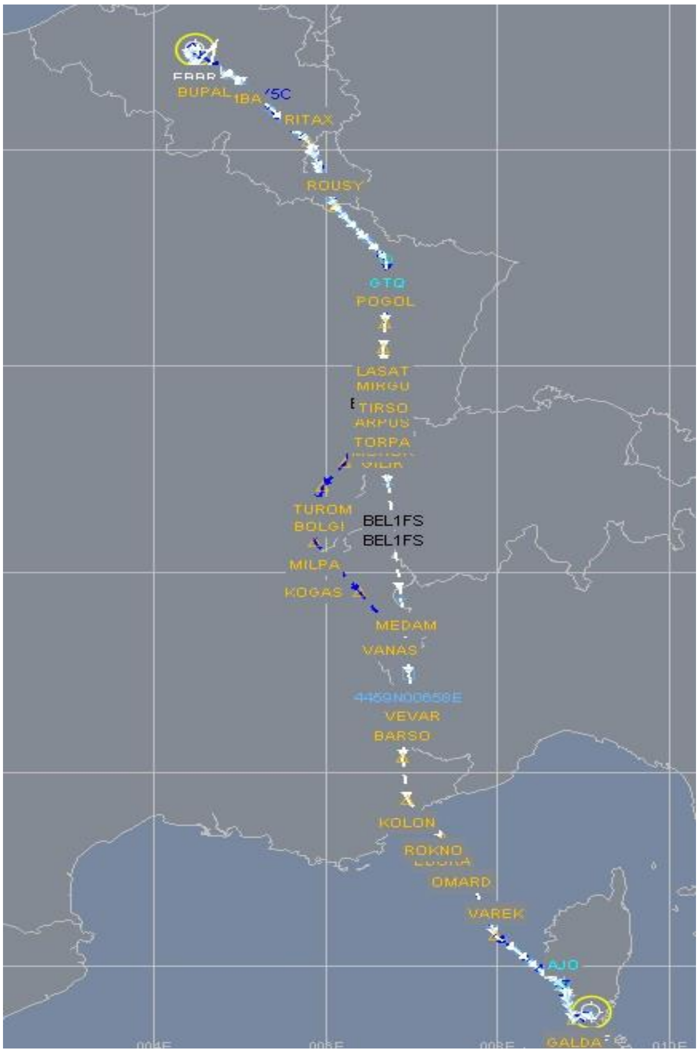
Indeed, location was very much correct, with TOPMET giving a pretty good indication of the top of cloud, allowing us to make a decision whether to climb or to turn...

Eventually it turned out to be impossible to climb above, so turns were initiated based on visual and wx radar info to avoid (extra track miles)."

5.2.2.2.1.3 Trajectory SN3581 screenshot.



5.2.2.2.1.4 Screenshots – SN3581 – 16/07/2014 – Network Manager Profile (Eurocontrol data)



5.2.2.2.2 Flight BEL82C / SN3582– 16 July 2014

5.2.2.2.2.1 General information

Flight ID	EOBD	EOBT	ETA
BEL82C / SN3582	16072014	1420	1615

LFKF – EBBR (FSC-BRU)

```
ATC PLAN
N0407F300 AJO UM622 PIGOS/N0354F320 UM622 IRMAR/N0395F320 UN853
DIK UY37 BATTY/N0350F180
```

5.2.2.2.2.2 Situation description

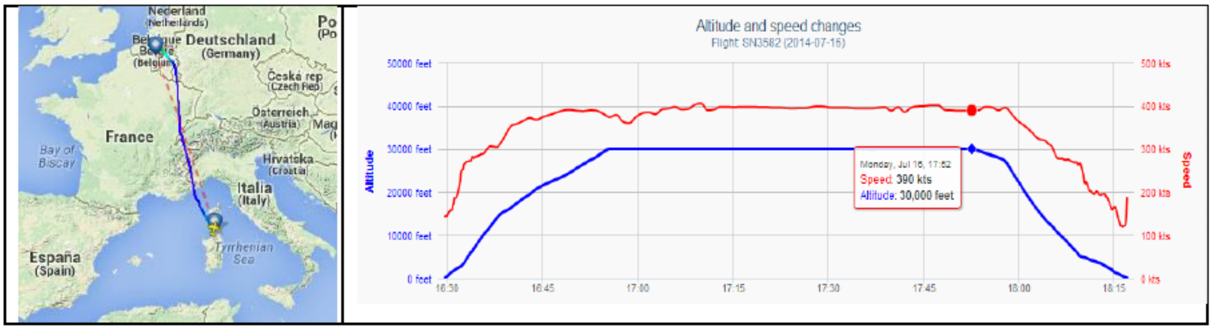
Airline Phase when issues are identified	Met hazard Location	MET hazards type	Info support means used	Abnormal scenario
In Flight	EN route	ASPOC / CB'S	TOPMET AOC	TBC

The flight could found some ASPOC en route close to departure airport.

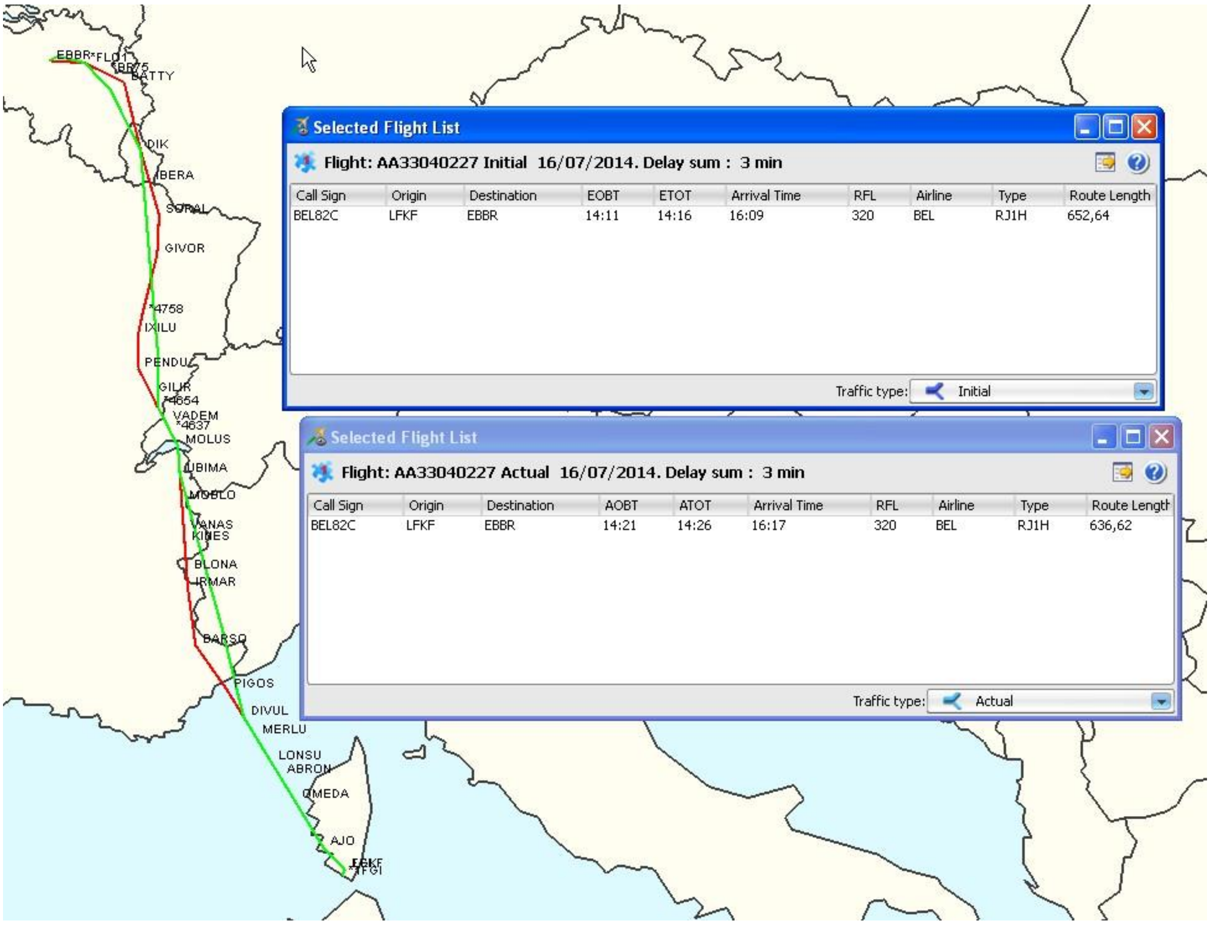
For this flight we recived a feedback from the pilot:

"Same situation as with SN3581 above, but CBs now matured... same avoiding action taken."

5.2.2.2.2.3 Trajectory SN3581 screenshot.



5.2.2.2.2.4 Screenshots – SN3581 – 16/07/2014 – Network Manager Profile (Eurocontrol data)



5.2.2.2.3 Flight BEL9GV / SN2719 – 24 July 2014

5.2.2.2.3.1 General information

Flight ID	EOBD	EOBT	ETA
BEL9GV / SN2719	24072014	1145	1300

EBBR – LSGG A319
RFL=310
TAS=411
N0411F310 ROUSY UT27 GTQ UN852 MOROK/N0391F230 UZ24 AKITO

5.2.2.2.3.2 Situation description

Airline Phase when issues are identified	Met hazard Location	MET hazards type	Info support means used	Abnormal scenario
In Flight	EN route	ASPOC / CB'S	TOPMET AOC	TBC

The flight could found some ASPOC en route close to departure airport.

For this flight we received a feedback from the pilot:

"• Crew indeed encountered some CB/TS along the route to GVA, if they recall well, ca 80 NM prior to LIRKO (located ca 25NM NW of GVA), so ca +100NM before GVA

• They circumnavigated this WX by a 30° course change to the right for ca 60NM (rough figures, but pretty much what is done in real life)

• Approach into GVA was started 20NM from LIRKO, they then got an AKITO 2R arrival from ATC (see att for chart)

• Followed by another ATC clearance direct to SPR VOR, and a straight-in for an approach on RWY23 (see att for chart)

Based on the facts, the following findings could be made so far

• The scheduled time of this flight was 01h15 (Commercial Schedule Times)

• Effective time flow was 01h14 (Note: FPL route and planned duration of the flight at this moment unknown to me)

• A small deviation of the intended route was performed

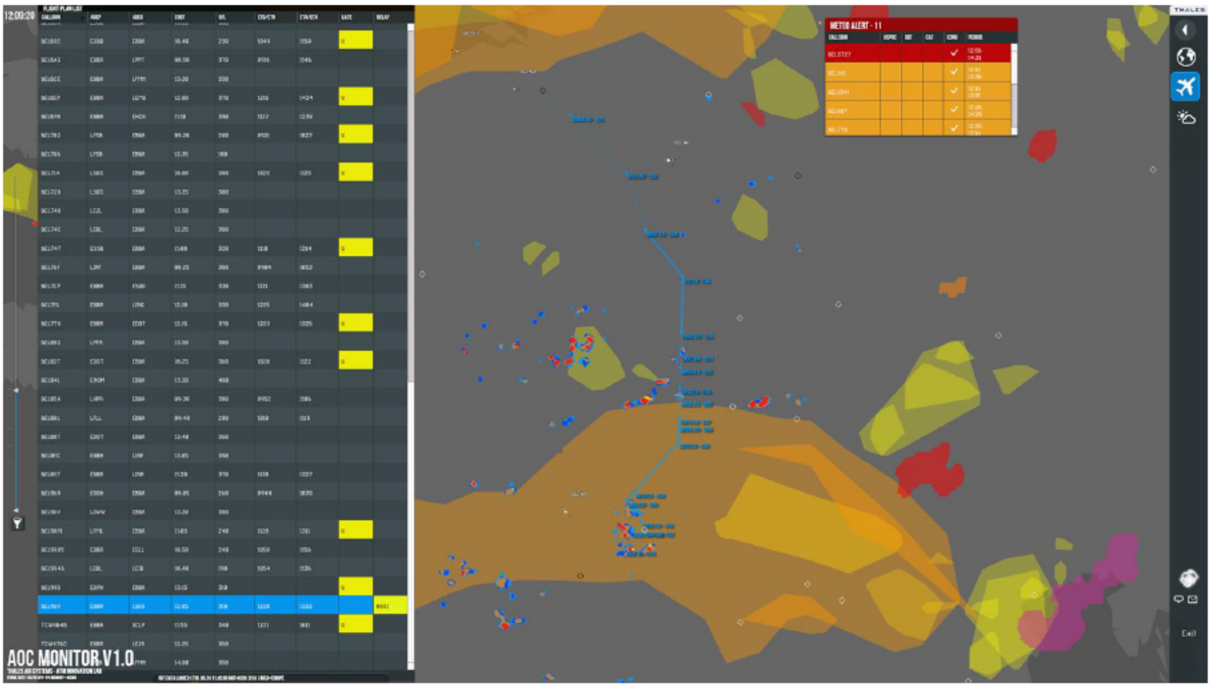
• Decision was not based on Topmet or OAC tool

• S02 Holding Pattern was not performed

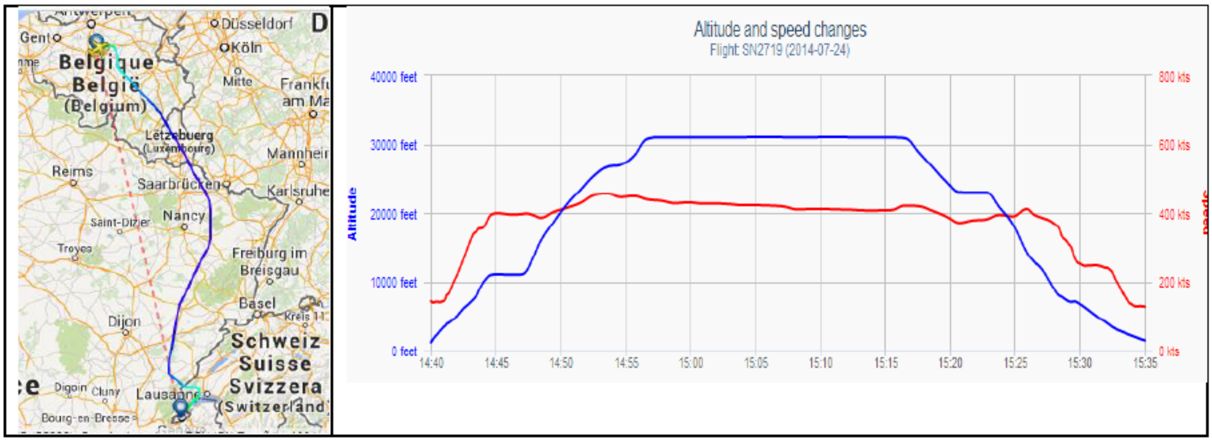
• The "Operational Decision Possibilities D03b an D04b" seem not the best ones to me

• WX picture at moment at 100NM to GVA would certainly help, CB's an TS can move and grow fast"

5.2.2.2.3.3 TopMet AOC screen shot



5.2.2.2.3.4 Trajectory SN2719 screenshot.



5.2.2.2.4 Flight BEL14Z/SN3714 – 29/07/2014

5.2.2.2.4.1 General information

Flight ID	EOBD	EOBT	ETA
BEL14Z / SN3714	2907	1300	1340

LEBB – EBBR (BIO-BRU)

```
ATC PLAN
N0409F300 SSN UL176 CNA/N0396F320 UN858 VANAD UN874 BAMES UT191
PODEM UN873 VEKIN/N0361F240 UZ173 ARVOL/N0347F180
```

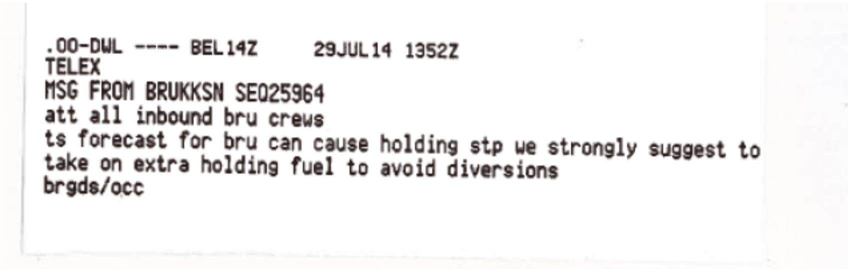
5.2.2.2.4.2 Situation description

Airline Phase when issues are identified	Met hazard Location	MET hazards type	Info support means used	Abnormal scenario
Close to EBBR	Deviation to LGG	ASPOC / CB'S	TOPMET AOC	Holding S2

Message from BEL OCC:

"I have just learned that an AVRO BEL14Z (BIO-BRU) has diverted to EBLG (Liège).

The OCC send an ACARS message to the flight crew showing that the situation was already doubtfull:



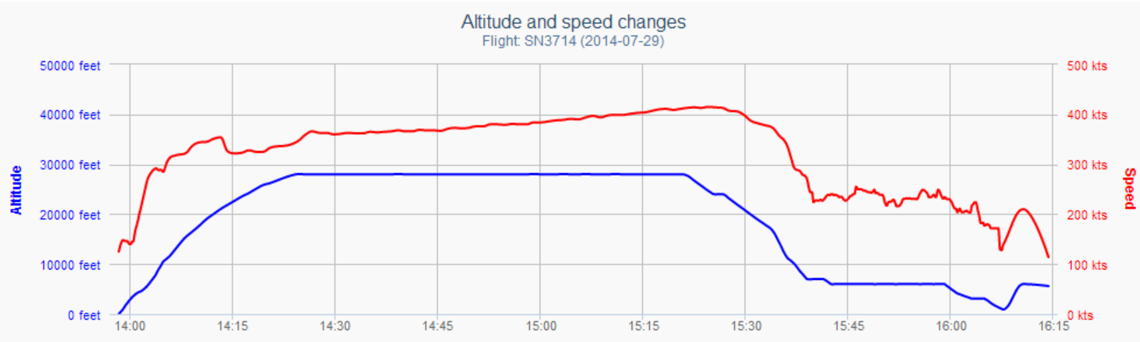
```
.OO-DWL ---- BEL14Z      29JUL14 1352Z
TELEX
MSG FROM BRUKKSN SE025964
att all inbound bru crews
ts forecast for bru can cause holding stp we strongly suggest to
take on extra holding fuel to avoid diversions
brgds/occ
```

The MET situation around Brussels airport was tough, a lot of thunderstorms around the airport area, as show in the picture below (at 14h00Z):

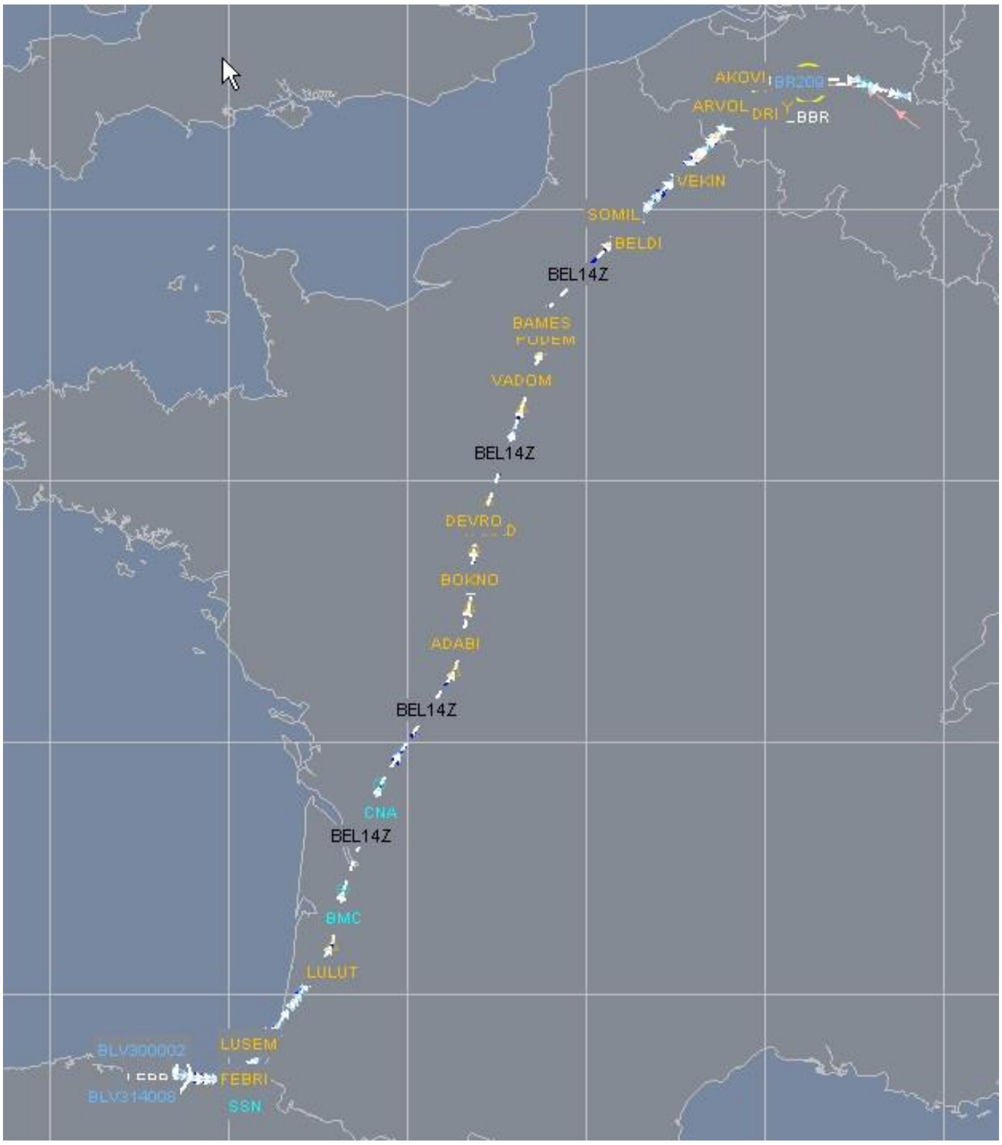
5.2.2.2.4.3 Trajectory screenshot.

