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TOWARDS A MORE HARMONISED AND WIDER USE OF SHORT-TERM ATFCM MEASURES (STAM)

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Abstract

STAM is a demand capacity balancing (DCB) procedure which allows flight management positions (FMPs) to identify pre-regulation hotspots and apply short term air traffic flow and capacity management (ATFCM) measures. It is a collaborative (CDM) process involving all partners in order to ensure that equity is maintained. The STAMs such as ground delays, flight level capping and horizontal re-routings are applied to a limited number of flights helping to avoid a considerable amount of the (sometimes unnecessary) ATFCM ground regulations and delays. This paper summarizes the results of one of the three validation exercises that were carried out in SESAR R&D program under the P13.02.03 project. It clearly highlights not only the positive feedback, but also the areas for improvement prior to wider and more harmonized use of STAM.

1 Dynamic Demand Capacity Balancing (DCB) Concept

Current network performance and flight operations are impacted by ATFCM measures imposed on individual flights in order to prevent situations that traffic demand exceeds available ATC and Airport capacity. In the European system the short-term ATFCM planning is taking place the day before and day of operations to adjust the Demand Capacity Balancing (DCB) plan, i.e. to detect residual overloads and to apply mainly a ground delay regulation plan at the airport departure to smooth the overloaded traffic. This centralized mechanism generates a systematic allocation of departure slots to all fight concerned by the congested area, regardless of how they contribute to the expected overload. This process, remaining valuable in case of major imbalance, is no longer acceptable when the demand does not significantly exceed the available capacity and when traffic can be predicted with a more refined level of granularity and accuracy. In addition, during the execution phase there is no reassessment to fine-tune the DCB plan. This requires enriching the mechanism of prevention against congestion with real-time corrective measures: STAM (Short-Term ATFCM Measure) [1].

In the SESAR program framework, the main improvement is to provide a new dynamic DCB process based on procedures and technics aiming at bridging the gap between the short-term ATFCM planning and the ATC execution phase [2]. It allows local flow manager (FMPs) in ACCs to play a key role in the reduction of traffic peaks by applying STAM Measures such as minor ground delay, flight level capping or small re-routings. Rather than applying a penalizing regulation to a group of flights as a whole, an FMP may target individual flights with STAM Measures while accommodating Airspace User preferred solutions. It represents a micro-surgery approach to resolve sector overloads, allowing the FMPs to cherry-pick the minimum of flight both in the pre-departure and execution phases with the minimum of penalties. In the today's operations, FMPs are starting to use STAM Measures but without a proper process.

- Airspace users (AU) and pilots are not able to identify whether an ATC instructions (i.e. level capping) is for ATC or DCB (STAM) purposes.

- STAM Measures are not entered and not managed into an information system enabling a transparent information sharing.
- No standardized procedures to coordinate the STAM Measures with Airspace Users and adjacent FMPs enabling a collaborative decision-making involving all partners.
- No support tools to manage the STAM Measures in order to replace paper, post-it and telephone.
- No supervision of STAM activities at the Network Manager level.

Promoting the implementation of local STAM Measures versus the centralized First Plan First Served ground delays implies to build a system providing the following essential features:

1.1 An accurate predicted workload

A more precise and reliable methodology has been developed to predict the sector imbalances. The use of occupancy counts with Occupancy Traffic Monitoring Values is the main enabler as advanced monitoring techniques are required for the application of targeted STAM. The confidence that some FMPs have developed in respect of this monitoring technique has allowed them to develop specific responses to specific issues, for which regulations are not or less efficient. The availability of occupancy counts has now given the FMP the opportunity to take decisions closer to real time because of advanced credibility is available from 2 hours prior to operation.

1.2 Hotspot Management

The hotspot (overloaded area) identified by the FMPs are notified to the Network Operations Plan (NOP). It aims at informing all the concerned actors about potential network problems.

