1. Introduction

The TOPLINK project was launched in 2014, as part of the SESAR Large Scale Demonstration Activities program. SESAR (Single European Sky Air Traffic Management Research) was set up in 2004 to modernize and harmonize ATM systems through the definition, development and deployment of innovative technological and operational solutions. Within this framework, the SESAR Demonstration Activities are co-funded by SESAR Joint Undertaking (SJU), a public-private partnership which pools the knowledge and resources of the entire ATM community in order to define, research, develop and validate technological and operational improvements (“SESAR Solutions”).

The TOPLINK project aimed at demonstrating the benefits for ATM stakeholders (ANSPs, Airlines, General Aviation, Airport operators) of the deployment of new System Wide Information Services, including Meteorological Services, Aeronautical Information Services, cooperative Network services, and Flight Information services (for their non-safety-critical aspects).

2. TOPLINK Platform

In a first stage, the project has enabled the development and deployment of a cloud-based TOPLINK information platform delivering support to both ground-based users (Flow Managers in ANSPs, Flight Dispatchers in Airlines Flight Operations Centres, and Airport Supervision managers), and airborne users (flight crew in the cockpit). The information service is delivered to ground users through a secure internet connection, and displayed through a standard web browser running on a commercial PC.

Figure 1. TOPLINK Architecture
This platform aimed first at collecting and storing into a "Big Data" architecture the information data flows from different providers such as:

- Flight Information, from Eurocontrol NM B2B services
- Flight Surveillance, from Flight Aware and Flight Radar 24
- MET information, provided by the "MET Gate" developed by members of the EUMETNET consortium in SESAR project WP11.02, and including the current and forecasted information on weather hazards such as convection, lightning, clear air turbulence, in-flight icing, or low altitude winter conditions
- Airport operational Information in Paris Charles de Gaulle, through a web-service delivered by Aéroports de Paris.

The collected information was consolidated and post-processed in order to provide each individual user profile with a fully customized HMI, enabling:

- A fully consistent situational awareness of the current and forecasted situation for the coming 3 to 6 hours
- The display of dedicated KPIs, and dedicated alerts when any change in the external constraints (weather hazards, traffic hotspot; navaid failure, ...) is identified as impacting the operations of the considered user
- Decision-support tools, to help the user in determining the appropriate reactions in order to mitigate the impact of the detected external events – through “what-if” algorithms.

The data collection flows made use - whenever possible - of existing SWIM services (based on the Yellow Profile). When no standardized SWIM service was available, the available "pre-SWIM" web services have been used in their current status.

![Figure 2. TOPLINK Human Machine Interface](image)
The “ground platform” included:

- the deployment of an IT infrastructure hosted on a Thales-operated secure cloud, from August 2015 until the end of the project
- incremental operational verification and validation performed without disruption to the users;
- the incremental delivery of a software configuration, with successive monthly updates throughout the demonstration phase; and
- demonstration of deployment as well as incremental upgrades without having to visit the user site or disrupt their operational usage – with no user action required.

The “cockpit platform” included the deployment of a number of “Pilot kits” (Windows tablet), and of “Connectivity kits” for Brussels Airlines (based on ACARS connectivity), Air Corsica (based on Wi-Fi / 3G connectivity) and ENAC (based on Iridium satellite communication connectivity).

The offered Pilot applications were enabling the Pilot to get a consolidated, up-to-date view of his Flight Plan in the current and forecasted MET environment.

3. **TRIALS EXECUTION**

In a second stage, the project supported the execution of 11 TOPLINK trials, conducted between May and September 2016, representing in total:

- 75 days of operation, by ANSPs (DSNA, Croatia Control, Austro Control) and Airport operators (ADP);
- 81 days of operation, by Airlines OCC staff (from Brussels Airlines, HOP!, and Air Corsica), corresponding to real-time monitoring of more than 15000 flights;
- 84 flights using the TOPLINK cockpit EFB application operated by Airlines pilots (from Air France, Brussels Airlines, and Air Corsica);
- 74 flights planned using the TOPLINK flight preparation application operated by ENAC GA pilots, of which 43 flights (representing in total 40,55 flight hours) were actually flown, and the results post-analysed; and
- 10 days of real-time flight monitoring operation, by ENAC OCC staff, corresponding to some 200 flights.

The trials have been used to explore a number of operational uses cases, performing benefit quantification when practical.

**“Improved Regulations” Use Case**

The “Improved Ground Regulation” use case illustrated how to generate « small gains on many flights » through the fine tuning of flow management regulations based on weather predictions and traffic forecasts. A quantitative assessment of benefits has been conducted based on a large number of occurrences. Analysis yielded reliable results (a good confidence level) and
reinforced the initial results derived during the previous TOPMET project in 2014. The table below summarizes the main outcomes of the first use case (improved regulations), where a quantitative assessment has been feasible over a total of several thousands of flights.