The flight path shows that the flight avoid Brussels, go into some holding patterns around Liège, and than land on LGG.

The vertical profile shows also the changes and almost 45 minutes of holding and diversion to LGG.



5.2.2.2.4.4 Screenshots –Network Manager Profile (Eurocontrol data)



5.2.2.2.5 Flight BEL99D / SN2064 – 29/07/2014

5.2.2.2.5.1 General information

Flight ID	EOBD	EOBT	ETA
BEL99D / SN2064	2907	1300	1440

EGPH – EBBR (EDI-BRU)

```
ATC PLAN
N0357F250 GOSAM P600 FENIK UN615 DCS/N0401F330 UN615 HON UL15
BIG/N0346F230 Q70 VABIK/N0340F190 Q70 KOK
```

5.2.2.2.5.2 Situation description

Airline Phase when issues are identified	Met hazard Location	MET hazards type	Info support means used	Abnormal scenario
Close to EBBR	Holding around BRU + long vectoring	ASPOC / CB'S	TOPMET AOC	Holding S2

Message from BEL OCC:

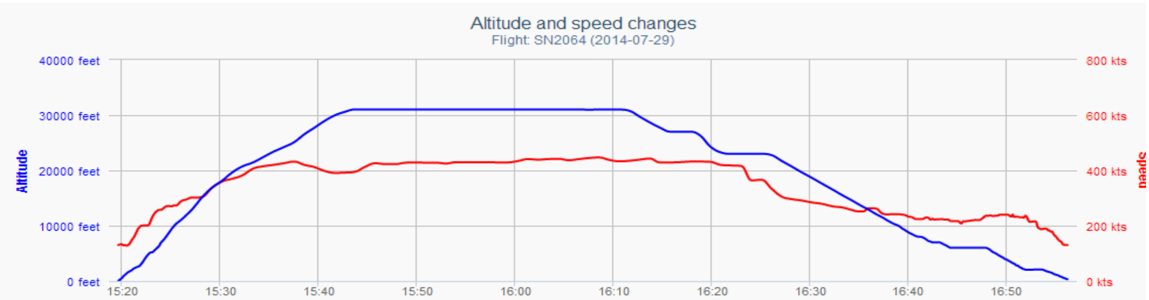
"One holding near AFI (West of EBBR) + long vectoring for the approach".

The MET situation around Brussels airport was tough, a lot of thunderstorms around the airport area, as show in the picture below (at 14h00Z):

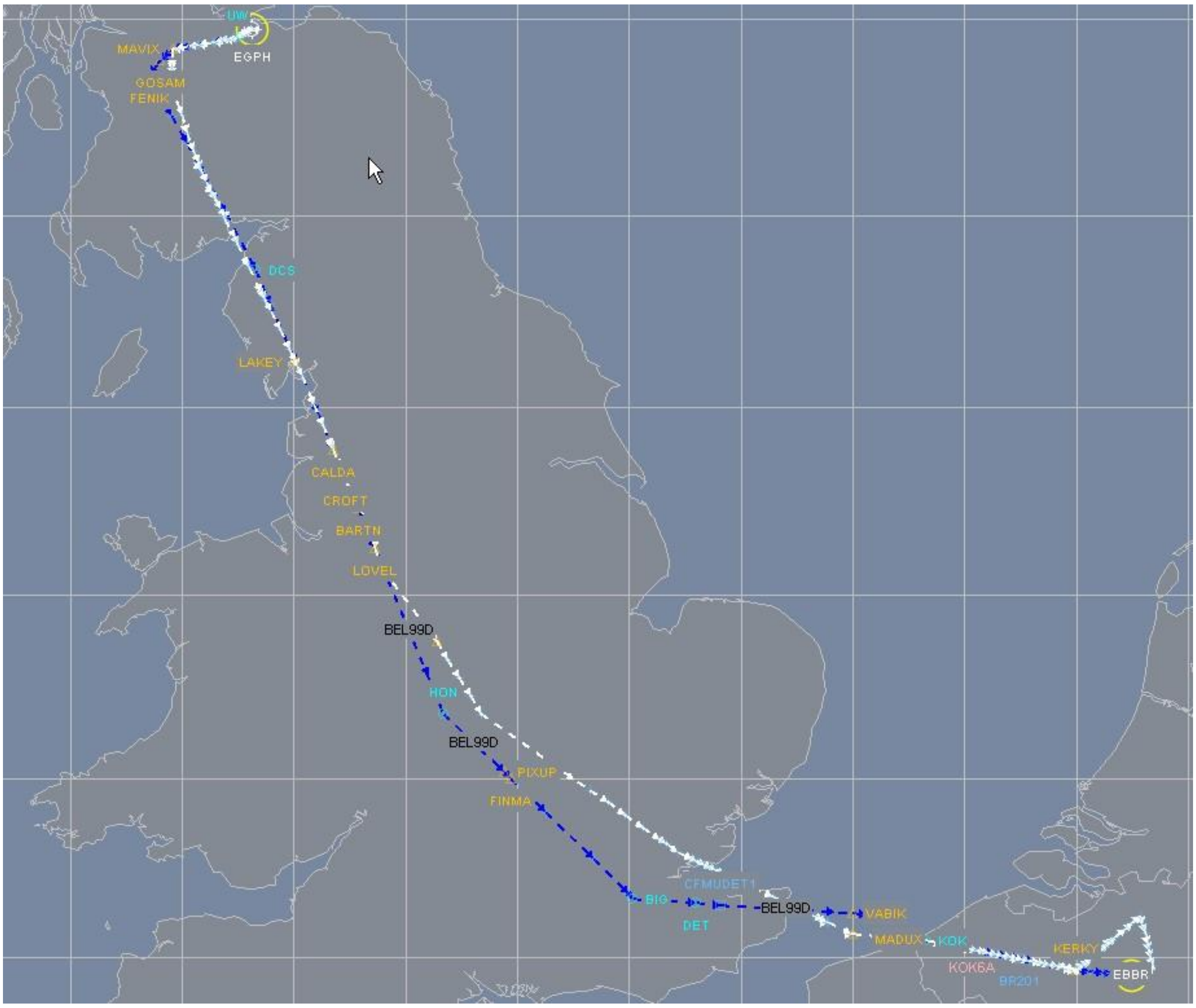
5.2.2.2.5.3 Trajectory screenshot.

	The flight path shows that the flight enter on holding just before BRU, and than a long vectoring trajectory to retrieve the STAR.

The vertical profile shows also the changes and the long way tromp Top of Descent to the airport (almost one hour).



5.2.2.2.5.4 Screenshots –Network Manager Profile (Eurocontrol data)



5.2.2.3 Deviation from the planned activities

See section 3.3.1.

5.2.3 Exercise Results

5.2.3.1 Summary of Exercise Results

See section 4.1.2, Table 10.

5.2.3.1.1 Results per KPA

See Section 4.2, Table 12

Detailed analyses are provided below for the flights documented in section 5.2.2

5.2.3.1.1.1 Flight BEL1FS / SN3581 – 16 July 2014

This flight is recognized as an occurrence of **MET-impact scenario S03**: (Avoid) Extra track miles due to MET phenomenon.

Basic data

Aircraft registration	OODWC
Departure IATA	BRU
Planned Destination IATA	FSC

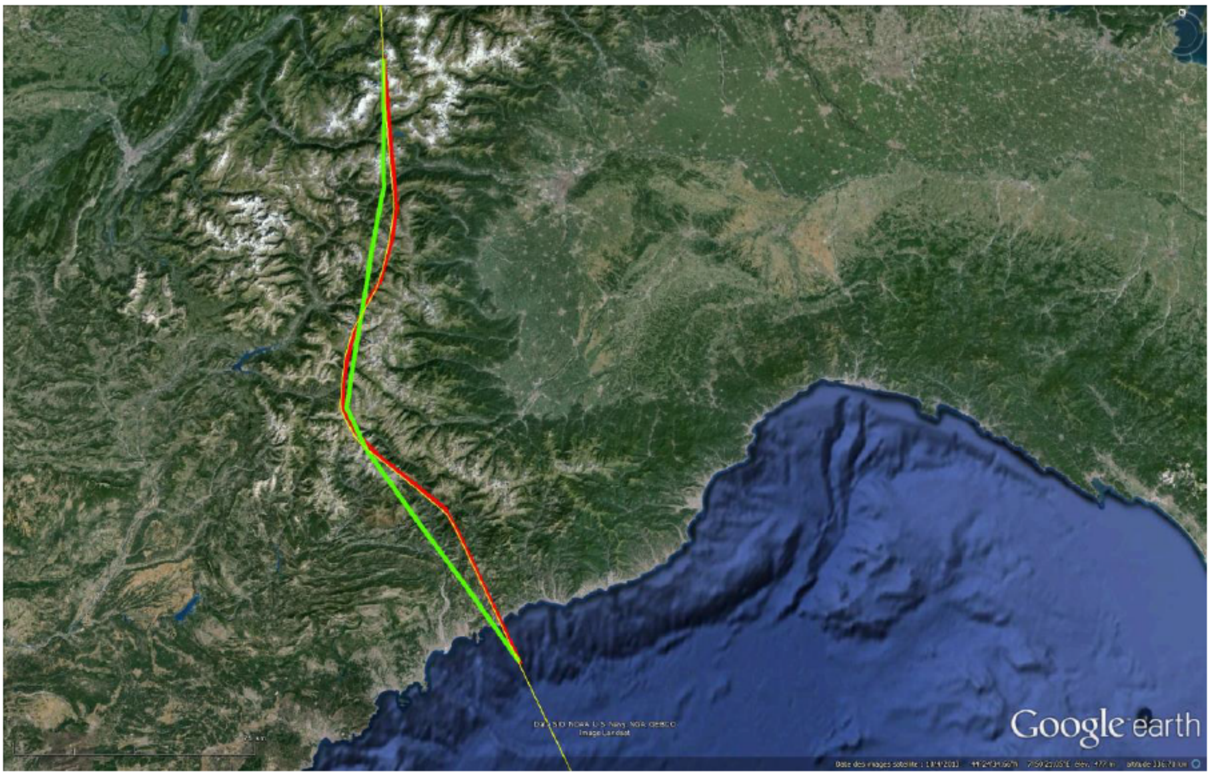
Assessment of the actual flight:

Source	Item	Value	Units	Remark
Pilot/GPS data/Flight Data	Additional fuel burn due to extra track miles	389	(kg)	
Pilot/GPS data/Flight Data	Additional time flown due to extra track miles	2	(min)	
Extra track miles due to MET	**Actually flown**	**11**	**(NM)**	

Extra cost spent due to MET	**389,19**	**(€)**

Assessment of the optimized flight:

The red track is the actual one, the green track shows that by anticipating the TS area avoidance (Decision D03 a or b) the pilot could add only 8 miles to his reference track instead of 11,



The outcome would be:

Source	Item	Value	Units	Remark
Pilot/GPS data/Flight Data	Additional fuel burn due to extra track miles	283	(kg)	
Pilot/GPS data/Flight Data	Additional time flown due to extra track miles	1	(min)	
Extra track miles due to MET	**Achievable if D03 had been taken**	**8**	**(NM)**	

Resulting extra cost spent due to MET	**283,04**	**(€)**

Assessment of the potential benefit:

An improved knowledge of the MET situation could lead to a more direct route of 2 extra track miles, by avoiding the CB's on the east side.

This route requires the cooperation from AOC and from ATC.

Source	Item	Value	Units	Remark
Pilot/GPS data/Flight Data	Additional fuel burn due to extra track miles	71	(kg)	
Pilot/GPS data/Flight Data	Additional time flown due to extra track miles	0	(min)	
Extra track miles due to MET	**Potential gain**	**2**	**(NM)**	

Resulting extra cost reduction	**106,17**	**(€)**

5.2.3.1.1.2 Flight BEL82C / SN3582– 16 July 2014

This flight is recognized as an occurrence of **MET-impact scenario S03**: (Avoid) Extra track miles due to MET phenomenon.

Basic data		
	Aircraft registration	OODWC
	Departure IATA	FSC
	Planned Destination IATA	BRU

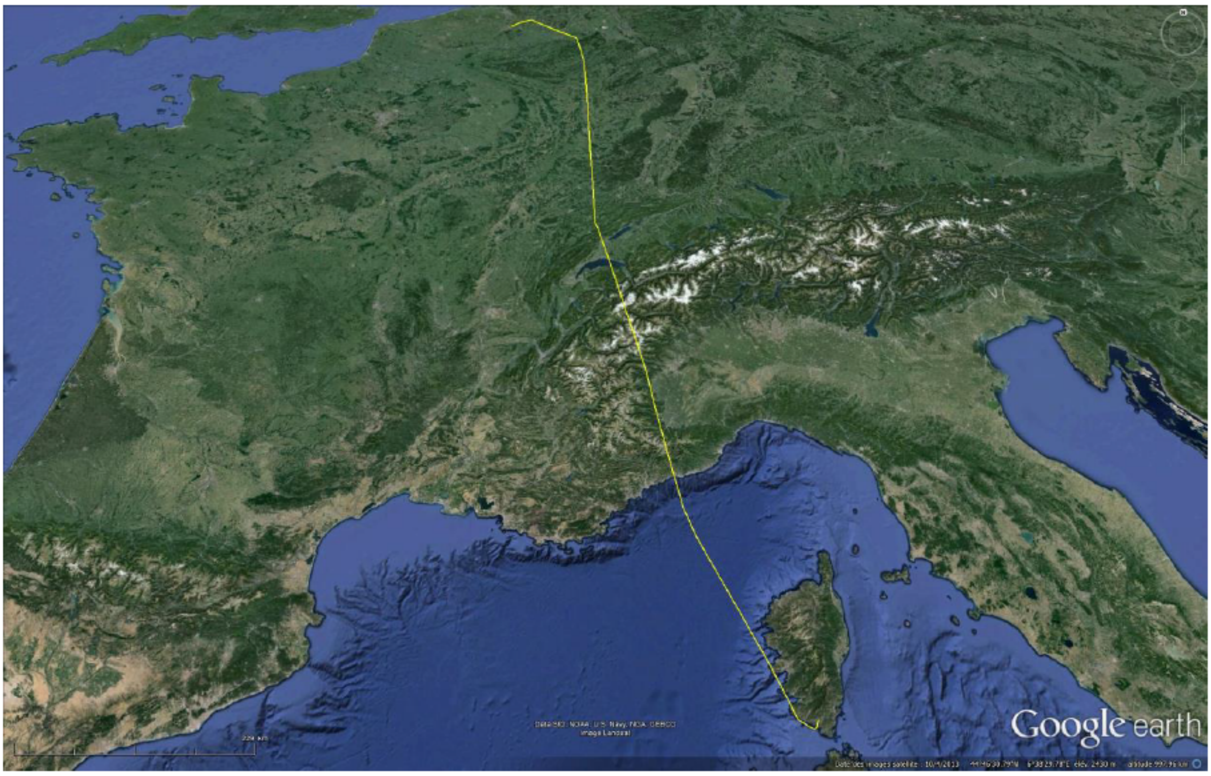
Assessment of the actual flight:

Source	Item	Value	Units	Remark
Pilot/GPS data/Flight Data	Additional fuel burn due to extra track miles	142	(kg)	
Pilot/GPS data/Flight Data	Additional time flown due to extra track miles	1	(min)	
Extra track miles due to MET	**Actually flown**	**4**	**(NM)**	

Extra cost spent due to MET	**110,78**	**(€)**

Assessment of the optimized flight:

The flight trajectory is quite direct, and at this point the avoidance is not really required, and the 4 extra track mileages could not be improved.



Assessment of the potential benefit:

None

5.2.3.1.1.3 Flight BEL9GV / SN2719 – 24 July 2014

This flight is recognized as an occurrence of **MET-impact scenario S03**: (Avoid) Extra track miles due to MET phenomenon.

Basic data

Aircraft registration	OOSSB
Departure IATA	BRU
Planned Destination IATA	GVA

Assessment of the actual flight:

Source	Item	Value	Units	Remark
Pilot/GPS data/Flight Data	Additional fuel burn due to extra track miles	395	(kg)	
Pilot/GPS data/Flight Data	Additional time flown due to extra track miles	1	(min)	
Extra track miles due to MET	**Actually flown**	**10**	**(NM)**	

Extra cost spent due to MET	**317,23**	**(€)**

Assessment of the optimized flight:

The analysis shows that by anticipating the TS area avoidance (Decision D03 a or b) the pilot could add only 8 miles to his reference track instead of 10.

Source	Item	Value	Units	Remark
Pilot/GPS data/Flight Data	Additional fuel burn due to extra track miles	316	(kg)	
Pilot/GPS data/Flight Data	Additional time flown due to extra track miles	1	(min)	
Extra track miles due to MET	**Achievable if D03 had been taken**	**8**	**(NM)**	

Resulting extra cost spent due to MET	**253,79**	(€)

Assessment of the potential benefit:

An improved perfect knowledge of the MET situation could lead to a more direct route of 2 extra track miles, by avoiding the CB's by the east.

This route requires the cooperation from AOC and somehow from ATC.

Source	Item	Value	Units	Remark
Pilot/GPS data/Flight Data	Additional fuel burn due to extra track miles	79	(kg)	
Pilot/GPS data/Flight Data	Additional time flown due to extra track miles	1	(min)	
Extra track miles due to MET	**Potential gain**	**2**	**(NM)**	

Resulting extra cost reduction	**63,44**	**(€)**

5.2.3.1.1.4 Flight BEL14Z/SN3714 – 29/07/2014

This flight is recognized as an occurrence of **MET-impact scenario S01**: (Avoid) Diversion due to MET phenomenon.

Basic data

Aircraft registration	OODWL
Departure IATA	BIO
Planned Destination IATA	BRU

Assessment of the actual flight:

Source	Item	Value	Units	Remark
Blue One	Alternate used IATA	LGG		
Blue One	Real fuel burn to alternate	1100	(kg)	
Blue One	Real flight time to alternate	20	(min)	
OFP	Planned fuel burn to destination	2100	(kg)	
OFP	Planned flight time to destination	20	(min)	
Ground Ops	Handling cost ALT	600	(€)	

OFP ALT-> Destination	Fuel burn alternate to original destination	1500	(kg)
OFP ALT-> Destination	Flight time alternate to original destination	32	(min)
OFP ALT-> Destination	Overfly charges	750	(€)

Extra cost spent due to MET	**3548,75**	**(€)**

Note that the cost of the diversion is an underestimated value, which does not take into account the over cost due to passengers transfer from LGG to BRU.

Assessment of the optimized flight:

The analysis shows that anticipating the MET situation at BRU could have allowed to make the decision D01 (with a 30 mn delayed take-off), potentially reinforced by D02 (slow-down in flight) in order to avoid the diversion at arrival.

The conditions to ensure this would be achievable are:

- A forecast up to 2 hours at least
- The permanent connectivity on board
- A situation survey at some important airports (alerts around BRU)

A 30 minutes delay at BIO would result in a cost **1020,00€,** and would avoid the issue of diverting the flight at arrival.

Assessment of the potential benefit:

Resulting extra cost reduction	**2528,75**	**(€)**

5.2.3.1.1.5 Flight BEL99D / SN2064 – 29/07/2014

This flight is recognized as an occurrence of **MET-impact scenario S02**: (Avoid) holding pattern due to MET phenomenon.

Basic data

Aircraft registration	OODWD
Departure IATA	EDI
Planned Destination IATA	BRU

Assessment of the actual flight:

Source	Item	Value	Units	Remark
Pilot/GPS data/Flight Data	Real fuel burn of holding	106	(kg)	

Pilot/GPS data/Flight Data	Real flight time of holding	4	(min)

Extra cost spent due to MET	**117,26**	**(€)**

Assessment of the optimized flight:

The analysis shows that anticipating the MET situation at BRU could have allowed to make the decision D02 (slow-down in flight) in order to avoid the holding pattern at arrival.

However considering the low cost induced by the holding, the alternative option does not appear worth of being implemented.

5.2.3.1.2 Results impacting regulation and standardisation initiatives

See Section 4.3.4.

5.2.3.1.3 Unexpected Behaviours/Results

See Section 4.4.1.

5.2.3.1.4 Quality of Demonstration Results

See Section 4.5.1.

5.2.3.1.5 Significance of Demonstration Results

See Section 4.5.2.

5.2.4 Conclusions and recommendations

5.2.4.1 Conclusions

See section 8.1 of the Final Demonstration Report

5.2.4.2 Recommendations

See section 8.2 of the Final Demonstration Report

5.3 Demonstration Exercise Report EXE-0206-300

5.3.1 Exercise Scope

See section 2.1.5.

