TITAN

Turnaround **I**ntegration in **T**rajectory **A**nd **N**etwork

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EXECUTIVE SUMMARY

The TITAN Air Transport System Integration Documents (TASID) define the details of integrating the output of TITAN into the information stream of the different partners concerned with the turnaround process as well integration with the business trajectory. The TITAN related transition considerations are also described.

The TASID comprises four documents as follows:

- Integration plan Airline Operations Centre (AOC)
- Integration plan airport operations
- Integration plan business trajectory
- Transition considerations

This volume is the integration plan for the business trajectory.

In view of the large variety of environments in which TITAN will operate, the description is kept at a relatively high level. At the same time, the aspects of integration that are common to all partners and environments (called integration vectors) have been specifically identified and described in more detail. These set the scene for all TITAN integration and transition activities and their thorough understanding is essential in order to plan and execute the integration task.

A detailed description of the business trajectory and its lifecycle is given, the details emphasized from the perspective of TTAN. The document continues with setting out how the business trajectory is represented in TITAN and what the main interactions are between the business trajectory and TITAN.

Since TITAN is built from the ground up with a view of incorporating the business trajectory, integration in this context refers more to a description of how the business trajectory is embraced by TITAN, rather than guidance on how it should be done.

1. INTRODUCTION

1.1 Purpose of the Document

The purpose of this document is to give a high-level description of how the concept and practice of the business trajectory and TITAN relate to each other.

The contents of this document are not prescriptive. This is guidance only, meant to be used with due consideration of the prevailing local circumstances while keeping in mind at all times the need for interoperability between the partners concerned.

1.2 Target Audience

The integration as such is shown in the form of descriptions and suggestions for the way forward, expressed on a relatively high level. This is not an implementation guide. The target audience is therefore experts concerned with improving the turnaround process and considering adding a TITAN tool to their arsenal.

1.3 Structure of the Document

The document has been structured in such a way that it leads the reader through the most important aspects of integration in a logical manner. At the same time, the main chapters have been made into elements that can also stand on their own, supporting both general reading and focused use of the document.

Following this introduction, a chapter is dedicated to describing what TITAN really is and how it will work. This is achieved by a short summary of the TITAN concept of operations (ConOps). The meaning of integration in the TITAN context is also contained in that section.

A large part of the document is devoted to describing the so-called integration vectors. These are in fact areas of activities common to the integration effort of all the partners and which need to be understood and taken into account for successful integration.

The essence and life-cycle of the business trajectory is described in detail to ensure a good understanding of the importance of this concept and its relationship with the TITAN concept of operations. After setting out how the business trajectory is represented in TITAN and what this means in practice, the document concludes with describing the main interactions between TITAN and the business trajectory.

It is highly recommended that users consult also Chapter 3 of the other TASID volumes (integration plan airport operations, integration plan shared business trajectory, transition consideration), as those contain information that is of interest for all partners. Chapter 3 is the subject specific chapter in each of the TASID volumes.

1.4 References

When creating this document, the following source material was used as reference:

- TITAN_WP1_INE_DEL_04_v0.2_Operational Concept (Issue 2)
- TITAN_WP4_SLO_DEL_01_v0.7_Turnaround_tool_specification_document
- SESAR “Airport Detailed Operational Description (DOD) Step 1”

- SESAR Factsheet No2/2010: Business Trajectory/4D Trajectory
- SESAR Factsheet No3/2010: System Wide Information Management
- CSIS/World Resources Institute “Managing the Transition to a Secure, Low-Carbon Energy Future” (Ladislaw, S., Zyla, K., and Childs, B. (2008)

1.5 Glosary of Terms

Acronym	Meaning
A-CDM	Airport Collaborative Decision Making
ADL	Additions and Deletions List
AIP	Aeronautical information publication
AIRS	Airport Information Report Service
ANSP	Air navigation service provider
AOC	Airline Operations Center
AOP	Airport Operations Plan
APOC	Airport Operations Centre
ASRS	Aircraft Status Report Service
ATM	Air traffic management
ATS	Air traffic services
BFIS	Baggage Flow Information Service
BRS	Baggage Reconciliation System
CDM	Collaborative Decision Making
CMFIS	Cargo and Mail Flow Information Servie
CPDLC	Controller/Pilot Digital Link Communications
CUTE	Common Use Terminal Equipment
DCS	Departure Control System
DPI	Departure Planning Information (message)
EC	European Commission
ECAC	European Civil Aviation Conference
EUROCAE	European Organization for Civil Aviation Equipment
EUROCONTROL	European Organization for the Safety of Air Navigation
FAA	Federal Aviation Administration
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisations

LDM	Load Message
MVT	Movement Message
N/A	Not applicable
NOP	Network Operations Plan
PFIS	Passenger Flow Information Service
PNL	Passenger Name List
PNR	Passenger Name Record
RBT	Reference Business Trajectory
SBT	Shared Business Trajectory
SITA	Société Internationale de Télécommunications Aéronautiques
SOA	Service Oriented Architecture
SWIM	System Wide Information Management
TIS	TITAN Information Sharing
TOBT	Target Off-Block Time
TTOT	Target Take-Off Time

2. UNDERSTANDING TITAN AND ITS INTEGRATION

2.1 Understanding TITAN

2.1.1 The purpose of TITAN

From the integration perspective TITAN should be seen as a decision making support system that receives information from its environment, processes it and then generates decision-making support for its users (airlines, airports, air traffic management, etc.) with the aim of making the turnaround process more predictable, efficient, flexible and cost-effective while also increasing the overall situational awareness of partners who make use of TITAN.

2.1.2 The TITAN Operational Context

TITAN is meant to add value to the existing environment and hence its chief operational context should be seen as an airport where airport collaborative decision making (A-CDM) has been fully implemented.

2.1.3 The TITAN Concept of Operations

The most important feature of the TITAN concept of operations is the embracing of trajectory-based operations that include also the ground part of the aircraft trajectory. When the aircraft is stationary, its trajectory continues to evolve but only in the time dimension. This means that the turnaround itself can be seen as a period during which the trajectory needs to be managed and during which the trajectory is subject to various influences exerted by the turnaround activities. By making these influences visible in more detail, e.g. by including landside influences too, TITAN enables a much finer management of the trajectory (via the time dimension) during the turnaround.

By introducing the trajectory view into the turnaround, TITAN also helps in building a more consistent overall view of an aircraft's movements within the air traffic management environment.

2.1.4 Net-Centricity and Service Orientation in TITAN

Net-centricity can be summarized as an arrangement of information exchange interconnections where each information generator and information consumer is a node on the global network, sharing a virtual information space. This is in contrast with the traditional, point-to-point connection paradigm which is a very rigid arrangement where adding new partners is cumbersome and expensive. Net-centricity also implies that information is properly managed both on the level of the network and on the level of the information providers and users. TITAN relies on the System Wide Information Management (SWIM) concept and principles to ensure proper information management. This is achieved by using standard information exchange models in TITAN, making it suitable for operation in environments where SWIM has already been implemented as well as legacy environments with the addition of standard translation facilities.

To have a better understanding of the turnaround process on both the business/operational and the IT levels, TITAN is using a service-oriented approach to describing the turnaround, however, IT services are out of scope in TITAN. A service in TITAN is understood to be something you need for the processes that make up the turnaround to be executed. Services typically deliver information about aspects of the turnaround that are essential for its successful completion. The initial set of services defined for TITAN are the following:

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

Service orientation means that it is always possible to define additional services and implement them in the TITAN environment with minimum effort. In any case, the services that have been defined cover most foreseeable requirements so that all information about aspects of the turnaround that are essential for its successful completion is delivered.

For instance, the Passenger Flow Information Service will monitor the passenger flow and react to any observed or likely disturbance. Such reactions may be the publishing of information about congestion for example. These services provide a much more refined, real time picture of the evolution of certain critical aspects of the turnaround than milestones on their own can.

2.1.5 The TITAN Model and the TITAN Tool

An important output of the TITAN project is the TITAN Tool, which is in fact a decision-support tool that enables the turnaround partners using it to exploit the information rich environment created by the fine granularity of TITAN through its additional milestones (compated to A-CDM). Interpretation of the information is undertaken by the logic embedded in the TITAN model, which is also a product of the project.

