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TURNAROUND INTEGRATION IN TRAJECTORY AND NETWORK: DEVELOPMENT OF AN AIRCRAFT TURNAROUND DECISION-SUPPORT TOOL

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Abstract

The aircraft turnaround is the major driver of aircraft departure delays. To mitigate such delays reliable information sharing between stakeholders involved in the aircraft turnaround process is necessary. Building on Airport Collaborative Decision Making (A-CDM) concept the TITAN project (Turnaround Integration in Trajectory and Network, a project co-founded by the 7th Framework Programme of the European Commission) defines an advanced operational concept to identify improvement opportunities in the information flow between the various aircraft turnaround stakeholders as well as the potential influence of external processes (passenger/baggage flows). After its validation the TITAN operational concept is realised in the airline operational environment by developing a conceptual decision-support tool as a tangible concept view. The TITAN operational concept and tool define a Service-Oriented Architecture (SOA) allowing data to be pushed to aircraft turnaround stakeholders based on their data requirements, and the milestones which they are expected to reach as their contribution to the aircraft turnaround. In this paper, we present a SOA which enhances sharing of a more predictive common awareness of all relevant influences on the aircraft turnaround as means of facilitating more predictable and intelligent decision-making including evaluation and negotiation of possible schedule changes to mitigate aircraft turnaround delays. The procedure to develop a robust and reliable tool capable of enhancing the turnaround process efficiency and providing simultaneous feedback for further work in this scientific field is outlined in this paper.

1. INTRODUCTION

The aircraft turnaround process is defined as a sequence of sub-processes (ground operations activities) required for servicing/handling an aircraft (and all passengers and baggage/cargo/mail it carries) from the moment it arrives at its stand/gate (aircraft arrival) until the moment it leaves it (aircraft departure). The detailed description of duties, responsibilities and tasks, and their relation in this chain of ground operations activities are contained in the aircraft turnaround plan to ensure the safety, security and efficiency of such operations, as well as compliance with the requirements of airlines and relevant authorities. The authority and responsibility to coordinate the implementation of an aircraft turnaround plan is assigned to the aircraft turnaround coordinators; this lies mainly in the jurisdiction of the ground handlers. [6]

Turnaround-related delays remain the main driver of departure delays (FIGURE 1). For the time period 2006-2011 their contribution to primary[1] departure delay at European airports fluctuated between 65%-70% (except for year 2010. Turnaround-related delays were therefore at the origin of more than 1/2 of late departures. [9]

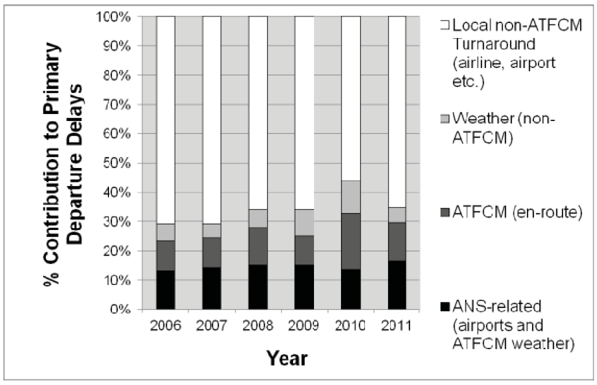

FIGURE 1. Drivers of departure delays [2006-2011] [9]

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[1] Primary delays constituted more than 50% of departure delays (53.3% in 2010 and 54.2% in 2011). Remaining delays are attributed to reactionary reasons (46.7% and 45.8% correspondingly); these are primary delays on earlier flight legs that cannot be absorbed during the flight or the aircraft turnaround process.

In order to mitigate delays stemming from inefficiencies of the aircraft turnaround process all stakeholders involved in it need to be provided with reliable information to better coordinate their actions. A promising initiative in this direction is EUROCONTROL's Airport Collaborative Decision Making (A-CDM) project that leads to more accurate target times through the definition of milestones [3]. However, the shortcomings of this concept can be summarized as follows; each stakeholder still keeps his own data and turnaround external processes such as passenger and baggage flows to the terminal and within it are not yet included. This is where TITAN project steps in. By building on the existing A-CDM logic and enhancing it, it aims at delivering an improved aircraft turnaround operational concept.