This exercise addresses the improvement of the ANSP KPIs.

5.3.2 Conduct of Demonstration exercise EXE-0206-300

5.3.2.1 Exercise Preparation

See section 3.1.

The configuration used in this exercise is depicted in figure 1, section 2.1.4 above, and focuses on the operational use of the “DSNA ground segments” (upper right part of the diagram).

5.3.2.2 Exercise execution

See section 3.2, Table 8.

The trial period represents 12 experimentation days.

The total delay due to weather regulations on the period is 14 376’ for 1512 regulated flights.

In total, 848 flights have been actually delayed, and have been further taken into account in the post analysis.

The next sections provide for each experimentation day where a MET-induced regulation has taken place, a screen shot of the MET situation based on ASPOC representation for each important event in the regulation lifecycle (creation, cancellation etc…).

5.3.2.2.1 Day 1 – 21st May 2014

A regulation is set at 14h29 on P123 sectors starting at 15h00 up to 18h00.

The regulation rate is 42 for a monitoring value at 47 for this groups sector.

The MET situation at 14h29 is represented in the screen shot below.

The regulation captured 82 flights for 49 delayed generating 659 minutes of delay.

5.3.2.2.2 Day 2 – 23rd June 2014

Four regulations are created.

	Duration	Delay	Nb of Regulated Flights	Nb of Delayed Flights	Avg Delay per Aircraft
L4 06h00/06h17	0:17	102'	17	8	12,8
X4 06h/07h40	1:40	195'	56	22	8,9
X4 09h00/11h00	0:00	47'	15	5	9,4
X4 19h20/20h40	1:20	219'	47'	17	12,9

The X4 regulation is cancelled before the T0 at 8h40. Nevertheless due to the ATFCM process, some aircraft are captured in the regulation, generating delays (47 minutes for 5 delayed aircrafts).

5.3.2.2.3 Day 3 – 28th June 2014

Three regulations are created for this day.

	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
R4 16h00/17h15	1:15	464'	52	24	19,3
R3 16h00/17h15	1:15	288'	51	20	14,4
X4 16h31/19h00	2:29	1 199'	89'	57	21,0

The regulation on X4 is changed:

Update Type	Time	New regulation rate
Creation	16h07	35
Update	17h15	39
Update	18h54	43
Cancel	19h09	

5.3.2.2.4 Day 4 - 1st July 2014

One regulation is created for this day.

	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
ZX4 14h30/15h06	0:36	907'	78	56	16,2

The regulation on ZX4 is changed:

Update Type	Time	New regulation rate
Creation	12h27	55
Update	13h24	59
Cancel	15h06	43

5.3.2.2.5 Day 5 – 3rd July 2014

Three regulations are created for this day.

	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
ZX1 15h00/16h05	1:05	190'	48	16	11,9
X4 15h40/16h44	1:04	267'	83	26	10,3
X4 19h00/21h20	0:00	171'	40	17	10,1

5.3.2.2.6 Day 6 – 7th July 2014

One regulation is created for this day.

	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
X4 06h00 / 08:00	0:10	92	36	11	8.4

The X4 regulation beginning at 06h00 is created by FMP with a regulation rate of 43. It is cancelled at 06h10, 10 minutes after regulation T0.

5.3.2.2.7 Day 7 – 19th July 2014

One regulation is created for this day.

	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
R4 08h20 / 15:00	1:50	524'	47	29	18,1

The R4 regulation beginning at 8h20 is created by FMP at 05:02 in the morning with a regulation rate of 40.

The regulation on R4 is changed:

Update Type	Time	New regulation rate
Creation	05:02	40
Update	07:20	44
Cancel	10h10	

The regulation captured 47 flights, delayed 40 of them, for a total of 524 minutes of delay.

5.3.2.2.8 Day 8 – 20th July 2014

One regulation is created for this day.

	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
P3 15h50/18h00	2:10	843	66	48	17,6

The P3 regulation beginning at 15h50 is created by FMP at 13h50 with a regulation rate of 50.

The regulation is unchanged.

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5.3.2.2.9 Day 9 – 25th July 2014

Four regulations are created for this day.

	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
RL1 12h40/16h20	3:40	466'	74	24	19,4
RL2 12h40/16h40	4:00	1050'	59	44	23,9
RL3 12h40/17h15	4:35	619'	61	32	19,3
RL4 12h40/19h20	6:40	1933'	177	121	16,0

The regulation on RL1 is changed:

Update Type	Time	New regulation rate
Creation	12:27	39
Update – End Time + 1 hour	13:53	39
Cancel	16:05	

The regulation on RL2 is changed:

Update Type	Time	New regulation rate
Creation	12:29	41
Update – End Time + 1 hour	13:53	41

The regulation on RL3 is changed:

Update Type	Time	New regulation rate
Creation	12:29	41
Update – End Time 17:40	13:53	41
Update – End Time 19h00	16:01	43
Update – End Time 17:15	17:14	43

The regulation on RL4 is changed:

Update Type	Time	New regulation rate
Creation	12:29	48
Update – End Time 17:40	13:53	48
Update – End Time 19h00	16:01	50
Update – End Time 20h40	17:23	50
Update – End Time 19:20	19:11	

The regulations are upgraded and extended from 15:40 to 16:40 for RL1 and RL2, and from 15:40 to 17:40 for RL3 and RL4, showing a major disruption due to meteo situation.

5.3.2.2.10 Day 10 – 2nd August 2014

Two regulations are created for this day.

	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
X4 18h20/20h00	1:40	611'	51	37	16,5
NH4 16h00/19h20	2:40	1106'	53	45	24,6

Both regulations are created around 16h00.

The regulation on X4 is changed:

Update Type	Time	New regulation rate	Period
Creation	16:31	43	18:20-20h00
Update	17:48		18h20-21h40
Update	18:31	46	18h20-21h00
Cancel	19:18		

The regulation on NH4 is changed:

Update Type	Time	New regulation rate	Period
Creation	15h46	49	16h00-19h00
Update	16:34	51	16h00-20h00
Update	16:58	53	18h20-21h00
Update	17:11		18h20-18h40

5.3.2.2.11 Day 11 – 3rd August 2014

Two regulations are created for this day.

	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
R4 10h20/12h00	0:00	275'	29	14	19,6
X4 8h40/12h40	0:40	311'	57	25	12,4

The regulation over X4 is created at 4h55 and cancelled at 9h20 for 40 minutes of effective regulation period from 8h40 to 9h20.

5.3.2.2.12 Day 12 – 8th August 2014

Two regulations are created.

	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
P123 16h20/16h40	0:20	215'	36	15	14,3
ZX4 18h20/21h00	1:57	1623'	108	86	18,9

The 123 regulation changed as follow:

Update Type	Time	New regulation rate	Period
Creation	14:36	51	16h00-19h00
Cancel	16h40		

The ZX4 regulation changed as follow:

Update Type	Time	New regulation rate	Period
Creation	16:07	53	18h20-21h00
Update	17h11		21h40
Update	18:35		21h00
Cancel	20h15		

5.3.2.3 Deviation from the planned activities

See section 3.3.2.

5.3.3 Exercise Results

5.3.3.1 Summary of Exercise Results

See section 4.1.3, Table 11 for the overall synthesis.

The detailed analysis of the weather regulation shows that several actions are available to reduce the regulation period, based on an improved weather monitoring and forecast:

- Avoid creating a regulation which will be cancelled before the T0 due to a wrong initial assessment of the MET evolution
- Better anticipate the need for a regulation and avoid the creation of "last minute" regulation (i.e. less than 30 mn before T0)
- Improve the forecast accuracy and better predict the start and end times of the MET disturbance on the considered sector.

The corresponding gains (G1, G2, G3 respectively) have been estimated and are summarized in the table below

Date	Sectors	Duration	Delay	G 1	G 2	G 3	Total
21-mai	P123 15h/18h	3:00	659'		66'	66'	132'
23-juin	L4 06h00/06h17	0:17	102'				0'
	X4 06h/07h40	1:40	195'			20'	20'

	X4 09h00/11h00	0:00	47'	47'			47'
	X4 19h20/20h40	1:20	219'				0'
28-juin	R4 16h00/17h15	1:15	464'				0'
	R3 16h00/17h15	1:15	288'				0'
	X4 16h31/19h00	2:29	1 199'		120'	120'	240'
01-juil	ZX414h30/15h06	0:36	907'			91'	91'
03-juil	ZX1 15h00/16h05	1:05	190'				0'
	X4 15h40/16h44	1:04	267'				0'
	X4 19h00/21h20	0:00	171'	171'			171'
07-juil	X4 06h00/08h00	0:10	92'	84'			84'
19-juil	R4 08h20/15h00	1:50	524'	204'			204'
20-juil	P3 15h50/18h00	2:10	843'				0'
25-juil	RL1 12h40/16h20	3:40	466'		47'		47'
	RL2 12h40/16h40	4:00	1050'		105'		105'
	RL3 12h40/17h15	4:35	619'		62'		62'
	RL4 12h40/19h20	6:40	1933'		193'		193'
02 août	X4 18h20/20h00	1:40	611'			61'	61'
	NH4 16h00/18h40	2:40	1106'		111'	111'	221'
03 août	R4 10h20/12h00	0:00	275'	275'			275'
	X4 08h40/12h40	0:40	311'	242'			242'
08-août	P123 16h20/16h40	0:20	215'				0'
	ZX4 18h20/21h00	1:57	1623'	406'			406'
	Total Mai-Aug	**44:23**	**14376'**	**1429'**	**703'**	**468'**	**2 600'**

The cumulated delay of 14376 mn could then be reduced by 2600 mn, i.e. an improvement ratio of approximately 18%.

Based on the same analyses as used in exercise EXE-206-200, the resulting cost of the ground delay is 488 784, 00 € for 848 delayed aircraft.

A total gain of 88 388, 10 € would be achievable, representing an average gain of 103,75 € per delayed aircraft due to weather regulation.

The section below summarizes the analyses conducted on each regulated day, to assess the achievable improved tuning of the regulations, which could be available with improved MET information.

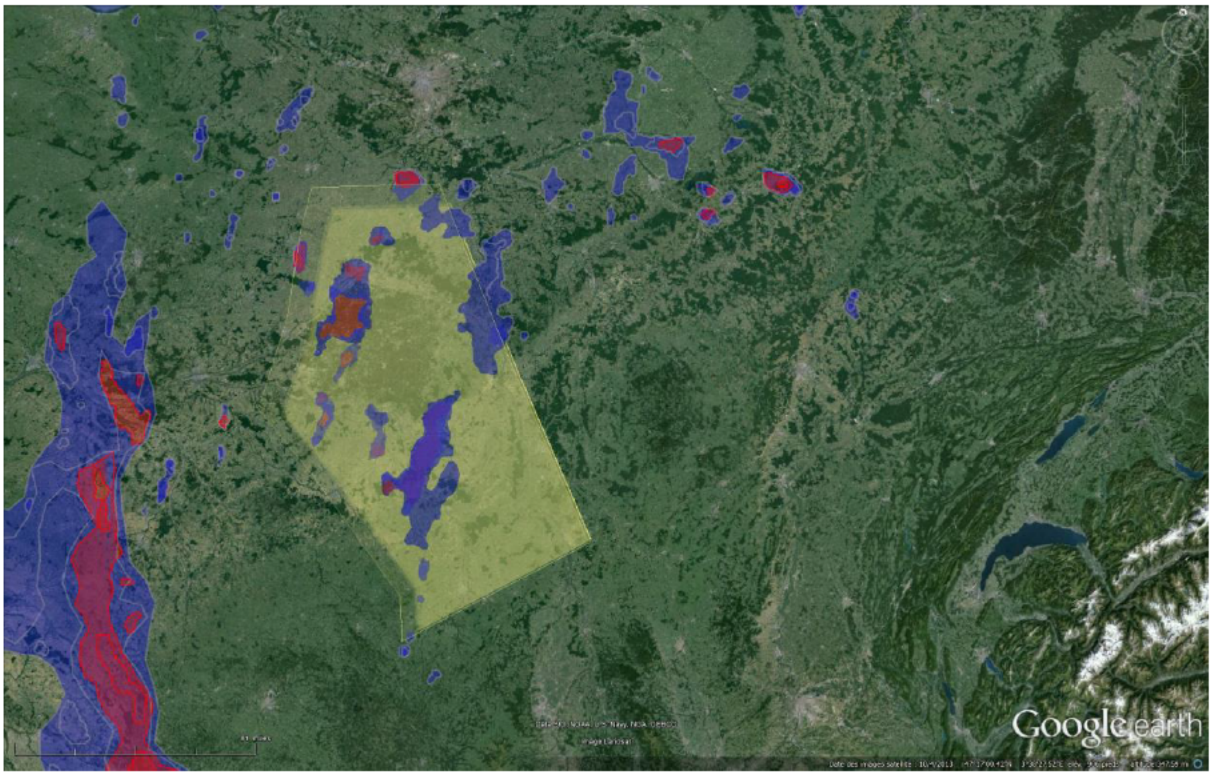
Note : the history of regulation settings is reminded, to make the interpretation of the analysis more readable.

5.3.3.1.1 Day 1 – 21st May 2014

A regulation is set at 14h29 on P123 sectors starting at 15h00 up to 18h00.

The regulation rate is 42 for a monitoring value at 47 for this groups sector.

The MET situation at 14h29 is represented in the screen shot below.

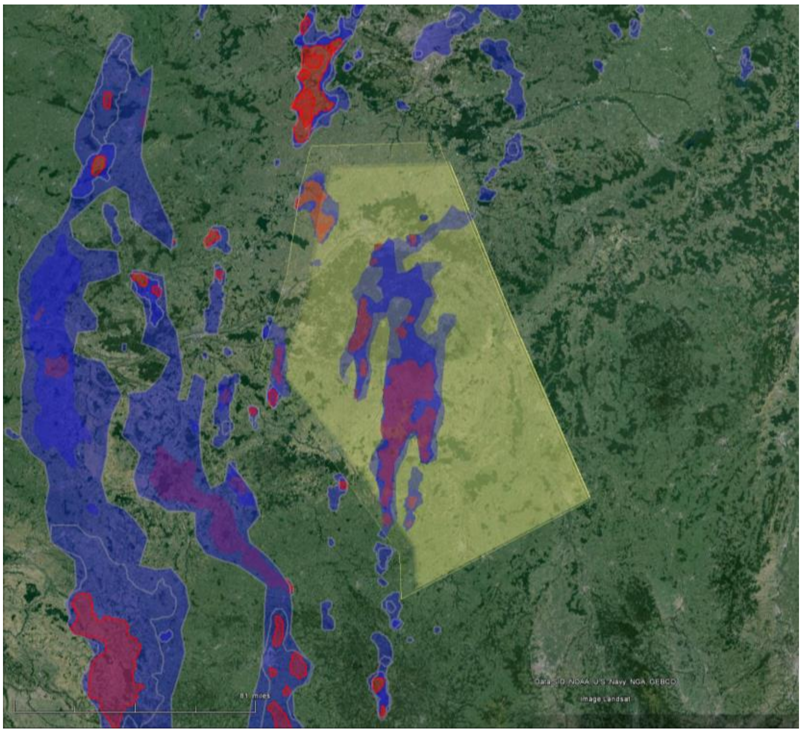


During the regulation period Bordeaux FMP has made some adjustments in the regulation rate:

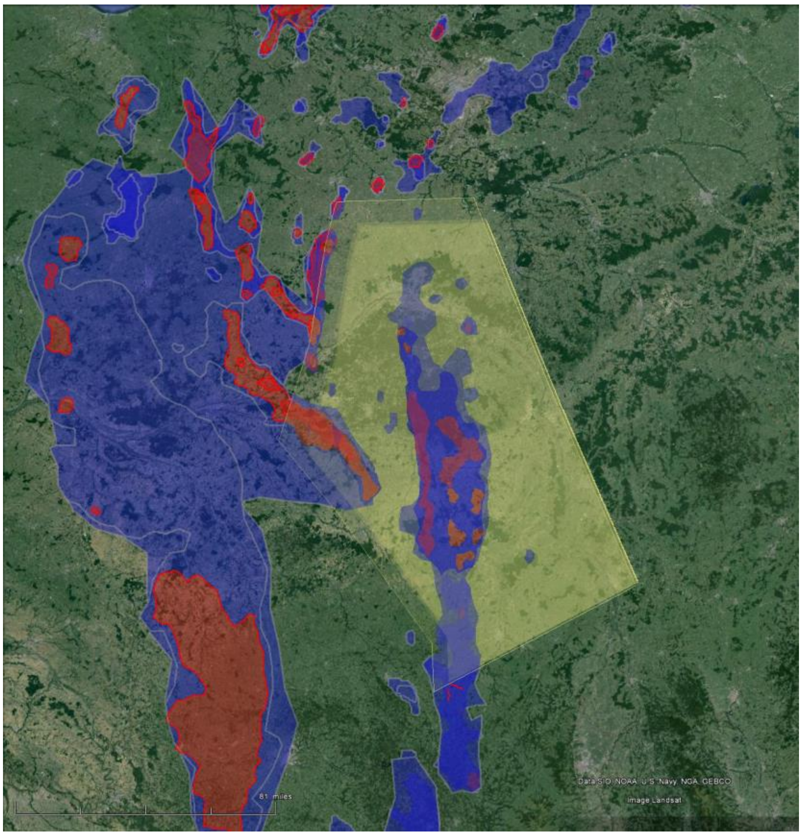
Update Type	Time	New regulation rate
Creation	14h29	42
Update	15h15	47
Update	16h40	53

The regulation captured 82 flights for 49 delayed generating 659 minutes of delay.

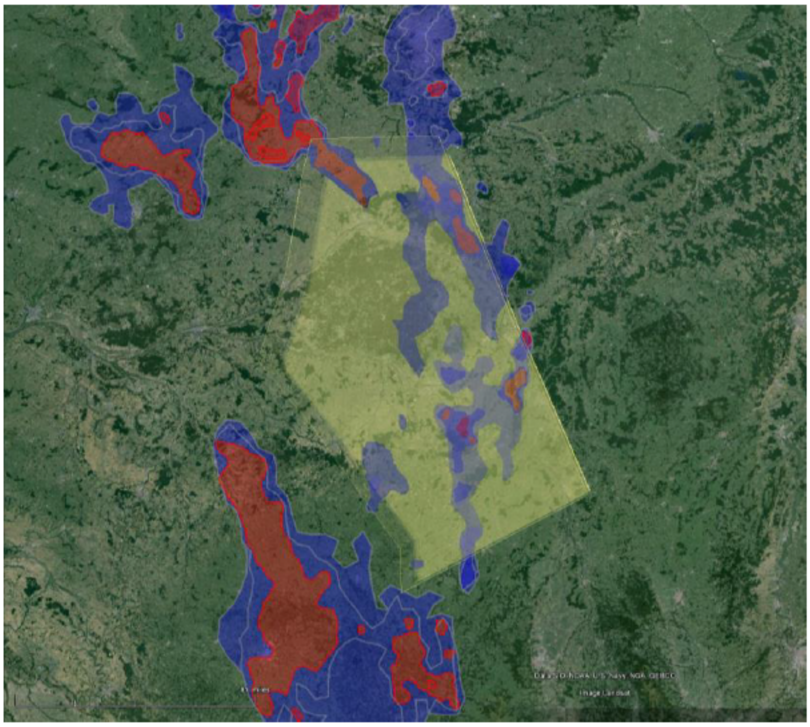
At 16h00 the situation is still complicate; the regulation is kept with a rate of 47.



Situation at 17h00



Situation at 18h00



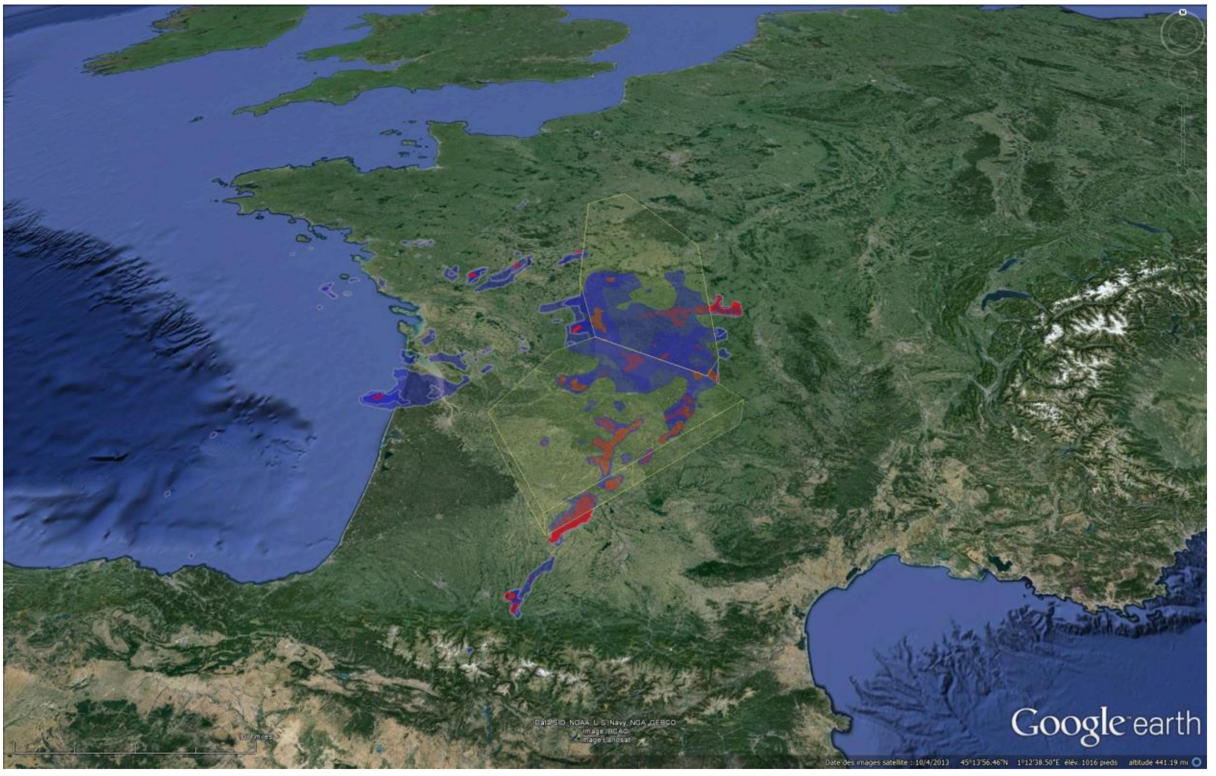
On this day, the regulation could have started one hour later, but as then situation is not improving, the rate and the end of the regulation period cannot be changed.