2.1.6 The End Users of TITAN

The information delivered by the TITAN services is processed and an appropriate output is generated. This output is made available by being published in the shared information space. The output is always relevant to the turnaround of a particular flight but TITAN as such does not determine how the information is to be used.

Accordingly, the end user may be a human or another application in a CDM environment.

2.2 Understanding Integration

2.2.1 What is the meaning of integration?

To understand the meaning of the word “integration” in the context of TITAN, we must keep in mind that TITAN is primarily meant to add value in environments where A-CDM is already fully operational. This also means that the CDM related procedures and institutional arrangements are presumably in place. So integration involves creating of additional inputs (e.g. from the landside) required by TITAN and building the additional “intelligence” into the existing applications to enable them to use the output of TITAN.

The concept of publishing TITAN output into the shared information space as defined in SWIM results in a very flexible integration concept, since users are free to utilize TITAN output as and when it best fits their needs.

In legacy environments the need to create direct interfaces with TITAN increases the costs and results in a less flexible arrangement, even if the functional utility and benefits of TITAN are not adversely affected.

It is important to note that at its simplest, the integration of TITAN into the air transport system means creating the ability to use TITAN in terms of feeding it with the required input information (including new elements) and enabling end-user applications to make use of the processed information published by TITAN. Where an instance of TITAN is actually running is of secondary importance.

2.2.2 Legacy ATC Environment considerations

Today's ATC environment supports the operations of the airport, but it does not integrate it into the regular ATC operations. This situation results in separate planning processes for both ATC and the airports that generate unwanted inefficiencies in terms of time and cost efficiency. TITAN will address these issues from the turnaround point of view.

Instead of providing a full list and description of all the elements that are part of the airport, the following text highlights those areas that are required for the implementation and operation of TITAN. The reader is referred to the TITAN document D1.1 for a complete description of the current turnaround concept and its associated environment.

- The Tower Runway Controller is the authority for assuring safe operations on the runway.
- Surface movement operations rely on the "see and avoid" principle as the primary mean to ensure the safety of surface movements.
- Controllers are responsible for issuing information and instructions to aircraft under control in order to assist pilots to navigate safely and timely on the airport surface.
- Controller/pilot digital link communications (CPDLC) will increasingly be used for routine communications.

Voice communications are used for time critical and tactical clearances.

2.2.3 Network management considerations

With the progressive implementation of the Functional Airspace Blocks (FAB), air traffic flow management is undergoing a fundamental change. Tactical ATFM will be more and more performed on the FAB level while the ATFM network as such will be managed by EUROCONTROL. These changes will impact A-CDM in time since the Departure Planning Information (DPI) message exchange with the CFMU as originally defined may undergo certain changes as the overall ATFM arrangement evolves.

Since the TITAN generated output is meant to be used only after proper interpretation by an end-user application or human being and because the output is not meant to be sent directly in messages to any flow management unit or position, changes in the overall network management setup are of no concern to TITAN.

Conversely, the enhanced performance of CDM made possible by TITAN will mean a better network operation and hence TITAN must be seen as an important enabler of improved overall air traffic network management.

2.2.4 SESAR environment considerations

Even though the Operational Concept presented in TITAN could be implemented in part at this moment, its full advantages will become available once Step 1 from SESAR becomes operational. At that moment, it is expected that airports will be fully integrated into the ATM Network, becoming a system node whose integration will be the key to accommodate the linking of multiple business trajectories executed by a single aircraft in order to prevent knock-on effects caused by delays early in the execution phase.

The trajectory provided by the aircraft system will be "take off to landing" (e.g. Flight Management System (FMS) output) and will not include ground segments or turnaround times. However the airport will not be considered as a start or end, but as part of a continuum. Monitoring of aircraft movement and handling on the ground will be part of the Airport Business Trajectory linking two flight segments of two different trajectories as a single continuous trajectory.

The airport will be required to accommodate the forecast traffic increases, in a safe manner, eliminating or recovering system delay, while providing levels of safety above today's standards and respecting the agreed flight schedules.

The main change to current surface movement operations is the transition from the "first come – first served" principle to an increased adherence to a predefined schedule of surface movement (Reference Business Trajectory) for the planning and execution of departure movements ("on time first served").