1.3 Building Optimized STAM Local Solutions

To resolve declared hotspots, STAM solutions are investigated seeking minimum impacts on Airspace Users, such as Cherry-picking actions based on the identification of the flights creating the complexity, using enhanced flight list attributes providing FMPs with an accurate flights status an aircraft attitude. Possible measures included the allocation of minor ground delays to specific flights, flight level reassignments or route changes negotiated with Airspace Users and, in the last resort, interventions on airborne flights coordinated with adjacent FMPs where needed.

A simplified what-if (simulated Occupancy Count) allows the FMPs to analyze whether the planned STAM measures resolve properly the hotspot.

1.4 Collaborative Decision-Making process

The Collaborative Decision-Making process underlying the dynamic DCB comes into play to negotiate and agree the best STAM Measure to apply. It is the key vehicle to allow Local FMPs and Airspace Users to accommodate their business needs. Depending of the time horizon, the proposed STAM Measures can be coordinated:

- with the Airspace Users to allow them to express their trajectory adjustment preferences or priority
- with concerned ACC (FMP) or airports to consolidate the consistency of the solutions.

The coordination workflow is managed by the FMP initiating the measures.

1.5 Network view

The declared hotspots and planned STAM Measures are stored in the NOP. It allows the Airspace Users and ACC/Airports to anticipate and to react to the NOP information. In next steps, it will support the processing of advanced what-if and Network Impact Assessment.

1.6 Network Management Supervision

The Centralized Network Manager supervises the local FMPs STAM measures activity. Escalation from local FMPs to the Network Manager will take place only upon specific request for investigation of alternatives and in case of undesired interaction and network impact of multiple STAM. A majority of the dynamic DCB problems will be solved either ACC-internally by the FMP or by limited coordination between adjacent FMPs and AUs.

1.7 Network Working Position (NWP)

The Flow Manager Working Position is re-invented in the footsteps of the Controller Working Position (CWP) re-invention of 20 years ago. There are working method similarities between the multitude of ATC conflicts to manage and the multitude of STAM measures to manage. Both are related to a collaborative work involving a limited number of actors to be engaged for a time limited tasks built around a defined procedure. The main innovative tools developed in the NWP are:

- A timeline tool to organize the workflow of the STAM measure management. This approach was inspired by the ERATO agenda (ATC conflict organizer) developed by DSNA for conflict management [3].
- A chat tool to support the Collaborative Decision-Making process allowing to propose, coordinate and implement STAM Measures.

1.8 The Assumptions & Rational for Benefits

The Occupancy Count provides a more accurate and reliable predicted imbalance increasing the confidence of FMPs. It allows FMPs to use STAM Measures instead of the more protective and penalizing ground delay regulations while maintaining the safety level.

The use of STAM Measures versus ground delay regulations reduces drastically the number of impacted flights, reduces the average delay and increases the flight efficiency. It releases a certain part of ATC capacity “frozen” with the regulation mechanism.

The use of a CDM process to coordinate STAM Measures allows to accommodate the Airspace Users business needs (AU preferences) and to avoid the risk of multiple STAM interferences.

The Network View provides a better information transparency to the Airspace Users, improving their understanding and situation awareness about the STAM constraints.

The Network Working Position (timeline, chat) allows the FMP to manage efficiently the hotspot and STAM Measures.

2. Step-wise validation

The development and validation of STAM concept is being done within the work package 7/13 of the SESAR R&D program [ref SJU]. As the concept is in the advanced development stage, considering the maturity in the European Operational Concept Validation Methodology (E-OCVM), the project team focused on the final steps of the validation in the Pre-industrial development and integration phase (V3).

The validation work is done under the umbrella of dynamic Demand Capacity Balancing project (dDCB - P13.2.3). There were three major validation exercises defined in order to finalize the V3 maturity level of the STAM concept. All three exercises were initially defined to be Live Trials. The following sections will cover the largest exercise conducted in October 2014.

2.1 Experiment setup

The first STAM live trial took place over 3 days in November 2011. The STAM concept was successfully demonstrated with very limited tool support, but the low number of participating airlines and Air Navigation Service Providers (ANSPs) did not enable to collect representative enough data of acceptable quality. A recommendation was made to organize a large scale live trial covering most of the core-European airspace.