5.3.3.1.2 Day 2 – 23rd June 2014

Four regulations are created.

	Duration	Delay	Nb of Regulated Flights	Nb of Delayed Flights	Avg Delay per Aircraft
L4 06h00/06h17	0:17	102'	17	8	12,8
X4 06h/07h40	1:40	195'	56	22	8,9
X4 09h00/11h00	0:00	47'	15	5	9,4
X4 19h20/20h40	1:20	219'	47'	17	12,9

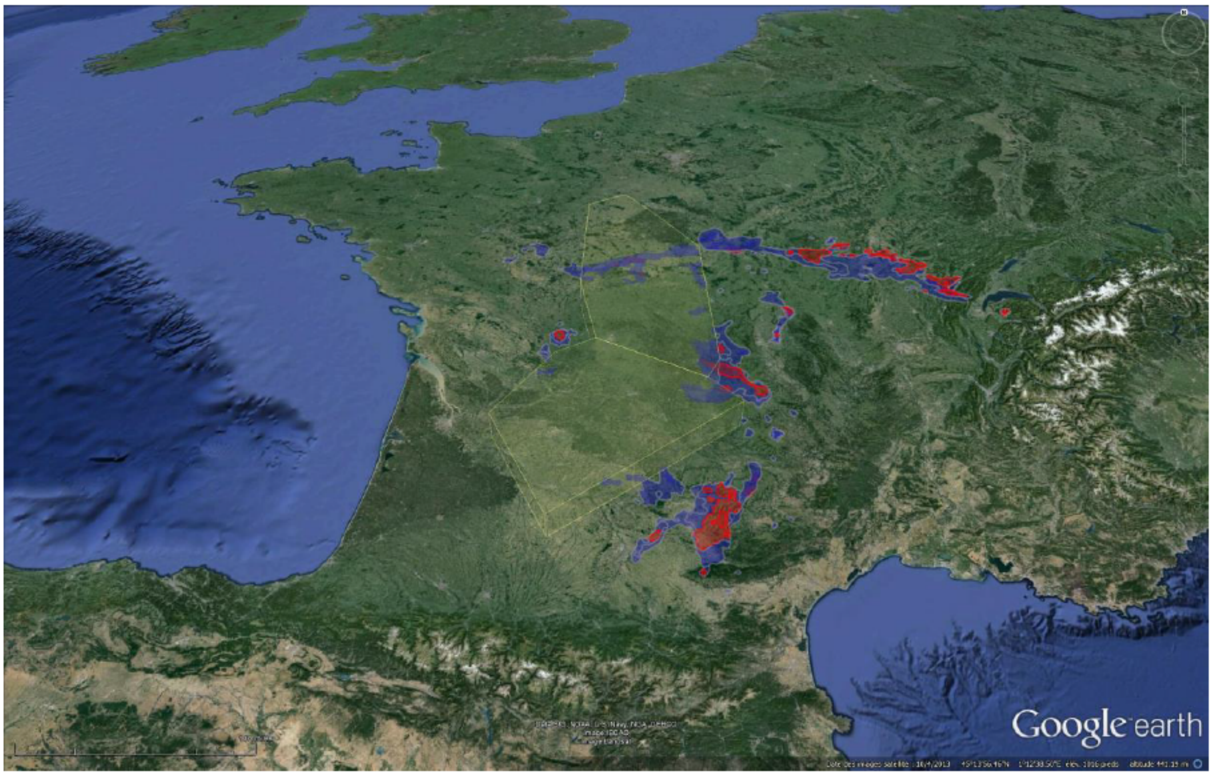
The meteo situation at 04h00 is represented in the screen shot below.



The X4 regulation is cancelled before the T0 at 8h40. Nevertheless due to the ATFCM process, some aircraft are captured in the regulation, generating delays (47 minutes for 5 delayed aircrafts).

A better forecast of the MET situation would prevent the creation of such a regulation, and 47 minutes of delay would be avoided.

The MET situation at 8h40 is shown in the screen shot below.



5.3.3.1.3 Day 3 – 28th June 2014

Three regulations are created for this day.

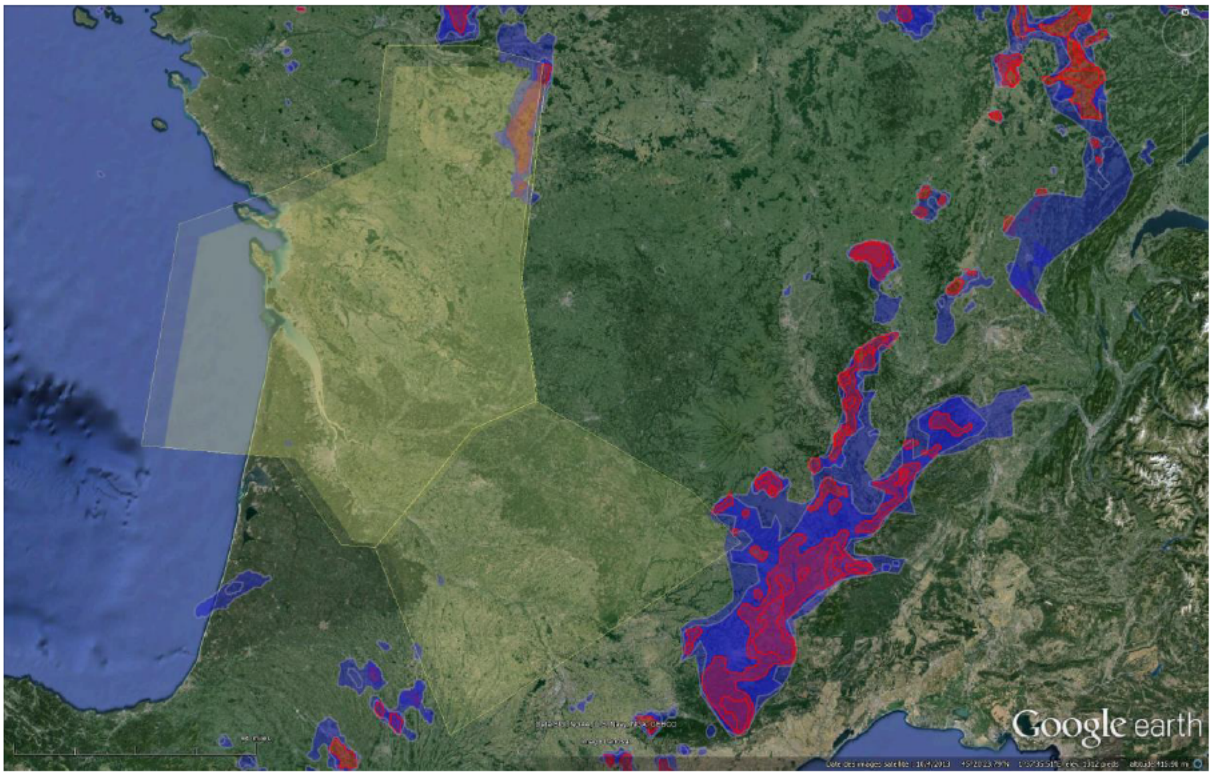
	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
R4 16h00/17h15	1:15	464'	52	24	19,3
R3 16h00/17h15	1:15	288'	51	20	14,4
X4 16h31/19h00	2:29	1 199'	89'	57	21,0

The regulation on X4 is changed:

Update Type	Time	New regulation rate
Creation	16h07	35
Update	17h15	39
Update	18h54	43
Cancel	19h09	

The meteo situation at 19h00, at the end of the regulation, shows that the ASPOC is no longer in the X4 sector. The regulation can be cancelled.

In this situation, a better forecast of the MET evolution is a key element to cancel the regulation. In this particular case, the cancel decision could have been taken 30 minutes earlier.

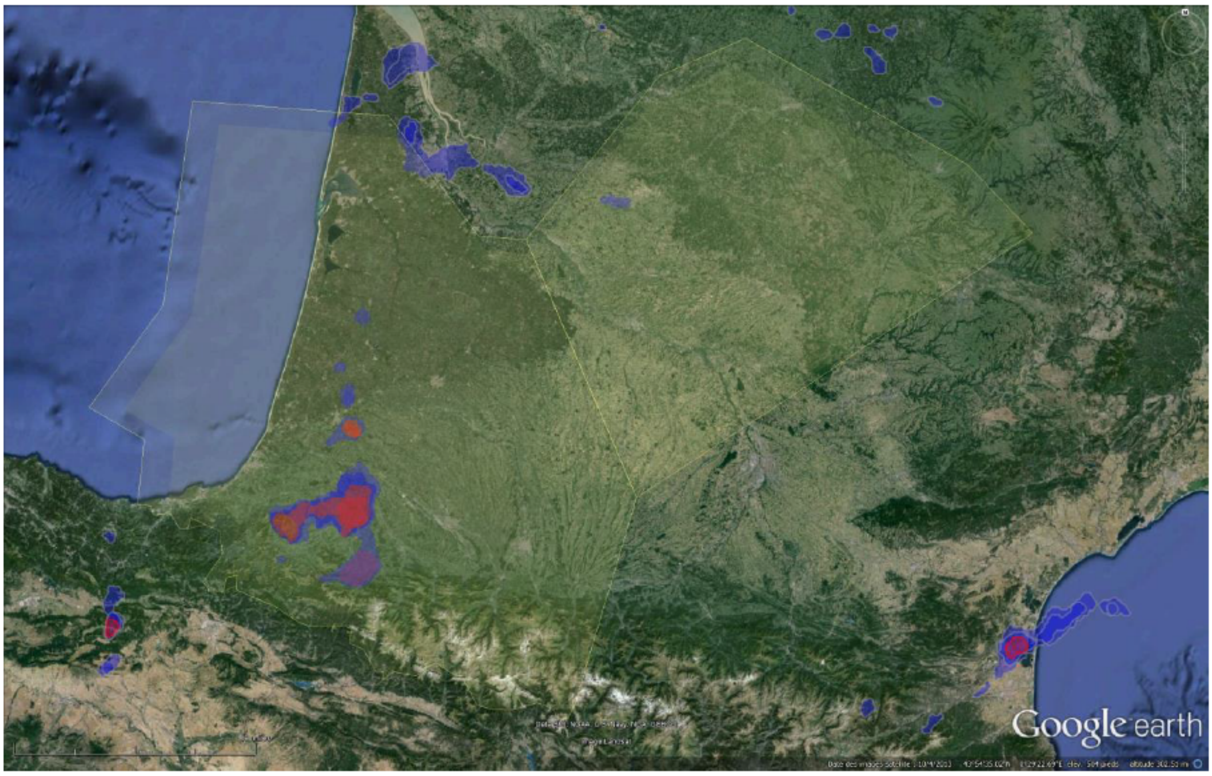


5.3.3.1.4 Day 4 - 1st July 2014

One regulation is created for this day.

	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
ZX4 14h30/15h06	0:36	907'	78	56	16,2

At the regulation creation the MET situation is:

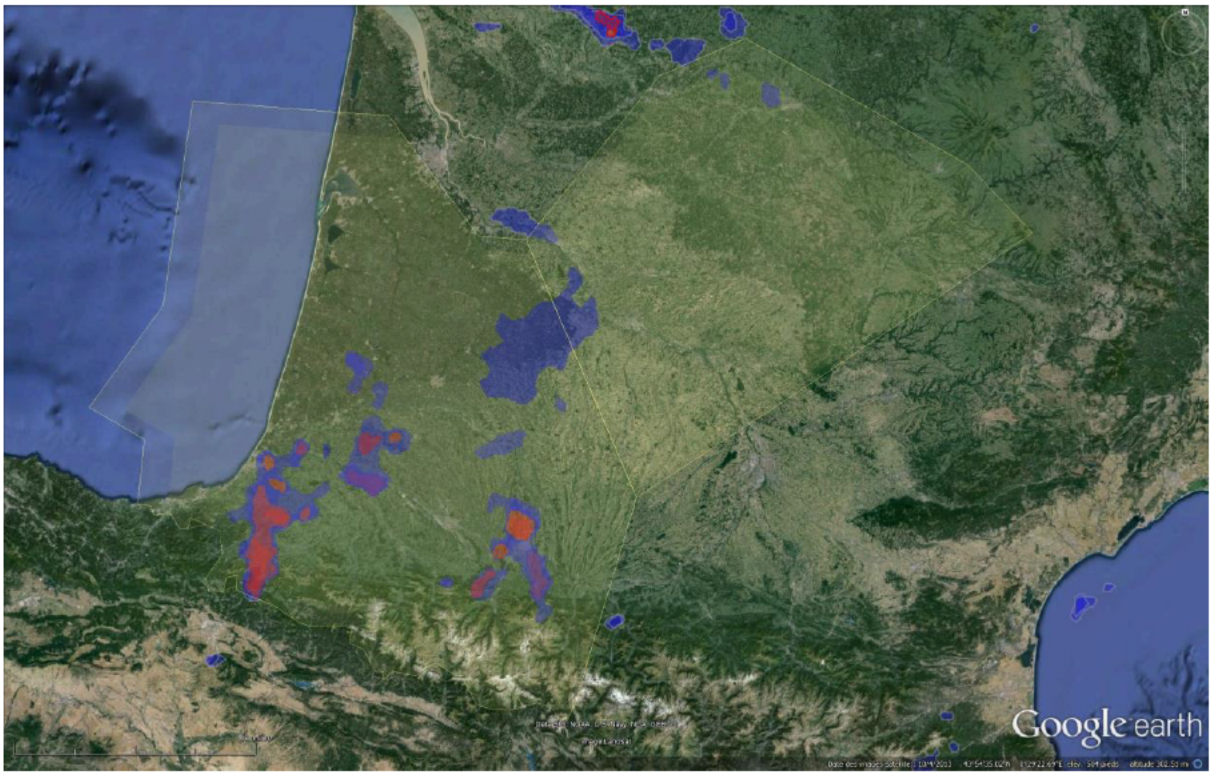


The regulation on ZX4 is changed:

Update Type	Time	New regulation rate
Creation	12h27	55
Update	13h24	59
Cancel	15h06	43

The meteo situation at 15h05 shows that the ASPOC is no longer in the ZX4 sector. The regulation can be cancelled.

In this situation, a better forecast of the MET evolution is a key element to cancel the regulation. In this particular case, the cancel decision could have been taken earlier, and may be no regulation is needed.



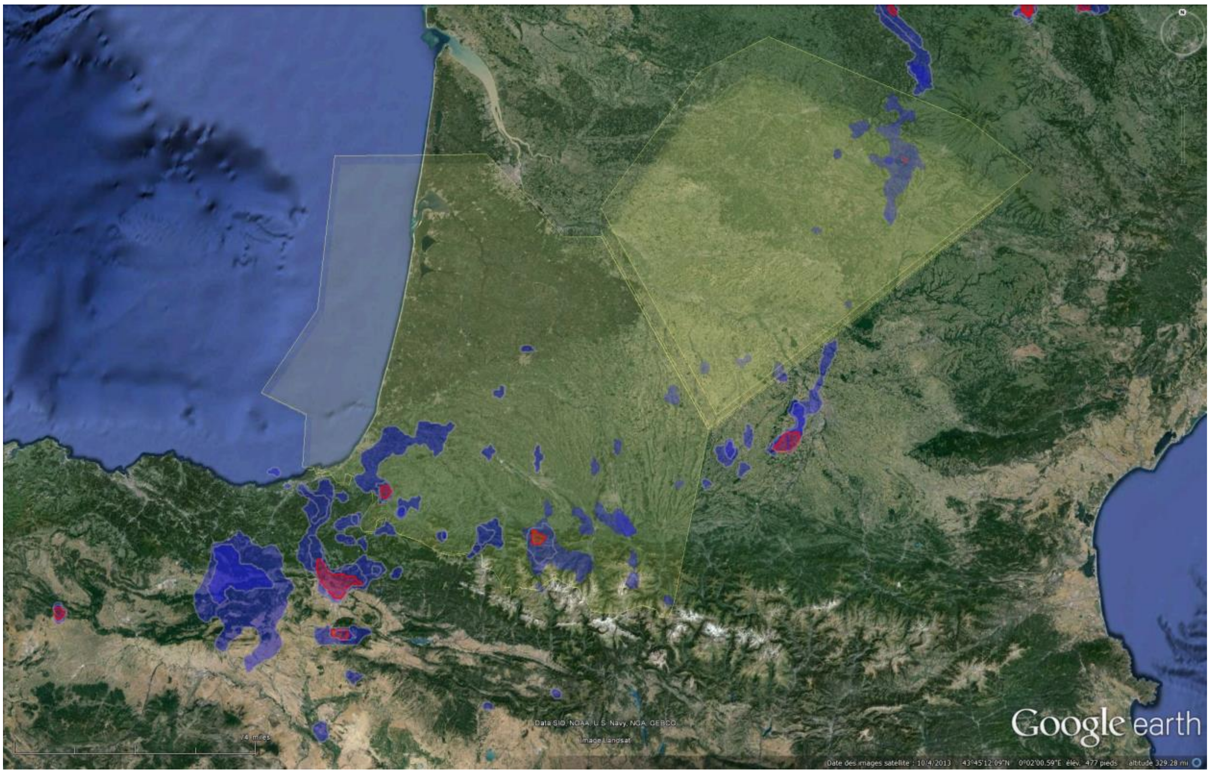
5.3.3.1.5 Day 5 – 3rd July 2014

Three regulations are created for this day.

	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
ZX1 15h00/16h05	1:05	190'	48	16	11,9
X4 15h40/16h44	1:04	267'	83	26	10,3
X4 19h00/21h20	0:00	171'	40	17	10,1

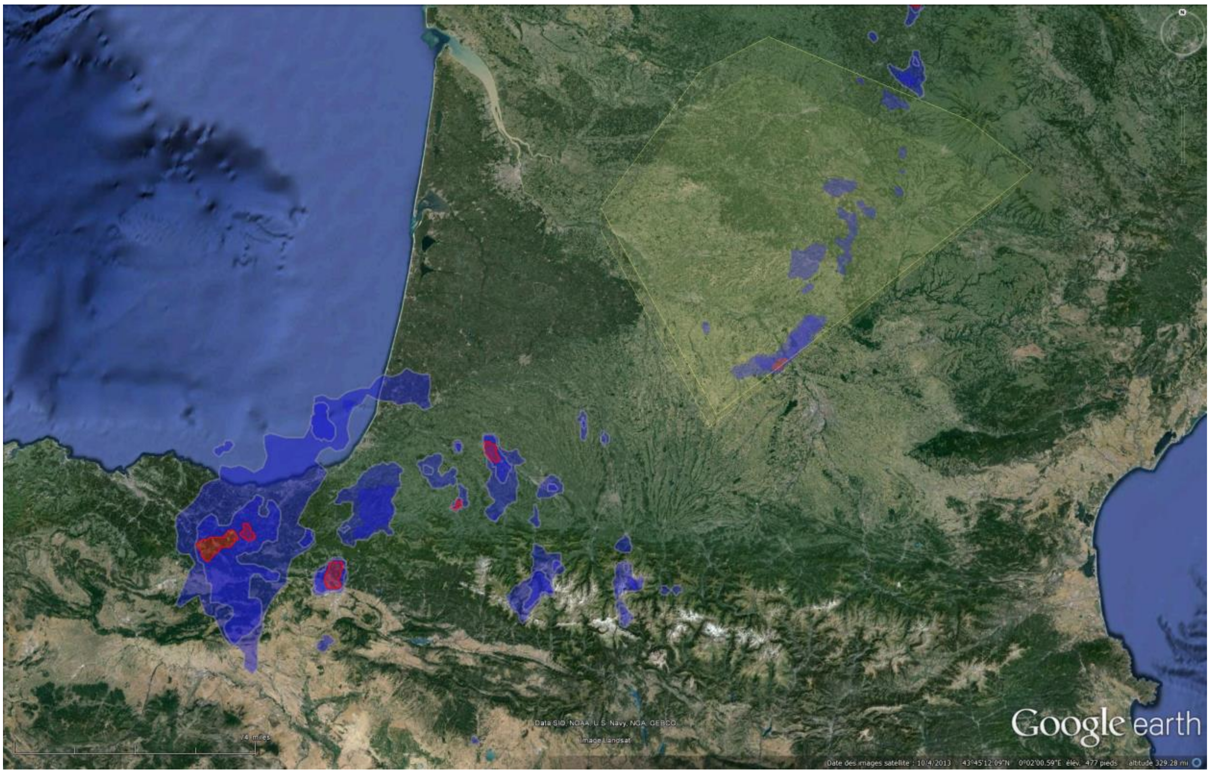
The X4 regulation beginning at 19h00 is created by FMP at 16h00 with a regulation rate of 41. It is cancelled at 18h41, 19 minutes before regulation T0.