The TITAN (Turnaround Integration in Trajectory and Network) project directly addresses the airport operations focusing on the aircraft turnaround process. Its aim is to deliver a new, advanced operational concept (ConOps) to improve aircraft turnaround performance in the following key performance areas; predictability, flexibility, efficiency and cost effectiveness. Furthermore, it is planned to provide a common situational awareness to all stakeholders involved in the aircraft turnaround process. The proposed ConOps has undergone rigorous validation using fast-time simulation and gaming exercises to measure its prospected effectiveness with respect to its target goals. Following the ConOps validation, an operational aircraft turnaround decision-support tool is under development to realize and demonstrate the ConOps in an operational environment.

In this paper, we will discuss the approach of designing and developing as well as considerations of deploying and verifying a tool, which realizes the TITAN ConOps with respect to a particular operational scenario. Section 2 briefly discusses the TITAN project, its operational concept and the validation activities. In section 3 an analytical description of the TITAN Tool is given focusing on the different tool life-cycle phases; from specification and design/architecture to implementation and verification, all steps of an agile procedure. Finally in section 4, the main conclusions of our work are drawn.

2. THE TITAN PROJECT

2.1. The TITAN ConOps [8]

An in depth analysis of the current state of the aircraft turnaround process was established from the key stakeholders involved in it, as a prerequisite for developing the TITAN ConOps. With their assistance, the aircraft turnaround process was analyzed with respect to the sequence of its sub-processes (ground operations) required to service the aircraft during the turnaround. Considered were all sub-processes from the moment the aircraft arrives at its stand/gate (AIBT - Actual In-Block Time) until the moment it leaves it (AOBT - Actual Off-Block Time) including those external services which have a direct influence on it (such as passenger flows to the airport and within its facilities as well as baggage flows). The different aircraft turnaround sub-processes and actors are illustrated in FIGURE 2.

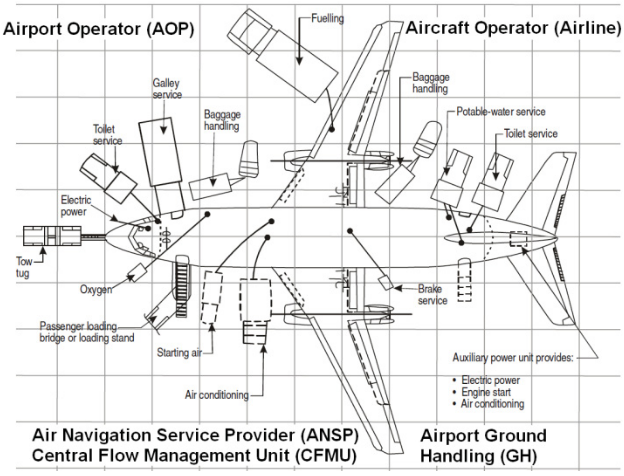

FIGURE 2. Aircraft turnaround stakeholders

Based on the identified stakeholders' needs, the TITAN ConOps was developed to describe different perspectives of performing the aircraft turnaround process by identifying the functions and processes, any interactions and information flows between them as well as all involved actors, their roles and responsibilities. The TITAN ConOps can be realized through the definition of services with specific aircraft turnaround milestones that are encapsulated in the TITAN Information Sharing (TIS) system/platform being the central TITAN data store:

- Passenger/Baggage/Cargo and Mail Flow Information Services (PFIS, BFIS, CMFIS);
- Aircraft Status Report Service (ASRS); and
- Airport Information Report Service (AIRS).

Through the TIS platform any aircraft turnaround stakeholder can access information necessary for the completion of his tasks.

The functional scope of the TITAN ConOps is built upon what has already been implemented in A-CDM by identifying the services and milestones which are additional to those already defined and implemented there. The TITAN services use a shared-information space (TIS) within a net-centric environment, into which they are integrating so that they do not work in isolation. In this context the TITAN ConOps is build upon the following two applications:

- the "TITAN Information Sharing" as an extension of the "A-CDM Information Sharing"; and
- the "TITAN Milestone Approach" as an extension of the "A-CDM Milestone Approach".

Through these means, the TITAN ConOps enhances the A-CDM concept by fully exploiting either existing capabilities or other capabilities that can be implemented in the short term.

Being in full alignment with the European project SESAR (Single European Sky Air traffic management Research) and based on the net-centric design principles of A-CDM and the System Wide Information Management (SWIM), TITAN has developed an advanced ConOps for the aircraft turnaround as an integral part of the aircraft trajectory as a means of integrating airports into the ATM network, also accounting for relevant landside processes.

2.2. TITAN Project validation activities [2]

The TITAN ConOps is validated by applying the European Operational Concept Validation Methodology. [4] According to the TITAN performance framework the following Key Performance Areas (KPAs) are defined:

- Predictability (aircraft turnaround process standard deviation);
- Efficiency (airline operations punctuality);
- Cost effectiveness (aircraft turnaround operational costs);
- Flexibility (predictability and efficiency in unexpected events or planned changes).