From 1 to 15 October 2014, a live trial covering a large part of Europe's core airspace was run. The aim of this exercise - known as VP522 and conducted under the auspices of SESAR R&D program - was to validate a harmonized STAM process and workflow for Flow Managers (FMP) of the area control centers (ACCs) involved, the Network Manager and aircraft operators [4].

FMPs from these ACCs took part in the trial: Brest, Reims (DSNA); Zürich, Geneva (SkyGuide); Swanwick (NATS UK); Maastricht (MUAC); Karlsruhe, München, Langen, Bremen (DFS); Roma (ENAV). These airlines gave their support to the trial: KLM, Air-France, Lufthansa, Regional-HOP!, EasyJet, Emirates, SAS and Alitalia.

The STAM process under validation was supported by a prototype enabling STAM creation, coordination and implementation. Both airline staff and FMPs from ACCs were connected to the STAM prototype via EUROCONTROL's NOP Portal.

2.2 Data collection

The observations of FMPs' activity were performed during all the days of the exercise by subject matter experts from project partner companies. Observations were performed in all ACCs. The main roles of observers were validation, system, human performance and operational experts.

In addition to the observations made by the experts, a SkySoft screen recording device was installed at two FMP positions: Reims and Zurich. The recordings have been made during the entire duration of the live trial. They provided a complementary data source and evidence for some validation objectives.

The FMP log was an on-line questionnaire which was filled in by each FMP after the STAM proposal (time and workload permitting). The log includes data on the used STAM type and the reasons for choosing this STAM relative to a regulation measure. Each FMP may have filled in several logs every day of the live trial, according to the number of STAMs proposed.

The FMP and AU survey was filled in by each FMP and AU participant at the end of every day of the live trial. The purpose of the survey was to collect the subjective data about the exercise which has been performed in the same day. The FMP survey had 39 questions which covered STAM concept, STAM tool support and Safety and Human Performance.

2.3 Exercise results

During the trial, FMPs reported they initiated 67 STAMs. However, the total number of initiated measures, as logged by NM system, was 103 (see Figure 1 below); out of which 61 are assumed to have been implemented. The final number of really implemented measures remains uncertain as airborne measures were implemented partly by ATCO and flight crew and their successful implementation was out of scope of the measurement focus.

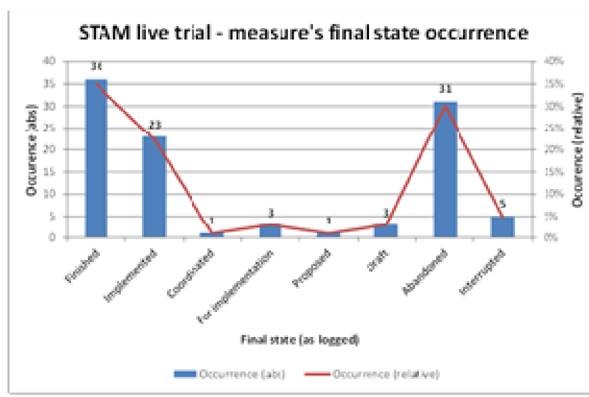

Fig.1 Final state of STAM measures

The most used subtypes of STAM are by decreasing number: Ground & Airborne Level cap, Ground delay measure, Horizontal Rerouting and MDI.

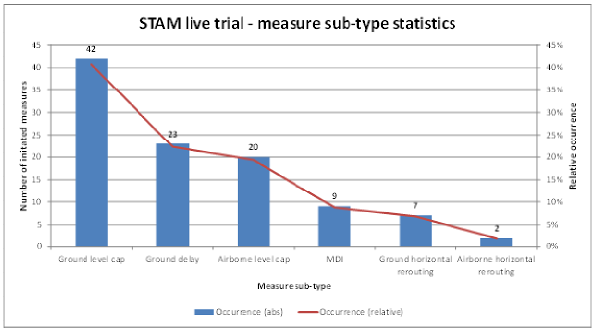

Fig.2 STAM sub-type overview

The relatively low number of STAMs initiated by FMPs each day is explained by the low load of traffic experienced during the trial. The low traffic load didn't allow the FMP to test simultaneously many measures. A few FMPs report that they initiated STAMs to evaluate the STAM tool and the STAM process rather than to solve a real hotspot.