The MET situation at 16h00 shows some ASPOC on X4 sectors



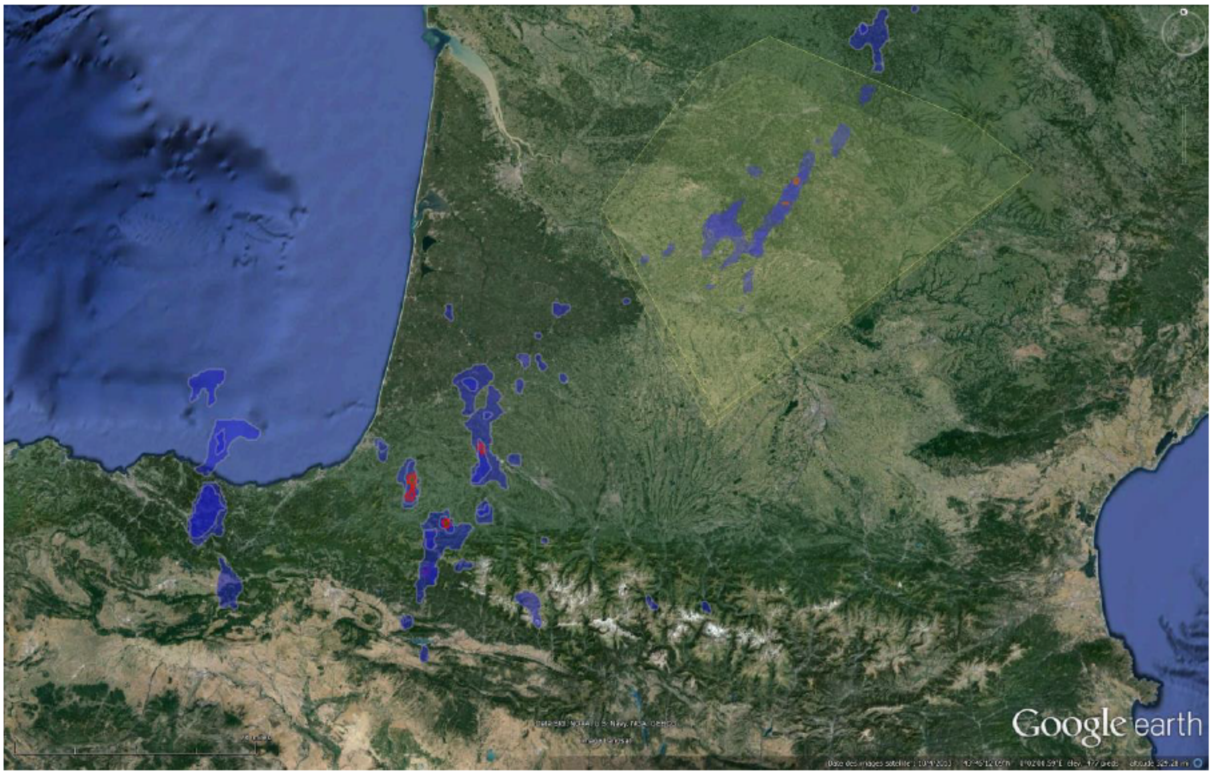
The evolution of ASPOC shows that some ASPOC remains in the X4 sector, but the activity seems not so strong as it was foreseen at the 16h00.

Below a screen shot at 16h45.



When the decision to cancel the regulation is taken, the MET situation is quiet, and the regulation could have not been created according to a better forecast of MET activity between 19h00 and 21h00.

Some CB's are present, but the level of activity is not so strong (situation at 18h40).



Even if the regulation is cancelled, it captured 40 flights and 17 flights were delayed for a total of 171 minutes.

The cancellation is too late to release these flights, and a better forecast could have helped the FMP in taking the right decision: do not create a MET regulation between 19h00 and 21h00. In this case, 171 minutes of delay are easily avoidable with a good air situation display and analysis tool.

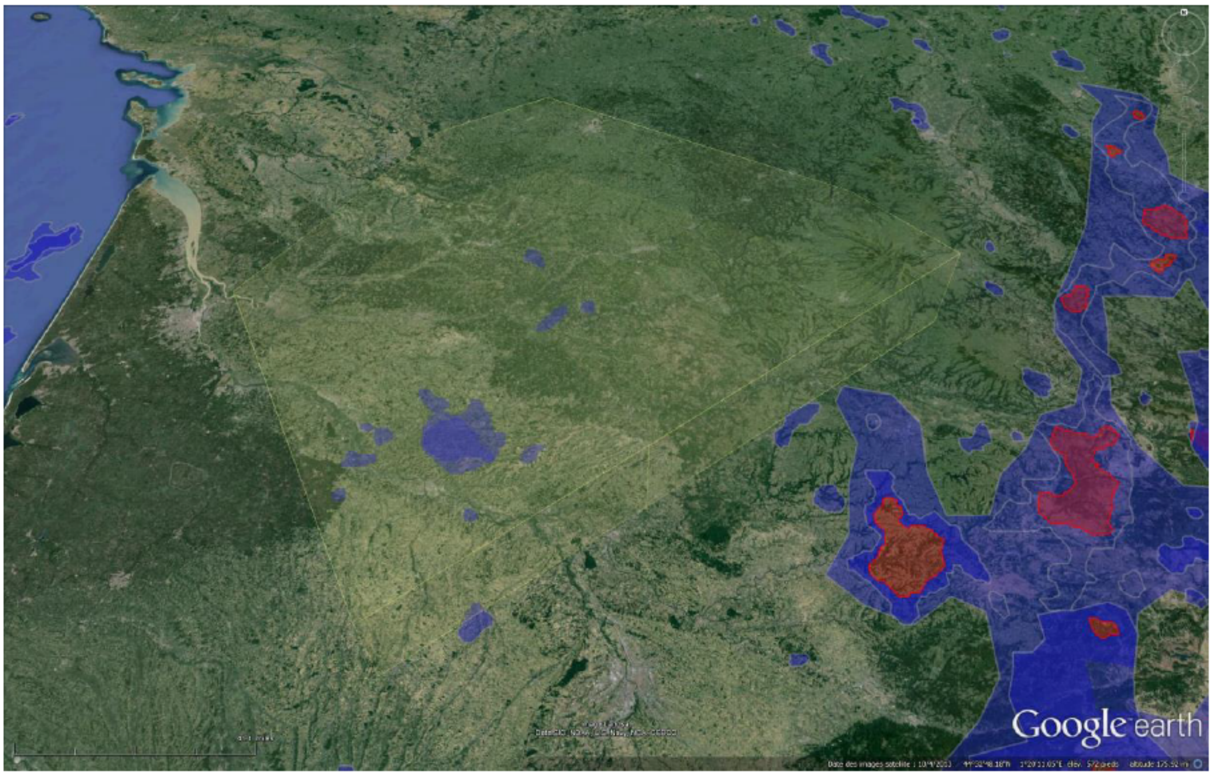
5.3.3.1.6 Day 6 – 7th July 2014

One regulation is created for this day.

	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
X4 06h00 / 08:00	0:10	92	36	11	8.4

The X4 regulation beginning at 06h00 is created by FMP with a regulation rate of 43. It is cancelled at 06h10, 10 minutes after regulation T0.

MET situation at 6h00 shows that CB's activity is not so strong, and the regulation may be cancelled. The decision is taken at 06h10.



Nevertheless, by construction, some flights are captured in this regulation, generating delay.

On this specific day 92 minutes of delay could have been avoided according to a better forecast of the MET situation.

5.3.3.1.7 Day 7 – 19th July 2014

One regulation is created for this day.

	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
R4 08h20 / 15:00	1:50	524'	47	29	18,1

The R4 regulation beginning at 8h20 is created by FMP at 05:02 in the morning with a regulation rate of 40.

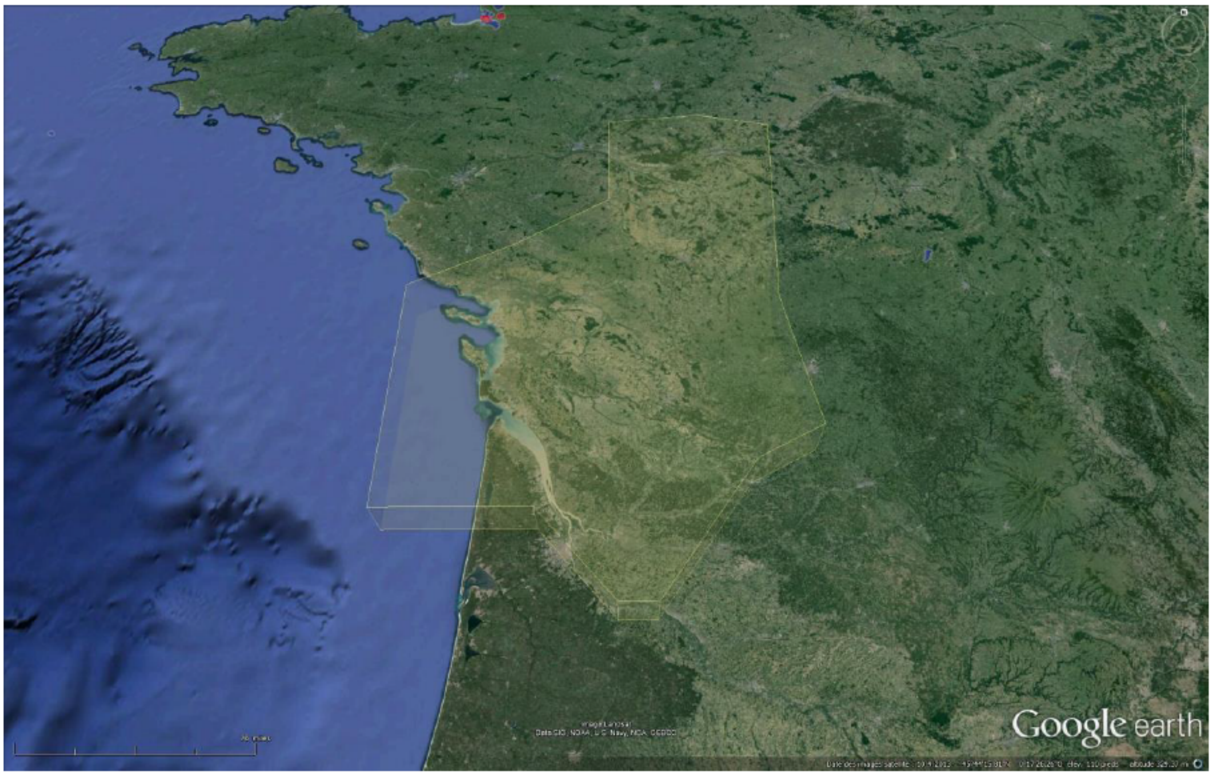
The regulation on R4 is changed:

Update Type	Time	New regulation rate
Creation	05:02	40
Update	07:20	44
Cancel	10h10	

At 6h00 the MET situation reveals some ASPOC in the R4 sectors.

MET situation at 8h00 shows that CB's activity is not so strong, and the regulation may be cancelled. The decision is taken at 10h10.

At 10h10, the MET situation is clear.



Obviously, the forecast leading to the creation of the regulation was too pessimistic, and may be, the regulation was not mandatory, unless, others issues linked with the MET forecast were also foreseen (general capacity problem, demand in excess).

The regulation captured 47 flights, delayed 40 of them, for a total of 524 minutes of delay.

According to the MET situation, a better forecast could easily lead to a gain of 204 minutes by changing the end time of the regulation.

5.3.3.1.8 Day 8 – 20th July 2014

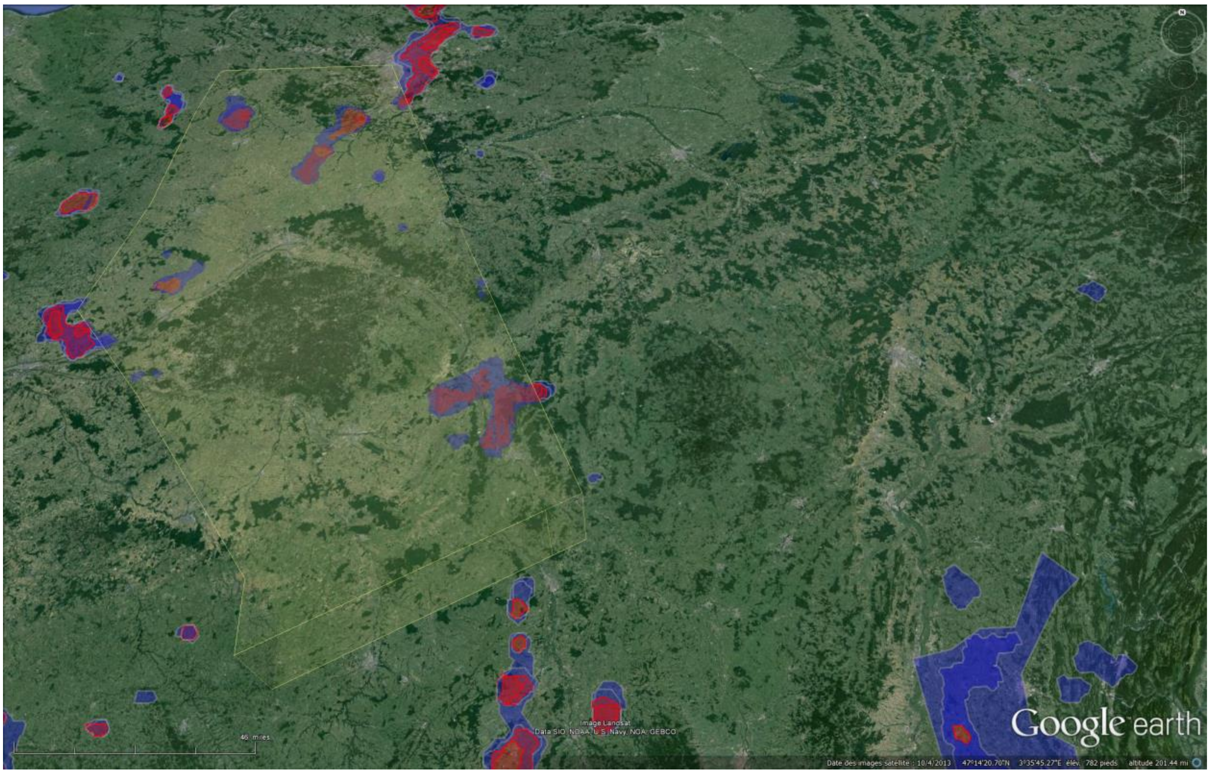
One regulation is created for this day.

	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
P3 15h50/18h00	2:10	843	66	48	17,6

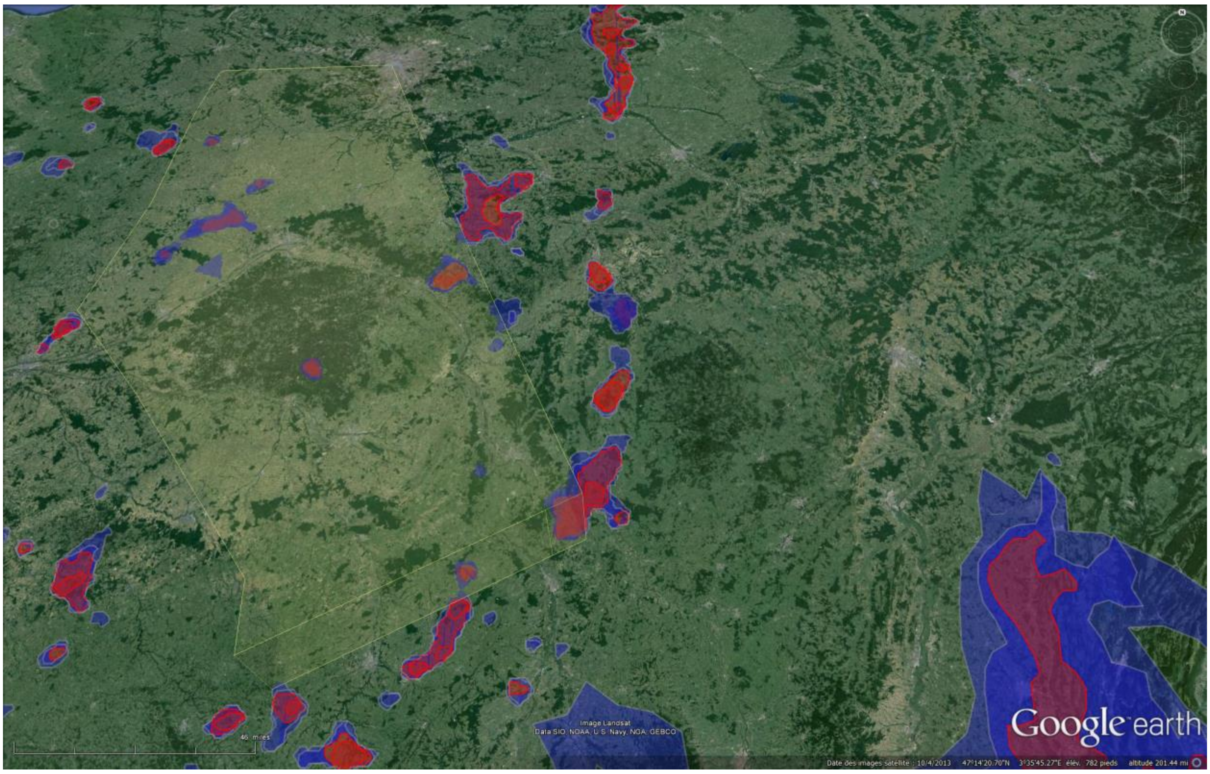
The P3 regulation beginning at 15h50 is created by FMP at 13h50 with a regulation rate of 50.

The regulation on is unchanged.

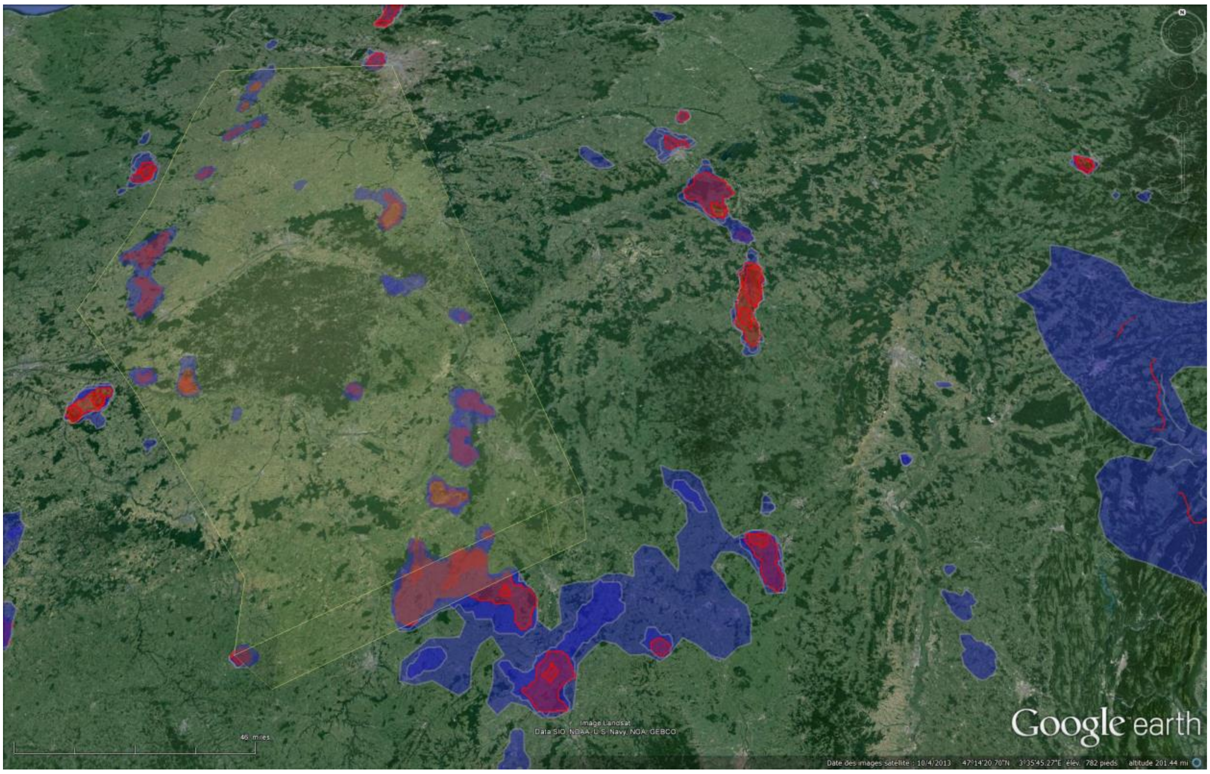
At 13h50 the MET situation reveals some ASPOC in the P3 sectors.