Validation of the TITAN ConOps is about demonstrating that integration of the identified stakeholders' requirements as well as concept's alignment with SESAR will contribute to a performance improvement in the above KPAs. As a transversal activity validation is active during almost the entire project. This is depicted in FIGURE 3.

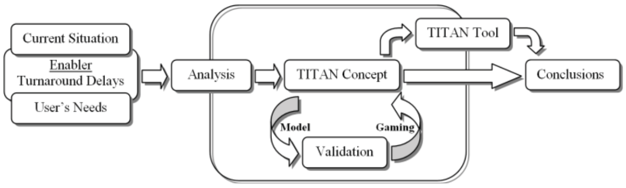

FIGURE 3. Validation activities within the TITAN project [2]

To validate the TITAN ConOps, the following techniques are used:

- *Fast time simulation*

  The selected simulation technique is the Outcome Driven Distinctive Simulation (ODDS), where an aircraft turnaround model is used to conduct a set of exercises to evaluate the degree of achievement of the validation objectives through a set of validation scenarios. Two different models are developed:

  - *Single Aircraft Model*

    It simulates the turnaround process of a single aircraft describing the TITAN turnaround operations, their processes, resources and involved actors and providing KPAs indicator information for individual processes.

  - *TITAN Model (cumulative single models)*

    It simulates the overall aircraft turnaround process in a generic airport, whereby network effects of TIS and A-CDM processes are modelled in order to assess their benefits.

  In both cases the validation scenarios take into account present and future situations of normal or (unexpectedly) disrupted airport operations (i.e. bad weather, delays); different traffic samples; and different airport/airlines/ground handling policies. Two generic scenarios (normal/unexpected situation) and four specific ones are defined, where during the course of the aircraft turnaround process a specific event (unexpected disruption) occurs being modelled as a "forced" delay. Each scenario has two sub-scenarios: one representing the current situation (baseline) and one representing the TITAN concept.

- *Gaming exercises*

  The selected gaming technique is the Human-In-the-Loop (HIL) gaming that allows the definition and exploration of roles and their responsibilities and the interaction of these roles within an automated environment. By focusing on the exploration of the situational awareness and the human-human and human-machine interactions, the feasibility of the information exchange defined in the TITAN ConOps is assessed. Games are played with air transport operation experts acting according to specific roles and interacting through specific processes, focusing the actors' attention on the information flow and the responsibilities associated to the processes. The gaming sessions are designed by defining the scenarios, the actors, the rules, and the results-collecting tools to be applied.

Following the TITAN ConOps validation, the TITAN Tool under development is verified against specified requirements as well as successful realization of the TITAN ConOps in an operational environment.

The validation activities, through which concept maturity is expected to increase, examine whether the proposed concept and all supporting technical enablers are defined at the level of detail required for the development of benefit mechanisms and for the identification of major feasibility and performance-related R&D needs.

3. THE TITAN TOOL

3.1. TITAN Tool specification [4]

3.1.1. Specification of tool requirements

The TITAN Tool is a non-commercial demonstrator software package which aims to prove feasibility and benefits of the TITAN ConOps through a clearly identified verification scenario. It is based on a Service-Oriented Architecture (SOA) concept. The architecture is semi-centralized with *TITAN Information Sharing* (TIS) in the centre and publicly available services in the periphery (PFIS, BFIS, ASRS, and AIRS). [2]

For the sake of the tool's interoperability and A-CDM connectivity, services are prepared to interpret and issue industry-standard messaging formats such as movement message (MVT), loading message (LDM) or weather information (METAR, TAF). System connection points are standard Simple Object Access Protocol (SOAP) or Representational State Transfer (REST) web service interfaces of the different services. A dedicated Hypertext Transfer Protocol Secure (HTTPS) interface of TIS is available for system administration. As the TITAN ConOps puts emphasis on the differentiation of information necessary to the different stakeholders, specialized user interfaces are used for each user class. In addition to specialized user interfaces, the TITAN Tool's architecture allows for different client implementations; both thin (applications displayed in a browser) and thick clients (specialized programs working on one device only) are supported. This architecture is important to ensure that TITAN is attractive from a business perspective. Where computing equipment already exists (e.g. PCs at check-in

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[2] CMFIS, which is part of the TITAN ConOps, is not implemented by the tool.

desks) it can be used for TITAN with no additional cost. In other locations, dedicated hardware that requires a specific client to be developed may be needed (i.e. onboard devices for bus drivers etc.). While there would be some software development effort, the existing hardware can still be used.