Another limitation in the use and the assessment of the STAM concept and tool was the number of aircraft operator participants. Even if 8 airlines were involved in the live trial, more airlines would be required in order to facilitate the choice of most appropriate flights for STAM and the coordination between the actors involved in the CDM process.

The live trial allowed FMPs to use in parallel STAM and regulations. 43 out of 68 logged measures have been proposed for safety reasons, while not aimed to avoid CASA regulation. There was an occasional issue reported, when a single flight was caught by both the STAM and CASA regulation. A rule was created as a follow on to avoid these cases to happen again (to avoid double penalty and increased workload).

The results [5] clearly confirm that 21 out of 68 logged measures helped to avoid CASA regulation. If the measure was created for other reason than avoiding regulation, the most commonly used reasons cited were: Safety, Avoid bunching, Optimize sector load, Optimize load balanced between sectors and Bad weather.

As a follow on from the previous small live trial, the good results was that large variety of FMPs from 11 different ACCs were able to apply STAM measures even without prior experience with the concept.

83% of FMPs (n=54) believe that roles and responsibilities of different actors were clear, however some specific issues were raised in relation to adapting rules for ground vs airborne measures.

STAM use depends of timeframes in which STAMs have to be decided, coordinated and implemented. Traffic predictability and complexity are key elements to fix the timeframes. Splitting STAMs between ATC-STAMs and ATFCM-STAMs relies on the STAM timeframes. Two timeframes may be described:

- Short delay, where the STAM has a local impact on the network and only few actors are involved.
- Long delay, where STAM has an impact at a larger scale of the network. The coordination process takes place at the network scale and all involved actors play an active role in order to propose, validate and act in the STAM implementation.

Some FMPs noticed they preferred to use airborne STAMs because the ground STAMs required a longer timeframe. The argument used by FMPs to justify such a preference is the delay that requires exchanges in a complex coordination process between several actors. They fear that the coordination and validation process of the ground measure isn't always compatible with the timeframe to implement it. This finding lead to a recommendation to add a list of predefined and pre-agreed scenarios into the STAM tool.

Transparency proposed by the STAM concept and the STAM tool is clearly an evolution in the way Network manager operations center (NMOC) is integrated in the use of STAMs in the tactical phase. Until now, STAMs were local measures in which NMOC was not involved and even, could not have information when the measure was implemented within the ACC. Identification of the NM escalation process and participation of NM in the decision making process has been evaluated in the trial. The recorded outcome was that working methods (roles & responsibilities of NMOC staff), better integration of the STAM tool and NMOC staffing issues have to be resolved.

The procedures for hotspot identification and creation were judged to be satisfactory, although a few recommendations were identified, especially related to FMP workflow.
The procedures proposed to analyze the flight eligibility and prepare a STAM measure were considered to be satisfactory for the FMP, although a few important issues and recommendations were raised (short vs medium term STAM, state machine, optimized approval process, etc.). The proposal flight feature was well appreciated and used, but available only for Ground measures. A recommendation for further enhancement was made (to include airborne flights).

One of the most negative outcomes of the trial was related to the operational feasibility with the tested tool support. FMPs' feeling was that STAM concept is good, but the tool's ergonomics and integration with existing tools has to be improved (especially for the airborne STAMs). It's not the STAM process in itself which is flawed but the process of using the prototype tool (not mature enough) for STAM measures.