At 15h00 the MET situation is getting worse on the south border of the P3 sector, the regulation is maintained to protect P3, and to protect the south sectors L3/L4 and T3/T4 from north flows.



The situation is still fuzzy in the south of P3 sectors, and the regulation is maintained with the same regulation rate.



On this case, the MET situation was a real summer thunderstorm situation with its high level of uncertainty on where the CB's are going to develop.

The regulation here has a real role of gatekeeper and protects the south sectors of the LFBB area.

The rate cannot be raised, or the regulation cannot be cancelled at any time of the regulation period.

To complete the analysis, the whole day was quite a nightmare over France as shown in the screen shot (MET situation at 18h00).

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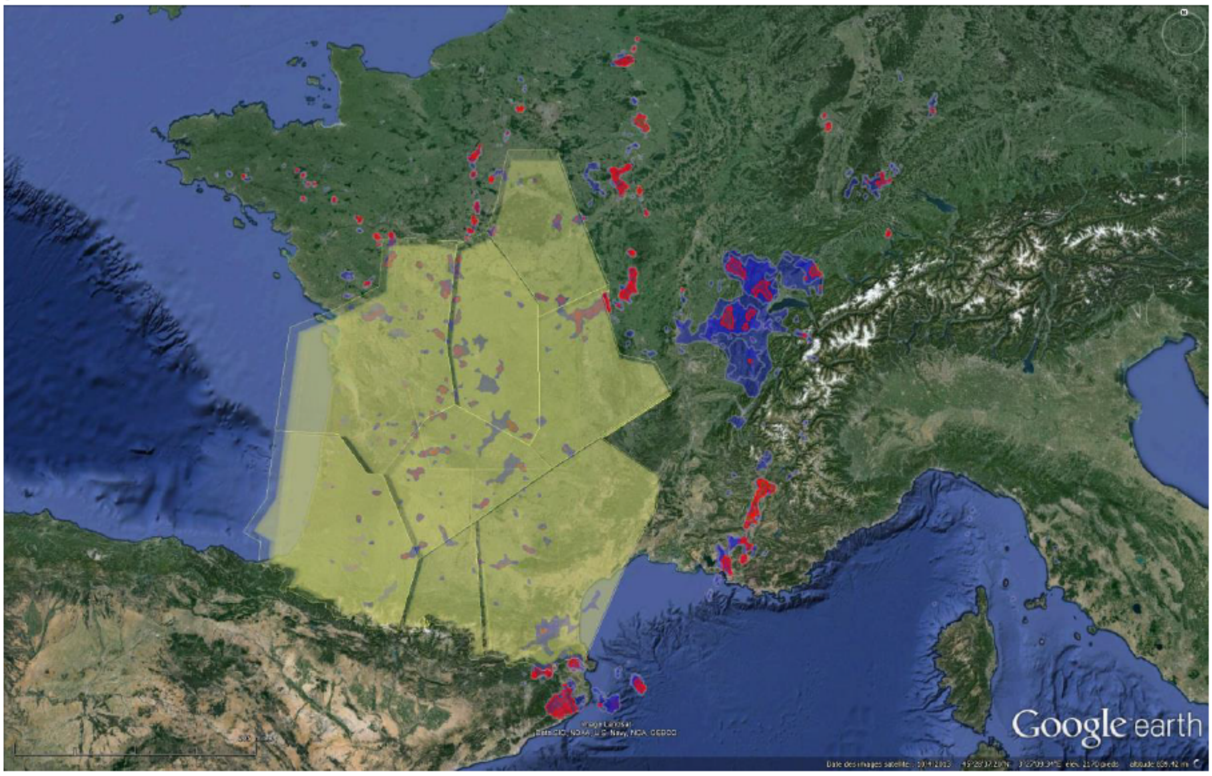


5.3.3.1.9 Day 9 – 25th July 2014

Four regulations are created for this day.

	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
RL1 12h40/16h20	3:40	466'	74	24	19,4
RL2 12h40/16h40	4:00	1050'	59	44	23,9
RL3 12h40/17h15	4:35	619'	61	32	19,3
RL4 12h40/19h20	6:40	1933'	177	121	16,0

Due to changes in the meteo data server, we don't have the meteo situation at 12h40.

The regulation on RL1 is changed:

Update Type	Time	New regulation rate
Creation	12:27	39
Update – End Time + 1 hour	13:53	39
Cancel	16:05	

The regulation on RL2 is changed:

Update Type	Time	New regulation rate
Creation	12:29	41
Update – End Time + 1 hour	13:53	41

The regulation on RL3 is changed:

Update Type	Time	New regulation rate
Creation	12:29	41
Update – End Time 17:40	13:53	41
Update – End Time 19h00	16:01	43
Update – End Time 17:15	17:14	43

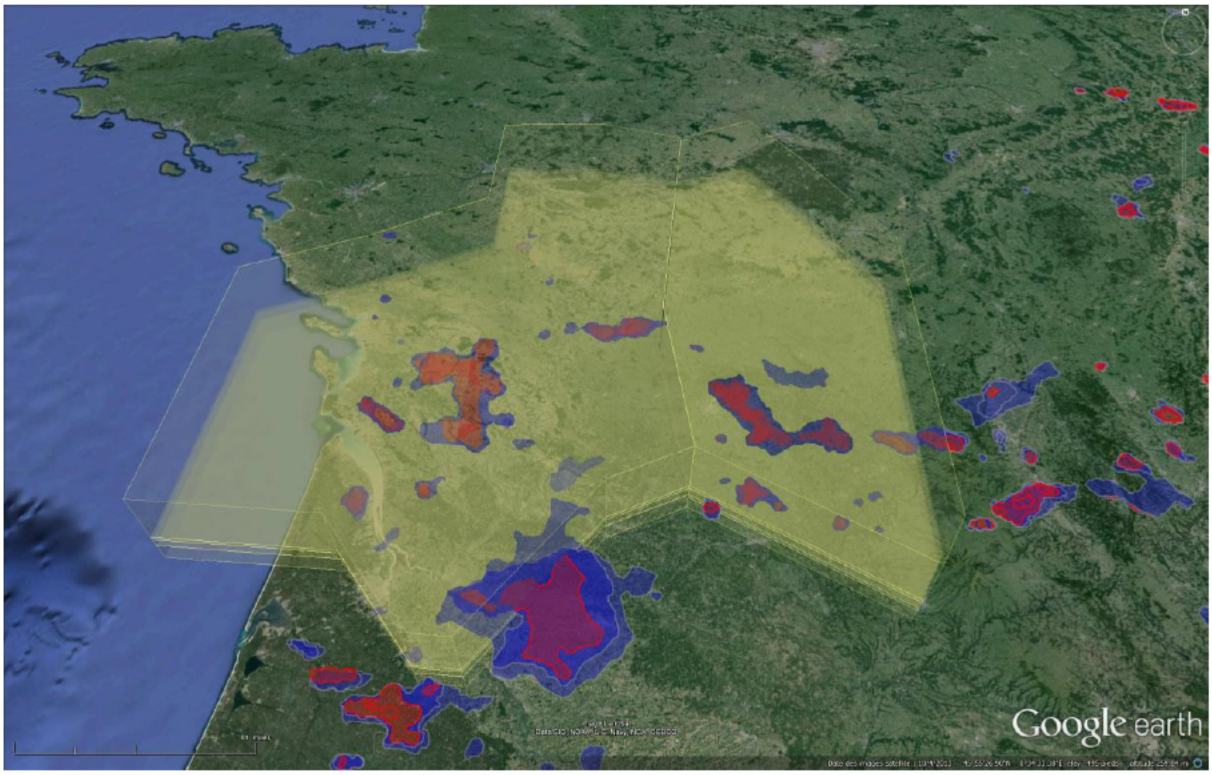
The regulation on RL4 is changed:

Update Type	Time	New regulation rate
Creation	12:29	48
Update – End Time 17:40	13:53	48
Update – End Time 19h00	16:01	50
Update – End Time 20h40	17:23	50
Update – End Time 19:20	19:11	

The regulations are upgraded and extended from 15:40 to 16:40 for RL1 and RL2, and from 15:40 to 17:40 for RL3 and RL4, showing a major disruption due to meteo situation.

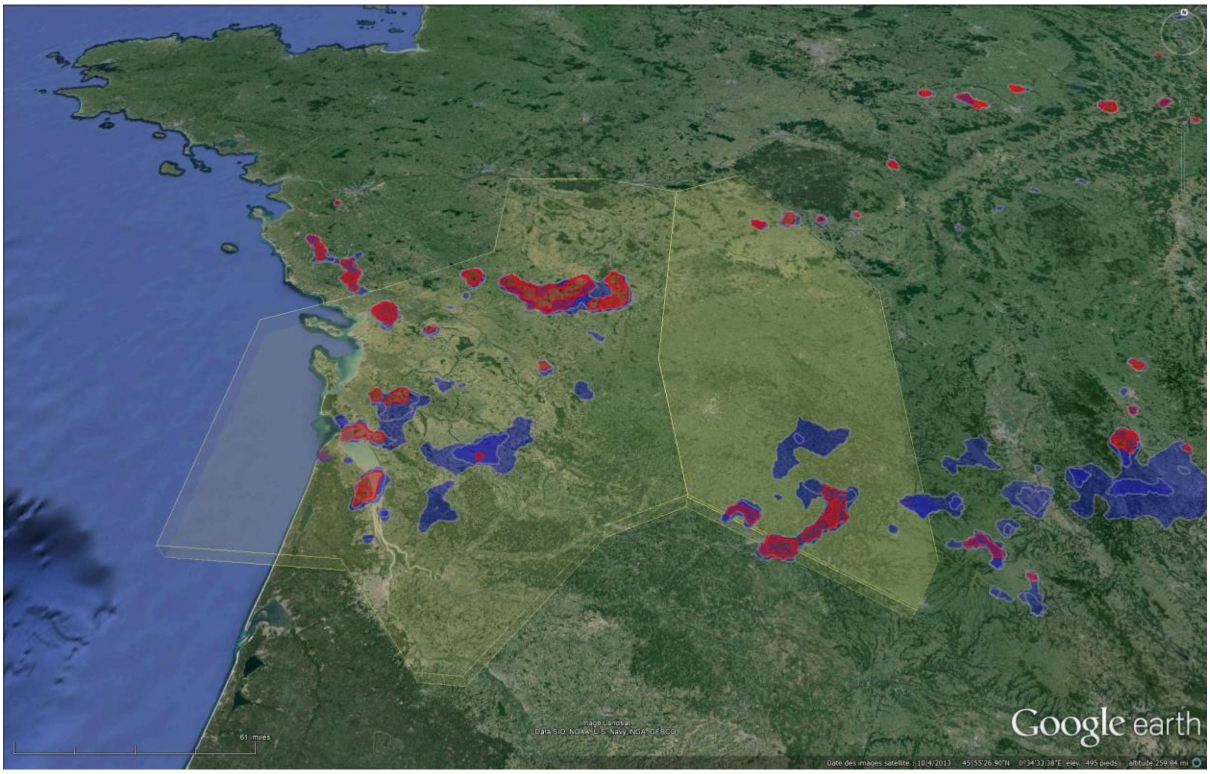
Nevertheless, at 14h30, the situation shows several ASPOC with high severity in the R and L sectors, and meteo bad situation at the south of R sectors.

The regulation in place looks necessary, and the delay due to weather during this period is justified.

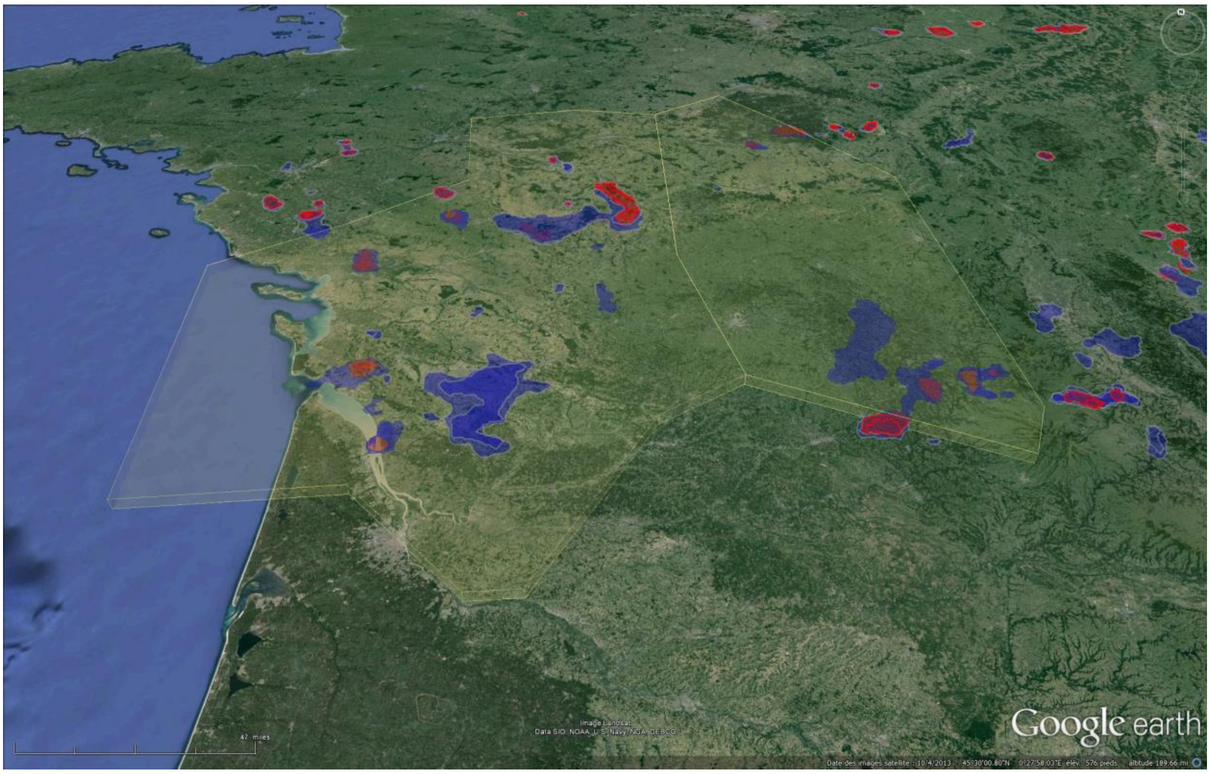


At 16h20, the regulation in RL1 is modified; the situation is calming down on RL1 according to meteo situation and demand. The RL1 regulation is cancelled at 16:05.

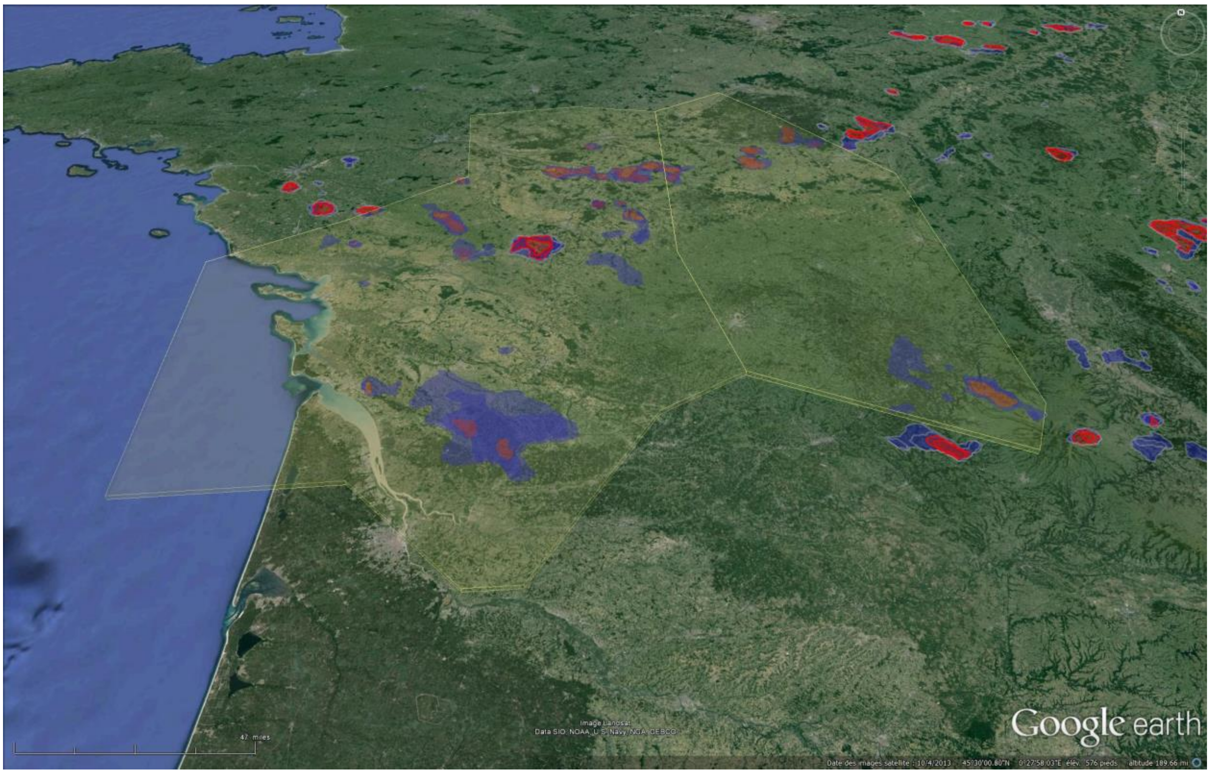
On upper level (LR2, 3 a,d 4), the situation is still problematic, and a decision to extend the regulation is taken by the FMP up to 19:00 for RL3 and RL4.



For RL2, 10 minutes later, the regulation is over, and for the same reason as for RL1, the regulation is not extended.

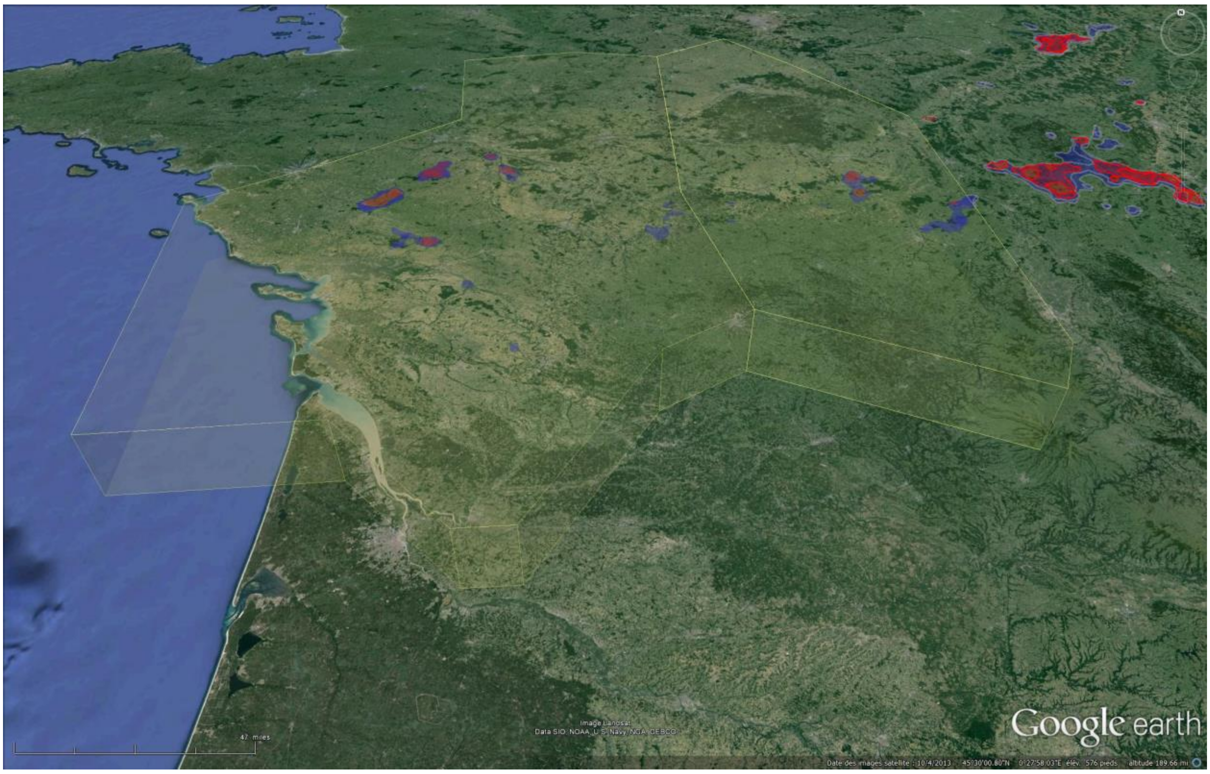


RL3 follows the same diagnostic at 17h15 the decision is to shorten RL3 by changing the end of the regulation period from 19h00 to 17h15. The situation is under control..