3.1.2. Users & levels of information

During the collection of users' requirements, the following aircraft turnaround stakeholders were identified as the main beneficiaries[3]:

- **Aircraft Operator**;
- **Airport Operator**;
- Air Navigation Service Provider (ANSP) and Central Flow Management Unit (CFMU);
- **Ground Handling**;
- Immigration;
- Fuel Company;
- Meteorological Service; and
- Public Transportation Companies.

Different levels of information were established to categorize the information needs of all stakeholders in terms of urgency. The main goal of TITAN is to make the actual status of the aircraft turnaround process visible in each one of its phases, with alerts to distinguish the importance of the information for a set of stakeholders. The levels of information summarized in TABLE 1 were defined to establish the urgency of any action required.

Levels of Information	
Level 0	A (re)confirmation that a given process is running on time.
Level 1	An indication that a process has a delay, but the aircraft turnaround itself is not affected.
Level 2	An indication that immediate intervention is needed to moderate the effects of a process on the aircraft turnaround otherwise the target off block time (TOBT) can't be reached.
Level 3	An indication that urgent re-planning of the whole aircraft turnaround is needed otherwise the target off block time (TOBT) can't be reached.

TABLE 1. Interpretation of TITAN information levels

The classification of information can be done independently by the stakeholders through an End User Application (EUA). As a result, the information at a given client's HMI is displayed according to the stakeholder's needs and information overload is reduced.

3.2. TITAN Tool development

The TITAN Tool development intends to prototype a system architecture, system design, interface design and SOA platform to facilitate information sharing and alerting as specified in the TITAN ConOps. Therefore, the core components of the TITAN Tool development are:

- the defined services with specific aircraft turnaround milestones; and
- the encapsulation of this service information in TIS, the main TITAN data store.

The TITAN Tool is entirely based on a SOA, given that the ConOps is also based on a service approach to push data to the relevant aircraft turnaround stakeholders. Therefore in the TITAN Tool, the services themselves are the core building blocks of the system. They are loosely coupled, with Internet Protocol (IP) infrastructure facilitating asynchronous communications between them. They read and analyze data internally held or externally referenced by TIS, therefore the TIS is the main data source. The services require processes to support the tool's end goals. Some processes apply to all services, whereas some processes are service-specific. All TITAN Tool users must be able to log in and log out, with default subscriptions to one or more of the TITAN services. Subscriptions to the information contained in the TITAN services can then be modified, most likely by a system administrator or a manager. Event handlers are also required to push information to the TIS database from the services, whenever updates are made to the information.

During the tool development, some parts of the real and external world (such as A-CDM systems) are to be emulated due to limited access to these types of systems for development purposes. The vision of the TITAN Tool is that the end user will see it as one or more web pages (applications) that he can interact with. Behind the scenes, server components will manage data persistence, message handling etc. The web-application approach allows several benefits, such as:

- most users can use the tool on existing hardware;
- different platforms can be accessed (such as mobile devices); and
- by selecting the correct technologies, the system can be available to the widest possible audience (not locking to a single operating system/software provider technology).

Furthermore, data displays are intended to be interactive, i.e. a timeline for a particular aircraft turnaround process would open by clicking on the flight's details section in a table of flights.

The development of the tool applies an agile software engineering process, whereby frequent iterations and updates to the tool architecture and design are delivered by implementing data-driven tests for core tool requirements as defined by the verification scenario named "Missing Passenger Scenario". [10]

The verification scenario concerns an aircraft undertaking a normal turnaround process at an A-CDM and TITAN compatible airport. However, the end of the turnaround process is disrupted by some (missing) passengers that fail to board, although they have arrived at the airport and have gone through security control. All appropriate steps are taken to locate them. Through the improved granularity provided by A-CDM and TITAN services, the missing passengers can be located (through their last

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[3] Only the highlighted (in bold) aircraft turnaround stakeholders are planned to be implemented in the TITAN Tool.

trace inside the terminal i.e. at a duty-free shop) and hence the impact on the operation is minimized. Even if they cannot be located on time, the impact of such a time-critical situation on the particular aircraft turnaround process or other processes is minimized.

Within the context of TITAN, the key points to be captured by the tool are:

- *Improved situational awareness*

  All stakeholders have improved access to aircraft turnaround process information to facilitate better decision-making.

- *Highlighting when issues occur*

  When an issue impacting (or potentially impacting) the aircraft turnaround process occurs, affected stakeholders are informed.