More information will be available to the pilots on-board to ensure a safe, expeditious and efficient movement on the ground. A-SMGCS will allow accurate surveillance and precise control of traffic on the surface. System features will include traffic advisories and alarms (safety nets) to reduce the risk of runway incursions and ground collisions, while providing guidance and situational awareness to pilots and vehicle drivers. Associated HMI will improve controller situational awareness, assisting in planning and routing of ground movements and allowing enhanced control of traffic in Low Visibility Conditions (head down).

A range of technical and procedural solutions, both ground and airborne, will support the safe and efficient management of the runway, taxiways and apron/stand areas in all weather conditions, achieving throughput rates, equal to or close to the best throughput rates achievable in good weather conditions and with a homogeneous aircraft traffic sequence.

2.2.5 External Partner considerations

Most of the passengers using air transport utilize other transport means such as train, private car, taxi or, underground to access the airport facilities. Some of the passengers arrive at the airport using public transport, shuttle buses from hotels, and some others using their own vehicles. Transport connections with the airport can have a direct impact on turnaround predictability. If real-time information regarding the status of those connections is available, appropriate decisions can be taken in advance to mitigate their impact on the turnaround. Public transport is normally subject to close supervision by dispatch services of the companies themselves or national organizations established for this purpose and these have information about the status of the road and railway network such as traffic jams, road conditions, etc., and this information can be used to predict more precisely when passengers will arrive at the airport for check-in, or go directly to security if they had checked-in at home.

The most useful information a passenger can offer for TITAN purposes is *where* the passenger is coming from, *when* the passenger will start the trip to the airport, by *which* means of transport will he or she arrive there, whether he/she has performed the check-in on-line and if so, whether he/she plans to deliver luggage in the fast-drop lane. Once the origin and destination (airport terminal) are known, the estimated time of arrival can be calculated using the public information mentioned above. Delivered to the partners involved in the turnaround in raw form or processed into deduced information, such external intelligence can provide important additional support to the turnaround decision making. After arrival at the terminal, the passenger interacts with a number of processes, each of which is time critical from the turnaround's point of view. This is why the passenger arrival time at the terminal bears such importance and why it is worth monitoring.

The collaboration of passengers in providing the required data is essential, although some information could be provided also by a common system used by the different means of transport and hotels already before leaving the starting point of their journey to the airport. Conversely, passengers could also be informed of some unexpected events regarding their flights or any other constraints that could be significant for them when getting to the airport. If a flight is two hours late for example, passengers could be notified and they may consider going to the airport later.
Currently, very few external partners are involved in providing information for aeronautical purposes. When they are signed on, the timeliness and accuracy of their information will need to be validated and its quality constantly supervised. Such information is not safety critical, however, it is critical from an economic point of view and the potential for avoidable costs (as a result of wrong decisions) must be minimized.

2.2.6 Non-ECAC environment considerations

Since TITAN is meant as a tool for, among others, airlines, it must be assumed that at least in some cases it will be used by companies whose AOC is not located in the ECAC area and which are operating flights into and out of that area. The turnaround process of such flights at an ECAC airport is of course a legitimate target for such a TITAN instance, however, the data concerned may potentially be subject to EU information privacy rules. This needs to be taken into account as part of the information management arrangements.

2.2.7 Transition considerations

In a true SWIM environment information sources, including new landside sources, publish their data into the shared information space as does TITAN its own output. TITAN will, if a certain item of information is not (yet) available, compensate in some acceptable way (determined locally for the particular implementation or built into the tool in the case of an off-the-shelf version) and so a TITAN tool can be implemented even if not all the input information is available. Once all sources are operational, TITAN will be able to gather all the information it needs and itself become fully operational. Until such time it may signal that its outputs are not yet fully in line with the specifications.

On the output side, again in a true SWIM environment, the TITAN generated output will be published into the shared information space without any need for TITAN to be aware of who will be using the output, which also translates to a very smooth transition procedure.

Making the legacy environment capable of working with the shared information space is one of the hurdles to overcome. Similarly, if TITAN's output is used in a legacy system, modifications will need to be made in that system which impacts the overall planning.

The nature of TITAN is such that while it can potentially improve the situational awareness of the partner using it as compared to those who are not, any operational conflict can be easily overcome during the transition phase via good agreements between the partners which are also followed up vigorously.