The last action on RL4 is to shorten the regulation by moving the end date from 20:40 to 19:20.

The meteo situation is really calm.



The experimentation with current TopMet feature does not allow us to gain delay on this day, nevertheless, with a good forecast, and simulations tools, a gain of 10% in delay is feasible.

The management of Meteo information requires further experimentation on how to translate a specific meteo situation into regulation or scenarios.

For this day the figures are:

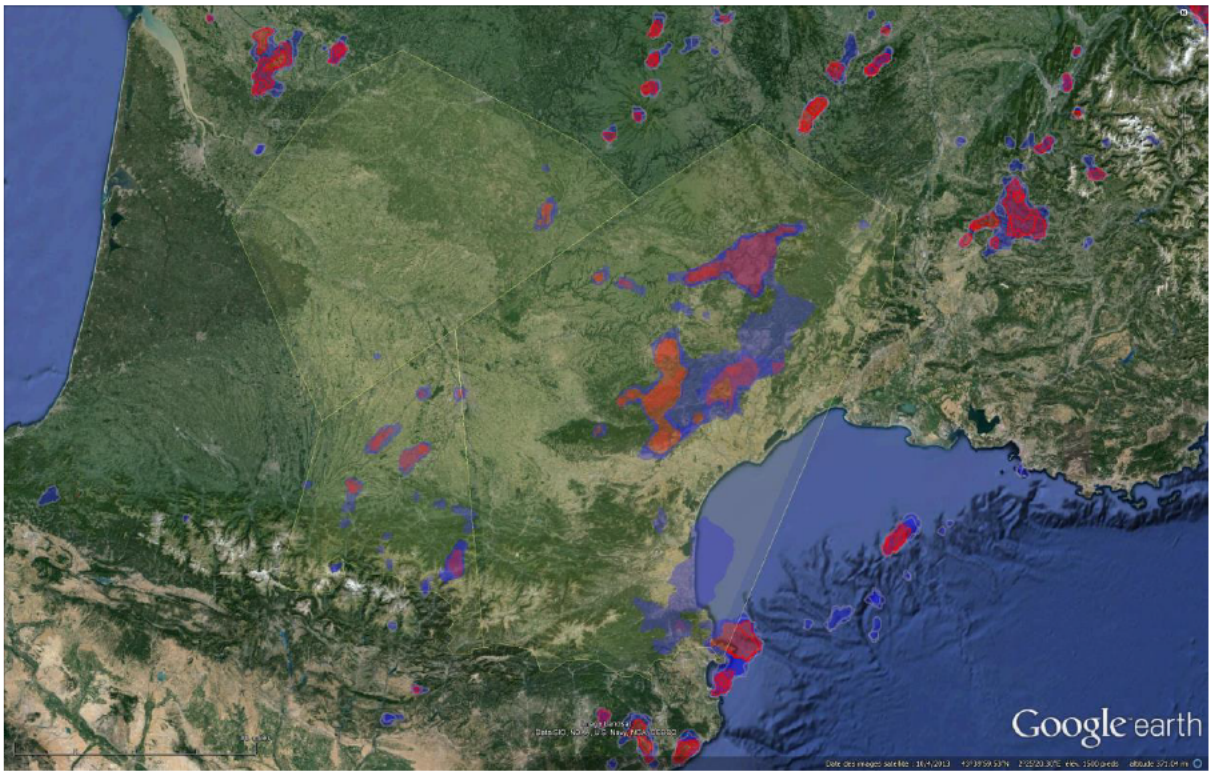
Sectors	Delay	Gain
RL1	466'	47'
RL2	1050'	105'
RL2	619'	62'
RL4	1933'	193'

5.3.3.1.10 Day 10 – 2nd August 2014

Two regulations are created for this day.

	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
X4 18h20/20h00	1:40	611'	51	37	16,5
NH4 16h00/19h20	2:40	1106'	53	45	24,6

The meteo situation is described in the screen shot below, at 16h00 in the afternoon.



Both regulations are created around 16h00.

The regulation on X4 is changed:

Update Type	Time	New regulation rate	Period
Creation	16:31	43	18:20-20h00
Update	17:48		18h20-21h40
Update	18:31	46	18h20-21h00

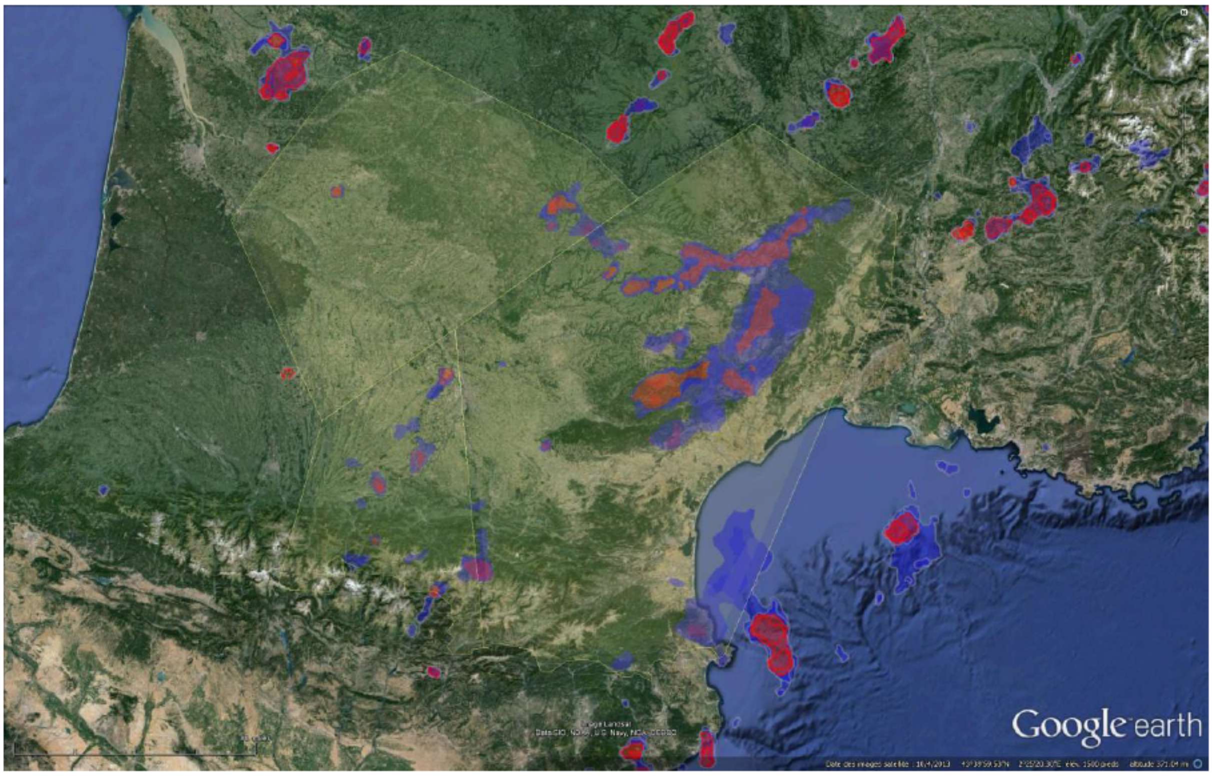
Cancel	19:18		

The regulation on NH4 is changed:

Update Type	Time	New regulation rate	Period
Creation	15h46	49	16h00-19h00
Update	16:34	51	16h00-20h00
Update	16:58	53	18h20-21h00
Update	17:11		18h20-18h40

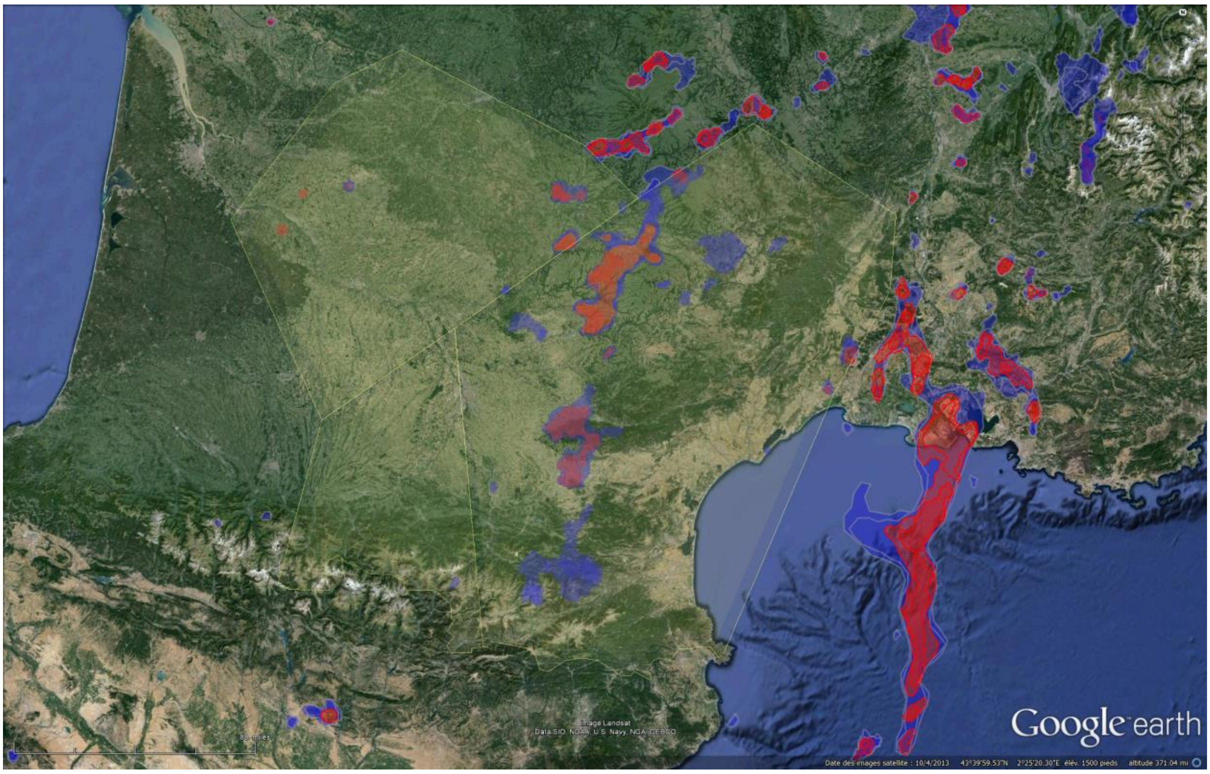
The screen shot below show the situation at 16h20, just before the begin date of NH4 regulation.

A strong CB's activity is detected, and has a real influence on traffic. The regulation is extended (+ one hour), with a small increase of the regulation rate.



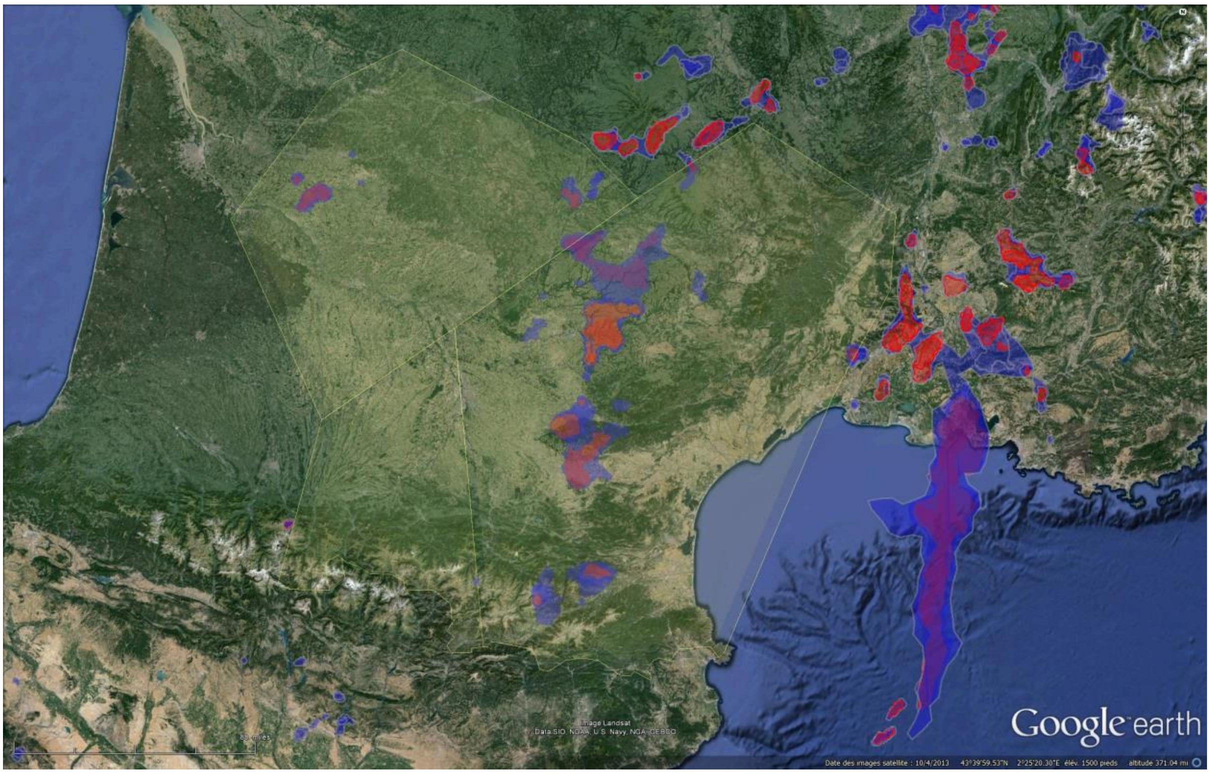
The meteo situation is evolving, and at 18h20, most of the CB's activity is moving east to Aix FIR.

Some ASPOC remain over N4 and H4 sectors.

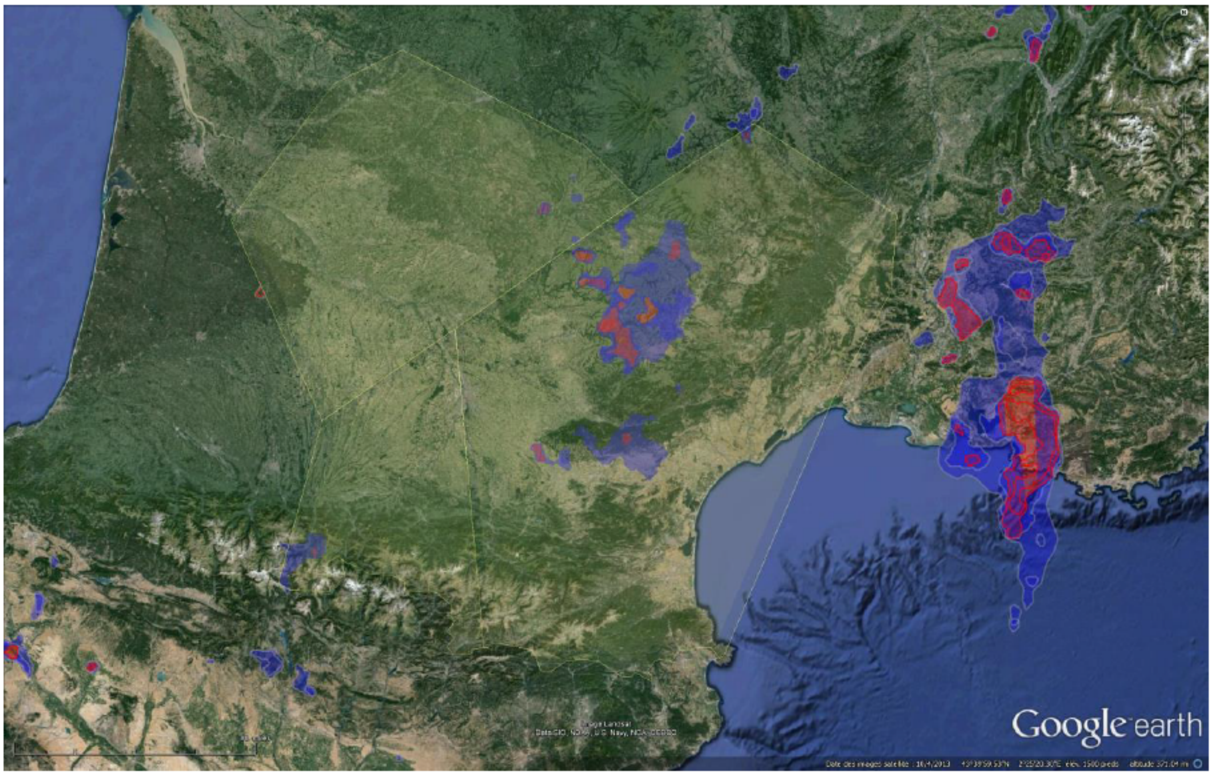


At 18h40, NH4 regulation is over, and no extension of the regulation is decided.

The situation over X4 sector is also calming down and a first small reduction of 40 minutes is decided according to the situation.



Later in the day at 20h00, the meteo is stable. And the severity of the ASPOC is decreasing strongly over H4, while no CB's are present in the X4 sector.



The experimentation with current TopMet feature does not allow us to gain delay on this day, nevertheless, with a good forecast, and simulations tools, a gain of 10% in delay is feasible.

The management of Meteo information requires further experimentation on how to translate a specific meteo situation into regulation or scenarios.

For this day the figures are:

Sectors	Delay	Gain
X4	611	61
NH4	1106	111

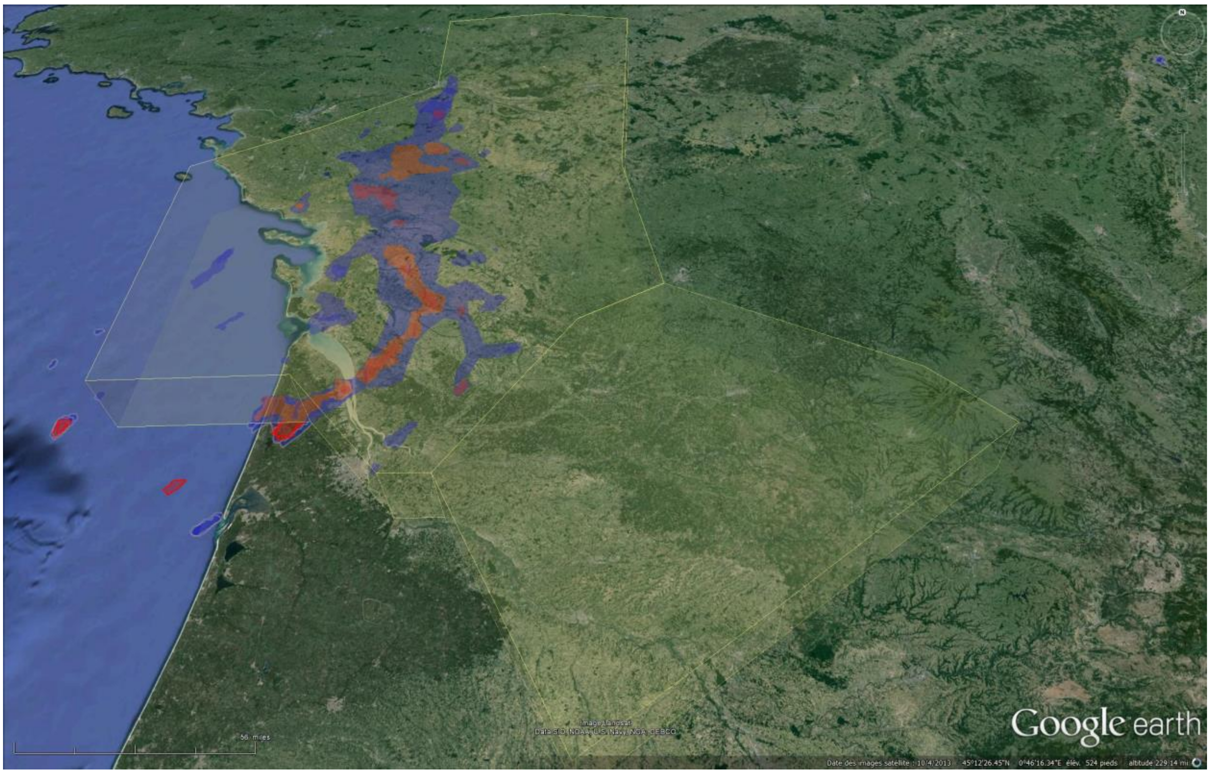
5.3.3.1.11 Day 11 – 3rd August 2014

Two regulations are created for this day.