Another critically judged element was the STAM coordination phase. The coordination between all the actors was possible, however, not really considered as effective in all situations. Further enhancements of the Tasks/Notifications/Chat windows are required, as well as utilization of phone in specific situations shall not be excluded. The average coordination time for airborne STAM measures was 14 minutes, while for the ground STAM it was 29 minutes. Each coordination process included on average 5 participants/actors with each measure containing on average 4 aircraft (flights). In total 23 measures required a modification after the creation and start of the coordination. The tool design was not ready for such type of coordination, which resulted in unnecessary workload increase.

The collaboration between FMP and ATCO, who were responsible for STAM measures implementation, was clear and efficient, although a few suggestions related mainly to addressing mechanism and integration with ATC were made.

Based on the subjective assessment the 33 out of 41 FMPs considered the STAM measures efficient in resolution of the hotspots. However, the measured/logged data are a bit less positive. Actually, the quantitative data is not very conclusive, as the external factors often contribute to (non-)resolution of the hotspot. The quantitative analysis was done based on the detailed assessment of 4 trial days (6, 8, 9 and 15 October 2014). The analysis consisted of checking the occupancy counts at four different timestamps:

- Hotspot creation time
- Measure proposal time
- Hotspot start time
- Hotspot end time + 1hour

In addition to analysis of occupancy counts, the list of flights and their trajectories have been verified to inspect whether a flight was successfully subject to a STAM measure and whether the measure was efficient in removing the flight from the hotspot. As a summary, two possible outcomes were possible:

- Contributed to the resolution of the hotspot (see example in Figure 3, where 4 flights were subject to ground level cap, 3 were successfully removed from the hotspot and the end OC were lower than initial: X axis time, Y axis # flights)

- Did not contribute to the resolution of the hotspot (see example in Figure 4, where all 5 flights subject to Ground delay were not removed from the hotspot and the OC did not improve)

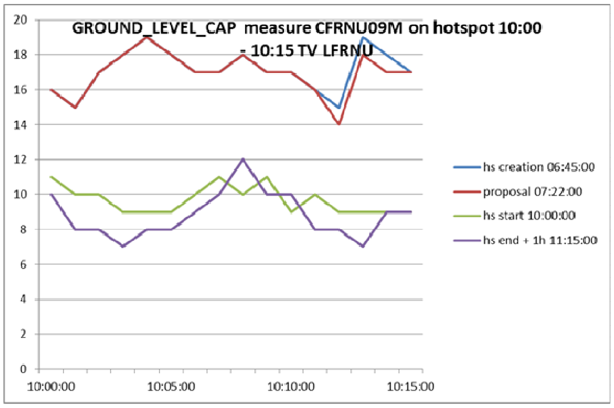

Fig. 3 STAM measure efficient

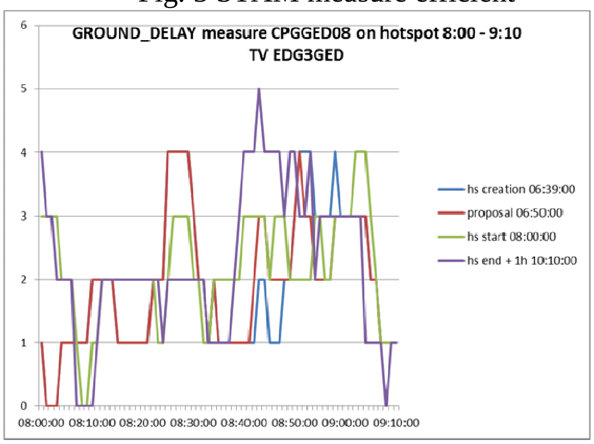

Fig.4 STAM measure not efficient

Out of 29 analyzed measures, 23 were judged to contribute to the resolution of the hotspots. Some of them contributed fully, some other partially, i.e. only partial success of the STAM measure, as not all intended flights were removed from the hotspot and/or the end occupancy count was not much lower than the initial. The remaining 6 measures did not contribute to resolution of the hotspot, as the flights were not removed from the hotspot and/or the end occupancy count was as high (if not higher) than initial. Although not all measures have been analyzed, 29 represent nearly 50% of the implemented measures. The result confirms a very good contribution of level caps (both airborne and ground), as well as it highlights an issue with cherry-picked ground delay measure, that was very often not efficient due to very short delay applied (many flights finally remained in the hotspot).