**TABLE I. IMPROVED REGULATION USE CASE**

<table>
<thead>
<tr>
<th>Airspace</th>
<th>Current</th>
<th>Benefit TOPLINK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Delays (min) (1)</td>
<td>Cost (k€) (2)</td>
</tr>
<tr>
<td>All Airlines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOVV (En Route)</td>
<td>18742</td>
<td>880</td>
</tr>
<tr>
<td>LDZO (En Route)</td>
<td>12747</td>
<td>570</td>
</tr>
<tr>
<td>LFBB (En Route)</td>
<td>45951</td>
<td>2159</td>
</tr>
<tr>
<td><strong>Total EU (En Route)</strong></td>
<td><strong>3651</strong></td>
<td><strong>1715</strong></td>
</tr>
<tr>
<td>Brussels Airlines</td>
<td>1704</td>
<td>79.8</td>
</tr>
<tr>
<td>HOP!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Airlines</td>
<td>39026</td>
<td>1834</td>
</tr>
</tbody>
</table>

(1) Sources: Eurocontrol
(2) Estimation based on average cost of ground delays source Univ Westminster
(3) Estimation based on a joint analysis of actual regulations and TOPLINK Tool capabilities,

**“Support to Flight rerouting” Use Cases**
The « Support to Flight Rerouting » Use Cases explored the potential to predict operational disruption to specific flights and find an optimal flight adjustment minimizing the impact. Quantitative analysis of these uses cases was more complex, and based on a case-by-case (flight by flight) analysis. Specific cases were identified, where early action would have resulted in a substantial reduction in the operational impact of weather-based disruptions. This group of use cases is well illustrated through a few examples:

- in a situation of severe thunderstorm over the Pyrenees, TOPLINK proposes more efficient rerouting compared to the actual avoidance route taken (based on the weather radar information only)
in the case of a severe thunderstorm at arrival over Bilbao airport, TOPLINK proposes a longer ground delay at departure, in order to avoid a diversion to Madrid due to low fuel as a result of extended holding in the arrival airspace waiting for the airport weather to clear.

Finally, a number of situations were observed, where important benefits were reported by end-users, but the project scope only supported qualitatively assessed. These use cases were concerning mainly airspace & airport capacity, safety, and passenger comfort. The proposed support for an acceptable “icing-free” low altitude route to operate a ferry flight from Birmingham to Brussels was one such example.
4. Conclusions

The project has demonstrated, based on an end-to-end supporting infrastructure, how Air Traffic Flow Management Controllers, Airport operators, Commercial Airlines staff (ground Flight Dispatchers, as well as Pilots), and General Aviation (ground Fleet Managers, as well as Pilots) could improve their operational performance (especially in terms of safety, efficiency, and capacity) by the use of those new Information Services.

The project implemented 15 demonstration exercises, focused on five main demonstration Use Cases, addressing the benefits of advanced information services:

- for large or medium Airlines (involving Air France, and Brussels Airlines).
- for ANSPs (involving DSNA, Austrocontrol and Croatia Control)
- in support to Airport operations at Paris CDG, involving the ANSP (DSNA), a major Airspace User (Air France), and the Airport Operator (ADP)
- in support to Regional Airlines (Air Corsica, and HOP!, an AFR affiliate).
- for General Aviation flights, involving ENAC (the French national civil pilot school).

The project clearly demonstrated the high added value of combining weather information (MET), Aeronautical information (AIM) and flight information to support strategic & pre-tactical decisions, including:

- a positive impact on all targeted performance KPAs (fuel & cost efficiency, predictability, punctuality, airspace capacity, ...)
- a better situational awareness resulting in reduced stress in abnormal / fast evolving situations; and
- increased safety through a better anticipation of unexpected events

Furthermore, the project has demonstrated the benefits of a tight interaction between ground personnel and flight crews in pre-tactical, pro-active decision-making. One important lesson learned is the need to filter information, in order to focus pilot’s resources on the relevant info only.
Finally, the project has demonstrated that tangible results could be achieved (under some pre-conditions) in such Use Cases as:

- better tailoring of MET-induced regulations (ground delays) by ACC and Airports with an immediate impact on all Airspace Users; and
- better anticipation of MET-related issues for Airspace Users to more efficiently manage flight plans revisions, and avoid costly « last minutes decisions » (e.g. late vectoring, diversion, holding...)

5. Acknowledgment

The present work was co-financed by the SESAR Joint Undertaking and each of the participating organizations to the TOPLINK Lot 1 and TOPLINK Lot 2 projects (namely: Thales Air Systems, Thales Avionics, Airbus, Météo-France, the Finnish Meteorological Institute, Germany’s Deutscher Wetterdienst, Direction des Services de la Navigation Aérienne, Croatia Control, Austro Control, Aéroports de Paris, Air France, HOP!, Brussels Airlines, Air Corsica, and ENAC.

6. References