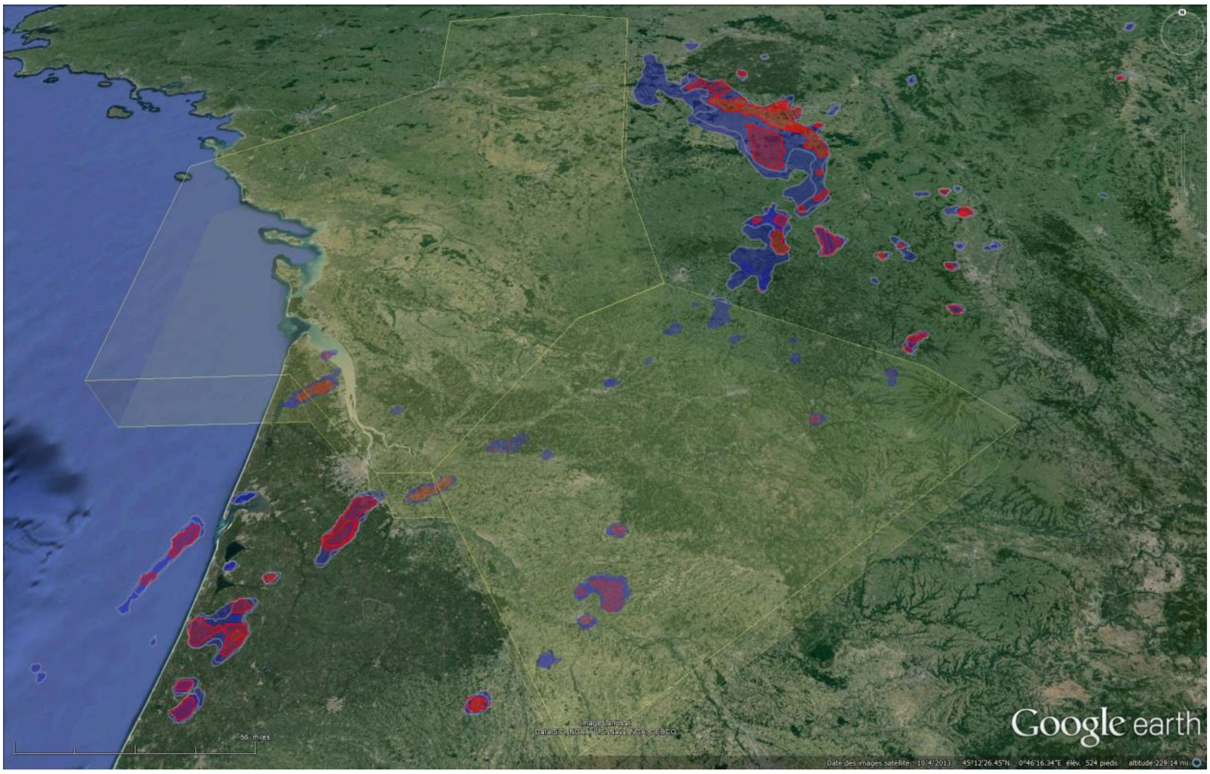
	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
R4 10h20/12h00	0:00	275'	29	14	19,6
X4 8h40/12h40	0:40	311'	57	25	12,4

The meteo situation is described in the screen shot below, at 4h55.

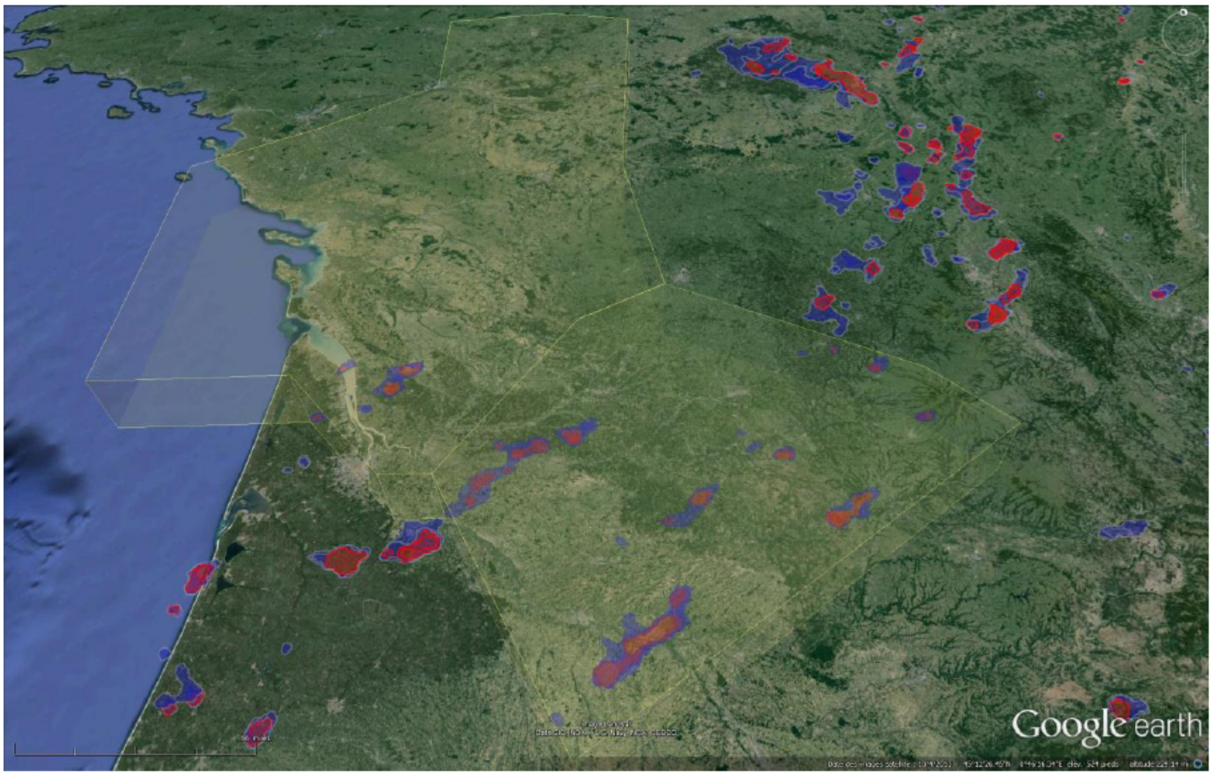
The regulation over X4 is created at 4h55 and cancelled at 9h20 for 40 minutes of effective regulation period from 8h40 to 9h20.



The regulation on R4 is created at 9h10 (screen shot), and cancelled at 10h18, 2 minutes before the official regulation T0.



As shown in the screen shot, the R4 situation is quiet, and the major part of ASPOC activity has moved east more quickly than expected. At 10h20, the regulation is cancelled.



According to this case, the major information is that the meteo situation evolved in a better way than the plan at 5h00. The regulations are cancelled, but produced delay due to regulation process.

This delay could easily avoided by using a real good forecast of the meteo situation.

For this day the figures are:

Sectors	Delay	Gain
R4	275	275
X4	311	242

5.3.3.1.12 Day 12 – 8th August 2014

Two regulations are created.

	Duration	Delay	Nb of Regulated Fligths	Number of Delayed Flights	Avd Delay per Aircraft
P123 16h20/16h40	0:20	215'	36	15	14,3
ZX4 18h20/21h00	1:57	1623'	108	86	18,9

The 123 regulation changed as follow:

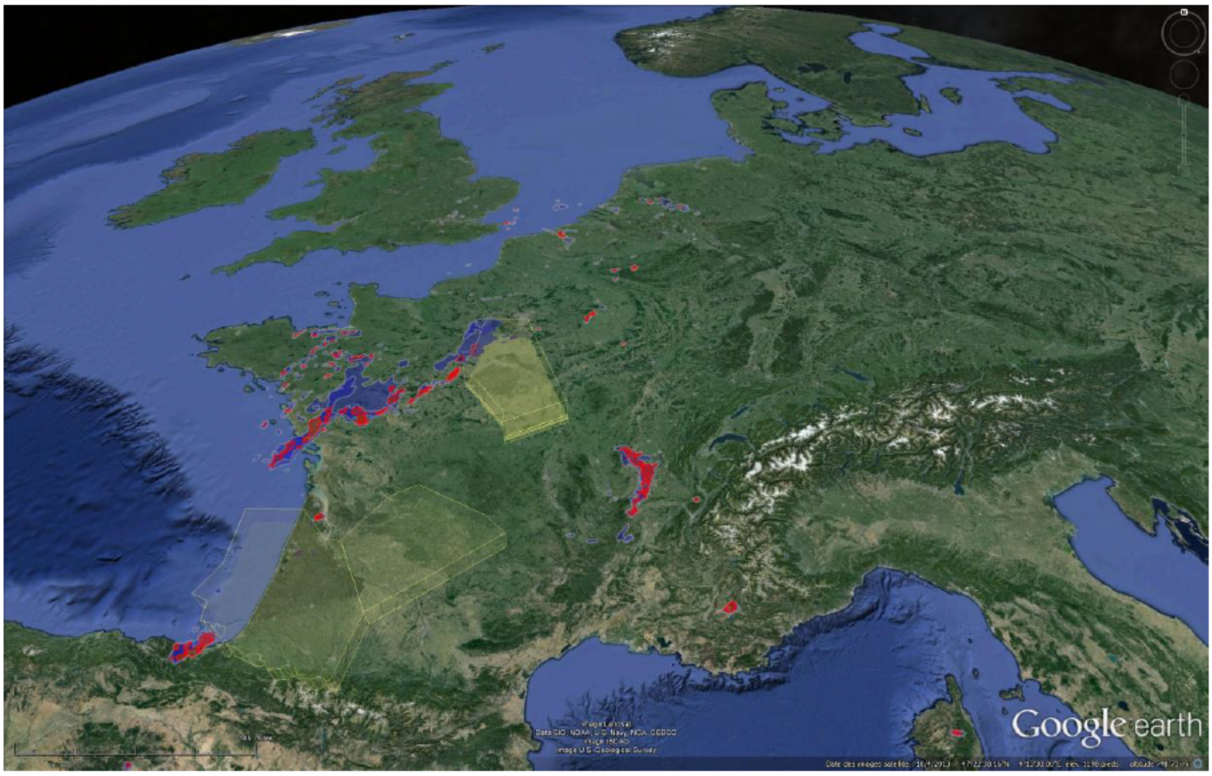
Update Type	Time	New regulation rate	Period
Creation	14:36	51	16h00-19h00
Cancel	16h40		

The ZX4 regulation changed as follow:

Update Type	Time	New regulation rate	Period
Creation	16:07	53	18h20-21h00
Update	17h11		21h40

Update	18:35		21h00
Cancel	20h15		

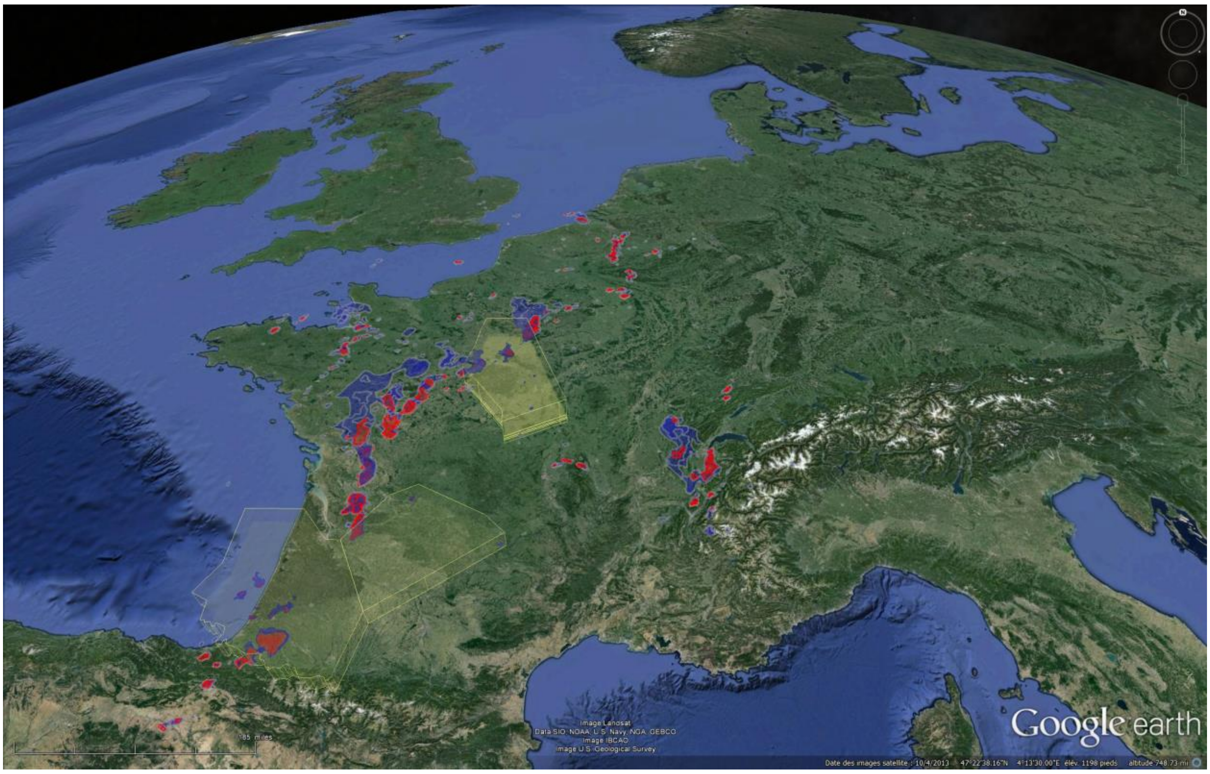
At 14h30, the situation is:



P123 in the north is under the threat of huge CB's area on the west. Depending on the evolution, the P123 must be regulated.

The south part of the ACC is also close to a bad ASPOC area, but no decision is taken now.

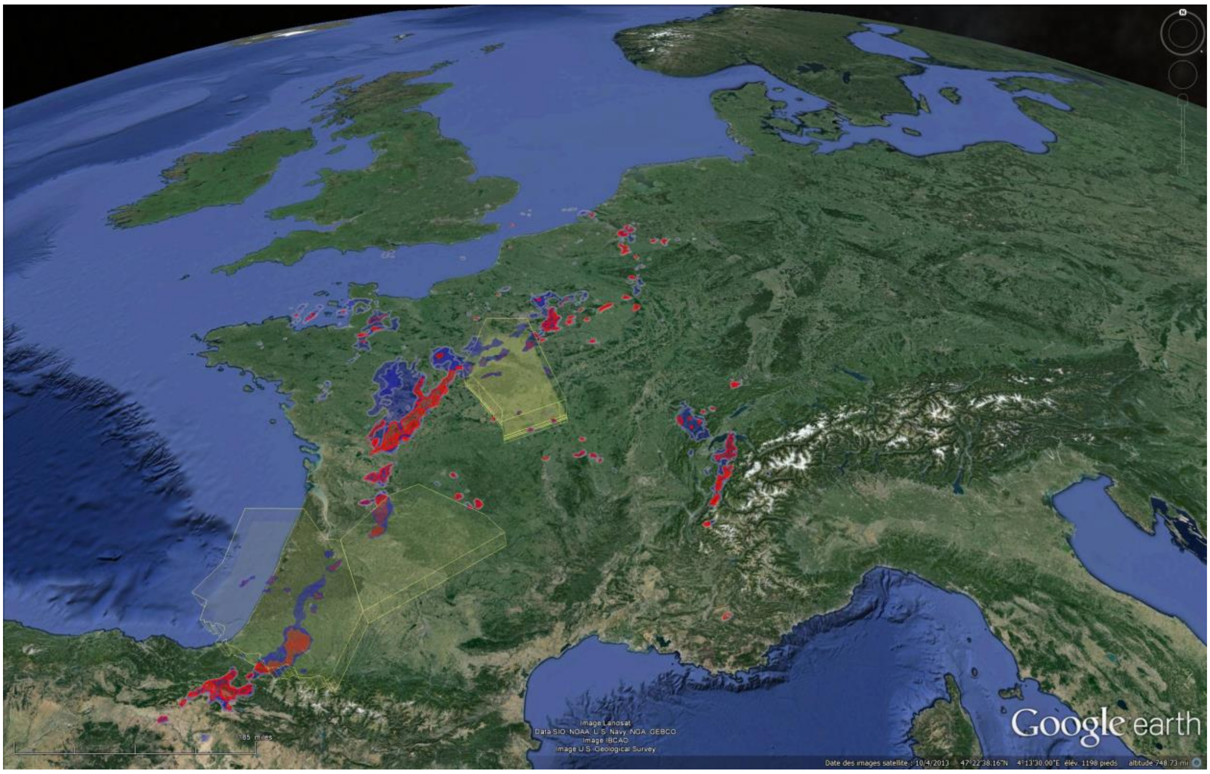
At 16:00, the situation has changed:



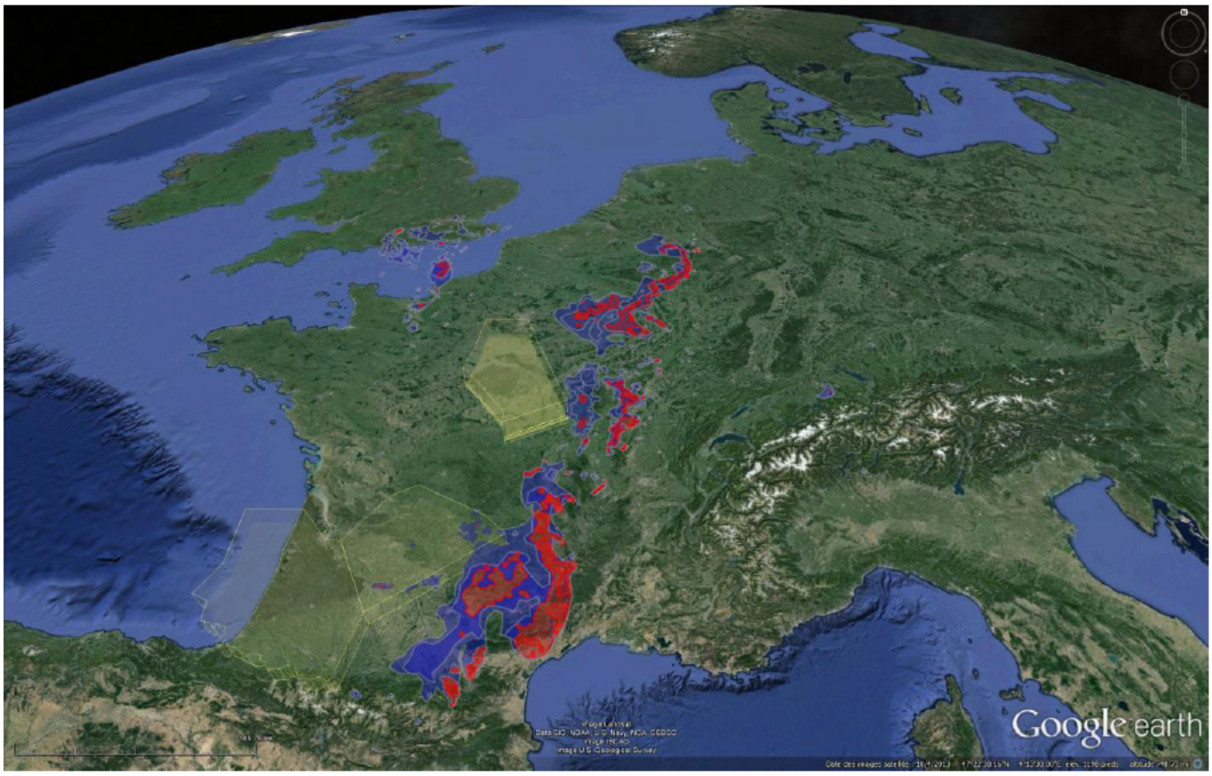
The south ASPOC area is moving north towards ZX4, and to protect the sectors a regulation is created.

A first decision point about P123 regulation appears, and according to the demand, the regulation could be cancelled.

At 16h40, the P123 regulation is cancelled. Meanwhile the regulation over ZX4 is extended.



At 20h00, all the major ASPOC activity has moved east, and the ZX4 regulation can be removed.



According to this case, the major information is that the meteo situation evolved in a better way than the plan for ZX4 sectors. The ZX4 regulation could have been stopped earlier according to the last picture of the MET situation..

For this day the figures are:

Sectors	Delay	Gain
P123	215	0
ZX4	1623	406

5.3.3.1.13 Results per KPA

See Section 4.2, Table 12

5.3.3.1.14 Results impacting regulation and standardisation initiatives

See Section 4.3.4.

5.3.3.1.15 Unexpected Behaviours/Results

See Section 4.4.1.

5.3.3.1.16 Quality of Demonstration Results

See Section 4.5.1.

5.3.3.1.17 Significance of Demonstration Results

See Section 4.5.2.

5.3.4 Conclusions and recommendations

5.3.4.1 Conclusions

See section 8.1 of the Final Demonstration Report

5.3.4.2 Recommendations

See section 8.2 of the Final Demonstration Report

6 References

6.1 Applicable Documents

[1] EUROCONTROL ATM Lexicon
https://extranet.eurocontrol.int/http://atmlexicon.eurocontrol.int/en/index.php/SESAR

6.2 Reference Documents

[1] AATM Master Plan
https://www.atmmasterplan.eu

[2] TOPMET Demonstration Plan, Edition 00.01.01, contractual deliverable D01, issued 18/12/2012

[3] TOPMET Demonstration Objectives, Edition 00.01.01, non contractual deliverable D002, issued 26/07/2013

[4] TOPMET Technical Specification, Edition 00.01.01, non contractual deliverable D003, issued 26/07/2013

[5] TOPMET Verification report, Edition 00.01.00, non contractual deliverable D004, issued 29/09/2014

[6] TOPMET Demonstration Exercise Report, Edition 00.01.00, non contractual deliverable D005, issued 29/09/2014

Appendix A Communication material

-END OF DOCUMENT-