In fact such mismatches between partner awareness and the corresponding higher quality of information will probably be one of the automatic marketing features of TITAN once it is out in the field.

2.2.8 The integration vectors

Integration vectors are in fact specific areas for which the integration considerations and integration activities must be defined. They are called vectors because they indicate the direction of the activities and also their timeframe. In this document we have specified the most important vectors which will generally be required. However, each implementation is unique in as much as some vectors may not be applicable at all and some new ones may need to be defined.

The integration vectors are common to each and every partner in as much as they will all have to consider at least the vectors contained in this document when planning their specific integration activities on the understanding that some vectors may not be applicable in a given situation while in others, additional vectors may need to be defined to satisfy the prevailing requirements.

In the following we will touch upon the most important vectors, explaining their significance and providing some guidance on how to approach them during the integration activities.

2.2.8.1 Operational Procedures

Current operational procedures are set up within a framework of a relatively imprecise turnaround operation and even with A-CDM, the granularity is refined only with the milestones. The various services introduced by TITAN will refine the picture much further, among others affording visibility of selected aspects of the turnaround also between the milestones, not to mention the capturing of the influence of factors totally ignored previously.

In an environment served by TITAN developing problems will be recognizable much earlier on the one hand and also much more frequently on the other. To make use of this enhanced granularity, a more instant and flexible reaction is needed. Operational procedures developed for the previous, less precise environment may not always be sufficiently speedy and flexible in which case the usefulness of better information is negated by the inadequacy of the procedures.

It is therefore essential that in parallel with the introduction of TITAN a thorough analysis of the existing operational procedures is also undertaken and changes made as necessary to make them suitable for working with TITAN.

2.2.8.2 Human machine interface

As a general rule, partners do not like to add new displays to what already exists on their desks or is built into their consoles. It is therefore a strongly recommended general principle that the introduction of TITAN be considered without creating a need for an additional physical display. If at all possible, any new information that becomes available as the result of TITAN's implementation should be made available/displayed in windows on already existing physical displays.

2.2.8.3 Training and reform thinking

The introduction of TITAN does not entail specific training for the end-users and only minimal training (probably in the form of web-based self study) for the IT personnel. On the other hand, TITAN introduces new concepts and approaches to collaborative decision-making, including the integration in trajectory-based operations, extended scope of services, etc. It is important that users on all levels become fully familiar with the essence and significance of these new features to enable them to make maximum use of the benefits they provide.

It is probably not necessary to arrange specific training for the personnel but a well-constructed, comprehensive brochure would appear to be required and will probably be sufficient.

2.2.8.4 Institutional

Institutional considerations will arise in particular due to the new information sources (e.g. on the landside) and the eventual involvement of new partners, some of whom may not have been part of the A-CDM environment in the past. To take an example: information on the transportation means serving an aerodrome, including the state of traffic on the motorways concerned, is probably available already but it may be under the purview of different organizations, state or local authorities etc. who may or may not be ready to share this information or demand payment and so on. It is important that timely and effective arrangements are made between all partners concerned to ensure the availability and use of information required and provided by TITAN.

2.2.8.5 Marketing

Experience with the introduction of the A-CDM concept has shown the importance of proper marketing. Although the benefits were not disputed (indeed, they have been demonstrated over and over again), the sheer inertia of the partners concerned was in most cases a major obstacle to be overcome and this was possible only with excellent marketing and the finding of an effective local leader (usually the airport or an airline) to provide the initial motivation and funding.

The benefits of TITAN can be demonstrated equally easily and the business case is clear. However, those benefits are only incremental above what A-CDM has already provided and so the importance of proper marketing and convincing of the partners is as important, if not even more important, than was in the case of A-CDM.

A credible, impartial agent is best employed to deliver the marketing activity and having early reference sites is probably a good idea as these can demonstrate the real capabilities of TITAN while also providing a ready comparison with A-CDM on its own.

2.2.8.6 ATC Systems

From an ATC point of view, the TITAN Concept may improve turnaround process predictability helping airlines and ground handlers to enhance their activities in order to ensure accurate target times. TITAN results are seen as applicable in the long-term complementing the SESAR concept with the aim of integrating the turnaround process into the business trajectory.