3.2.1. TITAN Tool design and architecture

The TITAN Tool architecture and design must incorporate the entities identified in the TITAN ConOps. Therefore the following entities are represented in the TITAN architecture:

- TITAN Information Sharing (TIS);
- A-CDM System as well as eventually other optional 3rd party data providers;
- TITAN services PFIS, BFIS, ASRS, and AIRS;
- customized user interfaces;
- system administrator interface.

The TITAN services are to communicate through standard web services, which will keep the system alive even if some of them need to be shut down for any reason (maintenance). In FIGURE 4, the system architecture for a full production system is illustrated; however, the red-dashed boundary identifies the components that fall within the scope of the TITAN Tool with respect to the operational (verification) scenario.

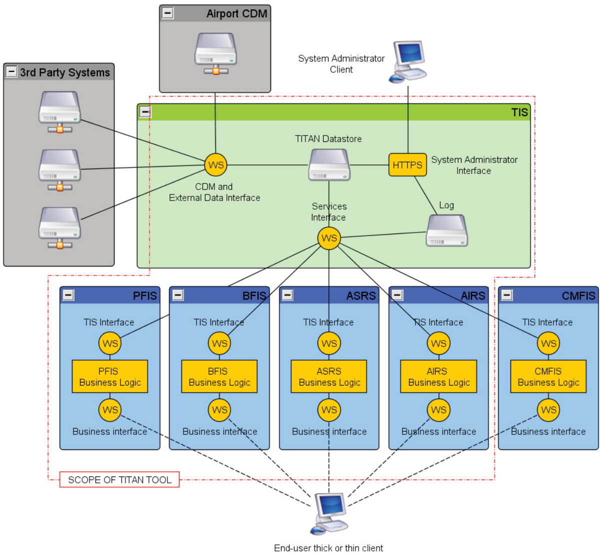


FIGURE 4. TITAN system architecture [4]

The TITAN Tool architecture is reasonably simple. At the back-end, TIS is essentially a large data store containing TITAN-specific information as well as information coming from systems (i.e. A-CDM). The back-end also contains the identified services; each service has the ability to read and write to TIS, and services can communicate with each other through the standard publish/subscribe mechanism. The key points of the high-level architecture are:

- TITAN clients can be either thin clients operating in as wide a variety of web browsers as possible, or purpose-built clients (possibly only one platform, potentially much thicker);
- TITAN server consists of common endpoints for all clients to connect to, a messaging layer for communication between all components, the TIS and its services.

External/3rd party systems can communicate via A-CDM, or directly with TITAN/TIS.

TIS is the central repository for all data related to TITAN and the aircraft turnaround concept. There will be self-contained data records as well as references of 3rd party data in TIS (there is no need to clone data of the underlying A-CDM into TITAN; it is much healthier to only store references in TIS). However, TIS must provide data so that from the services' viewpoint there would be no noticeable difference between the data stored by TIS and 3rd party referenced data. TIS database can be accessed only by asynchronous interface functions (processes) published by TIS. This is necessary for maintaining the adequate level of data security and controllability of the program flow. [1]

A "push" methodology is planned to push data from the server to the client as they change, rather than the client polling or listening for data changes. TITAN messaging consists of messages passed between TITAN and external systems (e.g. A-CDM system) as well as internal messages between TITAN components. Theoretically, a message hub could be utilized to implement TITAN messages. Within the internal messages, there is a small group of messages sent to/from a user's browser in order to retrieve and update data within the TITAN tool. These messages must use standard web protocols in order to be supported by the widest possible range of browsers without relying on additionally installed software.

Communication with external systems is not expected as an outcome of the TITAN Tool implementation. The design of the TITAN Tool considers the future integration of such a tool into an operational environment. A set of interfaces and Application Programmable Interfaces (APIs) are developed as part of the tool interfaces, which could facilitate intercommunication between TITAN, A-CDM tools and potentially any other 3rd party tools.

For effective use of IT resources, the TITAN Tool framework applies an event-driven concept. Events can be generated externally (end-users; hooked 3rd party data providers; system administrators), or internally (service requests to the TIS; TIS notifications to the services). An example of the event routing model can be seen in FIGURE 5. It is the role of the Service Event Handler to translate user events into user database create, receive, update, delete (CRUD) requests, whereby all database-related events must be captured by TIS Event Messenger to notify the subscribed parties.