The impact on environment has been assessed by quantification of the fuel impact. Three busiest live trial days (by number of implemented measures) were subject to detailed analysis (6th, 9th and 15th October). The analysis focused on comparison original flight plan vs STAM proposed trajectory (STAM-ORG) and STAM vs real flown trajectory (REAL-STAM) – the extra mileage and additional fuel burn were quantified.

This analysis was not possible for Airborne STAM, as the system did not generate proposal flights for airborne STAM; hence there was no estimate of the potential fuel impact. The only metric that can be compared is the actual flown trajectory vs initial trajectory (Flown vs Original). The airborne measures have a mean of -79.6kg, while the ground measure only -55kg (based on analysis of 49 flights in ground measures and 28 flights in airborne measures). In both cases, the impact of fuel efficiency was positive, i.e. fuel burn reduction. This can be explained primarily by the action of pilot and ATCO, who very often ask and grant the shortcuts or ATCO simply allow the aircraft to climb into problematic traffic volume. The observed 0.3% extra fuel (11kg) for ground level caps and horizontal re-routings was finally compensated by pilot/ATC actions, as the flown trajectory averaged in 1.6% (66kg) less fuel than the STAM proposal. In general, one can conclude that STAM fuel impact is negligible, as it is in the same order of magnitude as other external factors (e.g. weather, vectoring, runway change etc.).

The analysis of ATFCM delay per flight was done in the so called "replay" mode of the live trial. The FMP log provided a list of measures that was initiated in order to avoid a CASA regulation. The four days with maximum of such measures were replayed. It included in total 16 measures during 6, 8, 9 and 15th October avoiding in total 12 regulations. The replay mechanism would start with replaying a normal live trial day (as recorded during the live trial), but just before implementing the proposed STAM measure in the traffic volume, it would replace the measure by a CASA regulation with given characteristics (from FMP log – rate & activation period). A snapshot of network wide ATFCM delay was made before and after the activation of the regulation, as well as attribution of delay to flights present in the TV.

The outcome of this analysis is presented below and shows big potential in the ATFCM delay reduction. The green bars represent the theoretical ATFCM delay gain for flights in one traffic volume. It is calculated as a difference between cumulative delay of regulated flights and cumulative delay of flights with STAM. In the case of STAM, some flights could still be delayed because of other regulations (not the one that STAM avoided). There were only two occasions, where avoided regulation lead to minor increase of total delay, but this was due to exceptionally high delays caused by EGLL regulation (CPRKHN9A). The blue line represents the reduction of number of delayed flights (Regulation vs STAM) in one TV. There was only one case, where number of delayed flights went up in the case of STAM, but again mainly due to other regulations (external factors were not controlled in this case, as the STAM scenario was the recorded one – as it happened during the live trial).

The average cumulative delay per regulation (based on 12 avoided regulations over 4 days) was 290 minutes. The average cumulative delay recorded during the live trial during the same period as the activation period of regulations was only 39 minutes. This represents a potential of **87% ATFCM delay recovery**. It must be noted, this results is based only on a small data set and corresponds to October traffic levels. In busier traffic level, the delay recovery % would go down, as the traffic imbalances would be more significant and STAM solutions would reduce the load, but not always help avoiding the regulation.

The analysis of four live trial days (6, 8, 9 and 15 October) confirms the reduction of the number of delayed flights due to regulation in a given traffic volume, although a few flights remained delayed due to other regulations.
The average number of delayed flights in one traffic volume during the period of regulation activation was confirmed to decrease from 27 to 2 flights (if STAM avoids regulation). The average delay per delayed flight was also reduced from 27min to 10min, as well as average delay per flight from 6 to 1 minute.