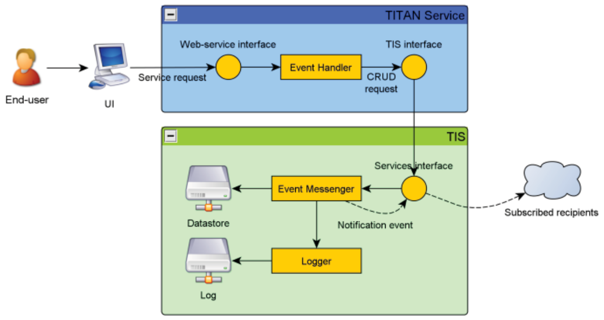
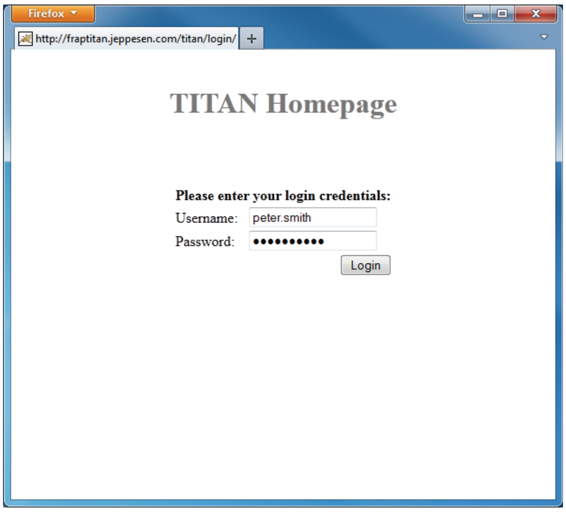


FIGURE 5. Event routing example [4]

3.2.2. TITAN Tool implementation

The TITAN Tool is currently under development with a prototype of the concept expected to be delivered by the end of 2012. Within the current architecture, TITAN Tool users will represent most of the actors involved in the aircraft turnaround process (identified in the TITAN ConOps).

On logging into the system (FIGURE 6), users' credentials are linked to their role which describes the services, and access to the data they can modify. With the requirements for the data and services the users can access, the milestones which they have a direct influence on are also known. Through the TITAN system, the stakeholders have the opportunity to view progress on milestones and processes within the aircraft turnaround. This information is easily accessed through the summary view of all flights being processed at the airport (FIGURE 7) where a row represents a flight pair. Basic information such as flight status, flight number, to/from designators and estimated in/off block times (EIBT and EOBT) are given. The implemented colour coding gives users immediate access to information on flights which are experiencing delays. With this simplified view of aircraft turnaround processes, ease of access to flight information allows turnaround delays to be mitigated and steps can be taken to correct them by reallocating resources; or by better informing involved actors of priority events or actions necessary to meet the key milestones for each aircraft's turnaround.



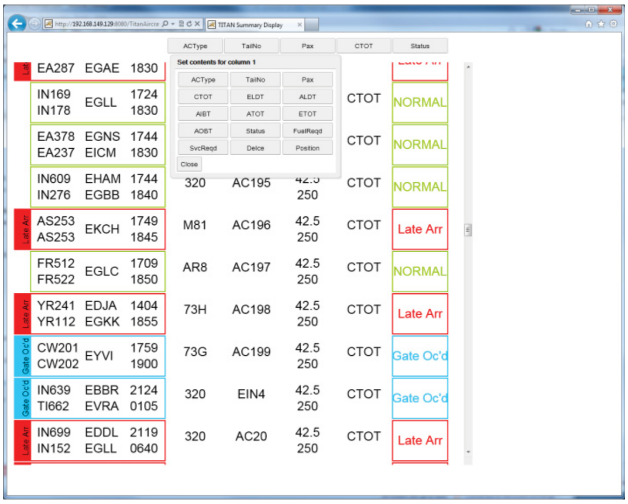
TITAN Homepage

Please enter your login credentials:

Username: peter.smith

Password: ••••••••••

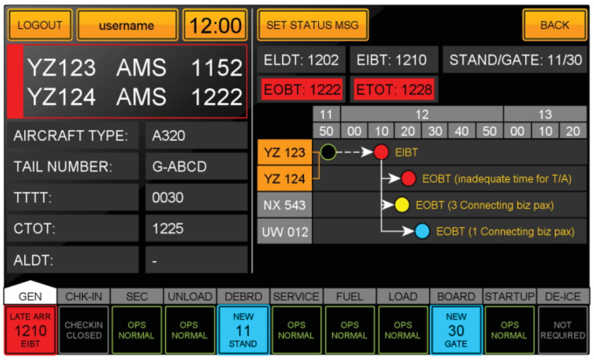
FIGURE 6. TITAN Tool simple login screen



				ACType	TailNo	Pax	CTOT	Status
Lat	EA287	EGAE	1830					
	IN169 IN178	EGLL	1724 1830				CTOT	NORMAL
	EA378 EA237	EGNS EICM	1744 1830				CTOT	NORMAL
	IN609 IN276	EHAM EGBB	1744 1840	320	AC195	42.5 250	CTOT	NORMAL
Late Arr	AS253 AS253	EKCH	1749 1845	M81	AC196	42.5 250	CTOT	Late Arr
	FR512 FR522	EGLC	1709 1850	AR8	AC197	42.5 250	CTOT	NORMAL
Late Arr	YR241 YR112	EDJA EGKK	1404 1855	73H	AC198	42.5 250	CTOT	Late Arr
Gate Oc'd	CW201 CW202	EYVI	1759 1900	73G	AC199	42.5 250	CTOT	Gate Oc'd
Gate Oc'd	IN639 TI662	EBBR EVRA	2124 0105	320	EIN4	42.5 250	CTOT	Gate Oc'd
Late Arr	IN699 IN152	EDDL EGLL	2119 0640	320	AC20	42.5 250	CTOT	Late Arr

FIGURE 7. Sample TITAN Tool interface - summary view

A flight-pair strip from the summary view can be further selected for an in depth analysis of the turnaround process details; the details view is provided with clickable tab areas to indicate turnaround milestones with active textual content (FIGURE 8). When process details are further selected for a flight-pair strip, the different levels of information can report on the severity of a delay; information is either contextual (no delay) or information that indicates the current user needs to take action to mitigate the delay. In the example of FIGURE 8, the provided information is of level 3, with the corresponding tab coloured in red to indicate that delay is unavoidable, as a delay of 18 minutes does not allow turning the aircraft around in the remaining 12 minutes. In this case, the client should also identify any additional flights that are affected by this. Say there are two flights departing with connecting business passengers on board of the delayed arriving flight. In the Gantt section of the interface, the scheduled EOBT of the first connecting flight is highlighted in yellow, indicating that immediate action is needed for its on-time departure if it is expected to wait for the arriving passengers (i.e. sending an electric car to the de-boarding gate to collect the passengers inside the terminal). On the other hand, the second connecting flight departs a bit later and for that reason it is highlighted in blue indicating that some action will have to be taken to start the flight on-time. If there is any information that the current user has write access to, this information can be also provided.



YZ123 AMS 1152
YZ124 AMS 1222

ELDT: 1202
EIBT: 1210
STAND/GATE: 11/30
EOBT: 1222
ETOT: 1228

AIRCRAFT TYPE:	A320
TAIL NUMBER:	G-ABCD
TTTT:	0030
CTOT:	1225
ALDT:	-

GEN	CHK-IN	SEC	UNLOAD	DEBRD	SERVICE	FUEL	LOAD	BOARD	STARTUP	DE-ICE
LATE ARR 1210 EIBT	CHECKIN CLOSED	OPS NORMAL	OPS NORMAL	NEW 11 STAND	OPS NORMAL	OPS NORMAL	OPS NORMAL	NEW 30 GATE	OPS NORMAL	NOT REQUIRED

FIGURE 8. Sample TITAN Tool interface - details view

As different stakeholders involved in the aircraft turnaround process require different views and level of detail of the available information, the TITAN Tool will combine a customizable client for the most common role requirements with special clients which can be configured for special needs. This allows user views and preferences to be created and stored for convenient access to the right information for each stakeholder. It is proposed that display configurations are stored in TIS user accounts on the server, so that users working in different areas of the airfield can re-access the stored configurations whenever they need to(which is not uncommon in an airport environment). Key milestones which are part of A-CDM can also be accessed and viewed via the TITAN Tool through a set of interfaces. Service-oriented interfaces are being designed to allow the flow of external information into and out of the TITAN Tool. A conceptual rule of the TITAN Tool is that it is not intended to issue commands, especially for events which are external to the aircraft turnaround. However, as changes spread through the system from ACDM into TITAN, the involved TITAN services are notified and changes are reflected in the user interface. The updates to the TITAN service information regarding turnaround milestones should give stakeholders more visibility into the aircraft turnaround process, facilitating improved ability to mitigate potential delays and offering more transparency to the aircraft turnaround process.