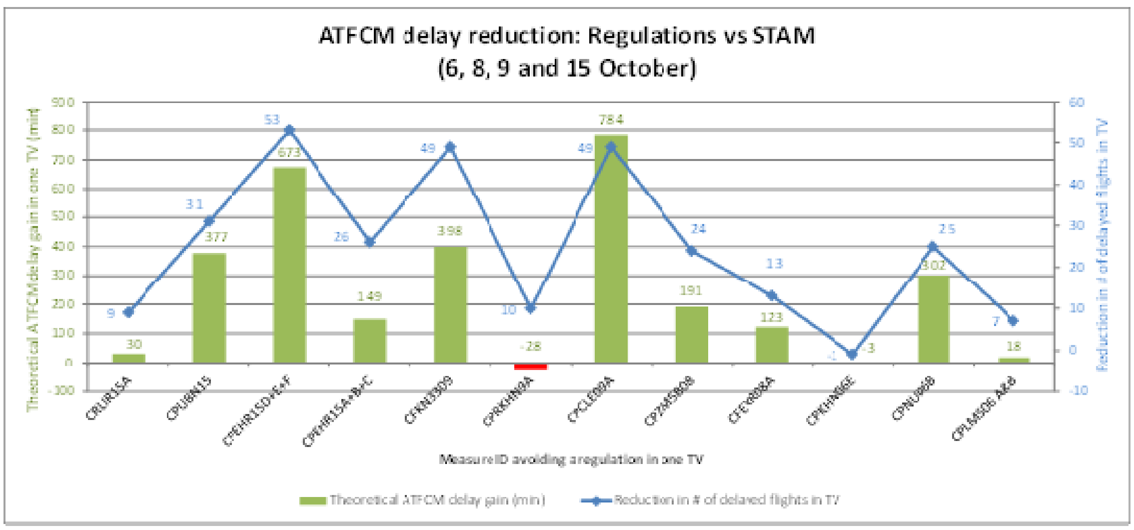

Fig. 5 ATFCM delay reduction

3 Conclusions and next steps

The VP522 STAM live trial provided an excellent opportunity to assess the STAM concept use at a large scale in real operational conditions. The detection of hotspot was straightforward, as well as creation of hotspot in the hotspot editor. The concept needs to differentiate between ATC level short-notice STAM and ATFCM level tactical STAM potentially as a set of tools instead of the single tool offering a generic solution. Workflow and coordination states shall be tailored to the needs of the individual STAM measures. The Role and Responsibility of FMPs in the CDM process and workflow were clear, but roles should be fine-tuned according to the defined STAM scenarios. The Role and Responsibility of the NMOC and the interaction of NMOC and other partners during the coordination process needs to be clearly defined for each individual type of STAM measure. Despite some positive subjective assessments, the overall result was that FMPs were not confident with the use of prototype STAM support tools in operational conditions. Main issues were around the interaction time consumed by measure creation and coordination tasks. It was suggested that development of local tools and predefined scenarios could probably solve 90% of the problems in an adequate time-frame.

Regarding environmental impact assessment, one can conclude that STAM fuel impact is negligible, as it is in the same order of magnitude as other external factors (e.g. weather, vectoring, runway change etc.). The ATFCM delay per flight was reduced in case of CASA regulation avoidance (both delay per delayed flight and average delay per flight). The analysis of ATFCM delay and avoided regulations confirmed the reduction in number of regulated flights.

The trial has created an operational community around the STAM concept in order to match the different approaches and to propose the common consolidated view. It experimented on the usability of the concept at the network scale and exposed the difficulties to overcome before the deployment. It allowed all the actors to gain in STAM application maturity by benefiting of mutual experiences and feedback.

The outcome of this exercise lead to the final SESAR 1 STAM experiment that was run between October 2015 and March 2016, where some of the major shortcomings have been addressed (e.g. development of the local tools, integration with existing FMP working environment, introduction of the predefined scenarios). The STAM concept has progressed well in the SESAR 1 R&D program towards the end of V3 maturity phase, although it still made a few important recommendations for the pre-industrialization phase – to be tackled in the context of the SESAR2020 R&D - see final SESAR Step 1 STAM validation report for details [6].

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