The tool is being developed as a web-based client application. The hosted solution involves a standard web-based infrastructure (Apache, HTML 5 enabled browsers) to allow clients to access the tool and its information from standard terminals, or mobile devices such as tablet PC's or web-enabled mobile phones. Ideally the tool will be optimized for touch-enabled displays for ease of access to those stakeholders who are mobile.

3.3. TITAN Tool verification [7]

The TITAN Tool is developed to realize the TITAN ConOps and demonstrate the feasibility of an aircraft turnaround tool to assist with more effective decision-making in the airline operational environment. The correct behaviour of its components in an A-CDM environment against pre-defined requirements will be verified as means of proving accomplishment of the above goal.

The selected verification technique is a hybrid form of testing and demonstration. An agile and iterative process of development, implementation and verification is followed, where the above activities are interrelated and for that reason continuously reviewed and refined. Following software code inspections during tool development, executable tool sub-releases will be verified too, preceding verification of the final tool release.

The TITAN Tool focuses on a particular operational scenario referred to as the “Missing Passenger Scenario” [10], and so verification takes into account all processes that take place between aircraft in-block and off-block times and the corresponding milestones as well.

Specification-based black box testing will be used for verifying tool behaviour against specified requirements:

- functional requirements
    - general/system requirements
    - specific/HMI requirements
- non-functional requirements

So called test (use) cases are set to verify the tool against the specified requirements; different functions are logically grouped together and tested according to specific performance criteria. They are defined in absolute accordance with the verification scenario and the aircraft turnaround stakeholders and functionalities to be implemented by the tool. In each test (use) case each stakeholder should be able to use particular functionalities of the TITAN services in the selected operational environment for providing/getting any necessary information, while all other actions are emulated (event emission according to a predefined schedule embedded in the system). The outcome of the test (use) cases should verify that the TITAN tool is able to push appropriate data to different users in order to enable the scenario's main goal to be met; whether the missing passenger is found and boarded or not, the TITAN tool assists/supports all involved stakeholders in decision-making by making them aware of the situation and its impact on the particular flight or any other affected aircraft turnaround process and enabling them to minimize or even eliminate it.

4. CONCLUSIONS

Realizing the TITAN ConOps in an operational environment, the TITAN Tool builds on a SOA to allow data to be pushed to the required aircraft turnaround stakeholders based on the data requirements associated with their operational access level. Accessing the information sharing platform of TITAN (TIS) through the TITAN Tool Graphical User Interface gives all involved stakeholders the opportunity to share common situational awareness of the progress of the aircraft turnaround processes. With a tool giving better access to more information indicating the ability to reach aircraft turnaround milestones, more predictable and intelligent decision-making can be facilitated by all involved stakeholders and turnaround delays can be reduced. The results of the tool design, architecture and development processes are intended to give input to a cost-benefit analysis too, allowing assessment of the potential benefits such a tool could offer in an operational environment.

Although the TITAN project is still in progress and planned to be completed by the end of 2012, there is no doubt that with improved management of existing airport infrastructure being the only sustainable solution left for capacity-constrained hub airports, increasing the efficiency and predictability of the aircraft turnaround can be nothing less than promising.

REFERENCES

[1] Butcher, J. (2011), *TITAN WP4 Data Required Document*, JEPPESEN, Melbourne.

[2] Etxebarria, I., & Koolloos, M. (2011), *TITAN Validation Strategy - Issue 1.0*, ISDEFE, Madrid.

[3] EUROCONTROL (2012), *European Airport Collaborative Decision-Making* [online], Available at: http://www.euro-cdm.org/ [Accessed at 23.07.2012].

[4] EUROCONTROL (2012), *European Operational Concept Validation Methodology (E-OCVM)* [online], Available at: http://www.eurocontrol.int/valfor [Accessed at 23.07.2012].

[5] Gurály, R., et al. (2012), *TITAN Turnaround Tool Specification Document - Issue 0.7*, SLOT, Budapest.

[6] International Air Transport Association (IATA) (2009), *IATA Technical Reference Manual (ITRM)*, IATA, Montreal-Geneva.

[7] Katsaros, A., et al. (2012), *TITAN Turnaround Tool Verification Plan Document - Issue 0.7*, RWTH Aachen University, Aachen.

[8] Luis, S., Sáez, A., & Serrano, L. (2010), *TITAN Operational Concept - Issue 1.0*, INECO, Madrid.

[9] Performance Review Commission (PRC) (2012), *Performance Review Report 2011 (Draft Version)*, EUROCONTROL, Brussels.

[10] Zerkowitz, S. (2010), *TITAN Turnaround Scenarios - Issue 2.0*, BLUSKY SERVICES, Brussels.