TITAN services are seen as a powerful tool that provides information that can be customized enabling each stakeholder to receive the most appropriate data to share common situational awareness at the airport. Tower controllers consider that TITAN results will have an indirect impact on their operations; however TITAN is not enhancing controllers' way of working, as the only trigger required by the controller comes from the pilot.

ATC performs a tactical task whose trigger is the aircraft situation acknowledgement, known through the first flight crew communication. Tower controllers are interested in Target Off-Block Time (TOBT) and Target Take-Off Time (TTOT) that will be directly communicated by the flight crew. The final responsibility over aircraft status belongs to the pilot, so until the pilot requests a clearance for start-up, the controller will not perform any action over that aircraft and will not monitor aircraft status during the turnaround. For planning proposes, ATC works under the hypothesis that the flight will be on time, unless the pilot announces a delay in the first communication. Consequently, the inclusion of TITAN feedback in the tower – e.g. through HMI- may cause excess information for the controller working position leading to a higher workload without adding extra value.

The following diagram shows the communication process between the pilot and the controller summarizing what is explained above.

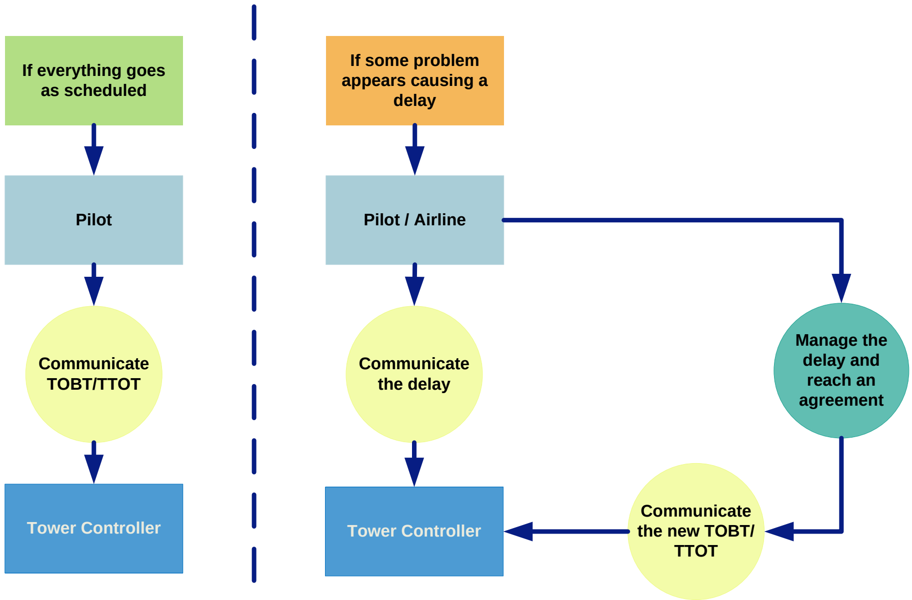

Figure 1: Communication process between the pilot and the controller

From the above it is clear that TITAN integration into the ATC system makes sense only if a specific requirement for information TITAN provides can be identified. On the other hand, air traffic control always benefits indirectly from more predictable turnarounds and early announcement of possible delays, since this enables better planning for ATC also.

2.2.8.7 Airport CDM Systems

As a result of the way Airport CDM was initially implemented, there is little commonality between the various solutions. Their ability to exchange DPI messages with the central unit for air traffic flow management is standardized but they are not as a rule built along the SWIM principles. It is therefore likely that most legacy A-CDM environment will require some kind of dedicated interface to enable them to use TITAN output. It is strongly recommended, however, that updates to the environment are made in a direction that would bring them closer to the SWIM principles rather than perpetuating the legacy solutions.

2.2.8.8 Airport Operations Systems

Airport operational systems in the current airport environment can be logically grouped into three sectors of operations:

- **Terminal**
  - Systems involved in the departure and arrival processes of the passenger.
- **Baggage Handling Systems**
  - Concerned with the handling of baggage.
- **Apron**
  - Systems concerned with all ramp services as well as taxiing of aircraft.

The systems can be described as segmented – that is personnel operating in each area of the airport work with their own local systems. The application of trans-sectoral systems (as depicted in Figure 2) allows limited access to share and access information that may be relevant to other sectors.

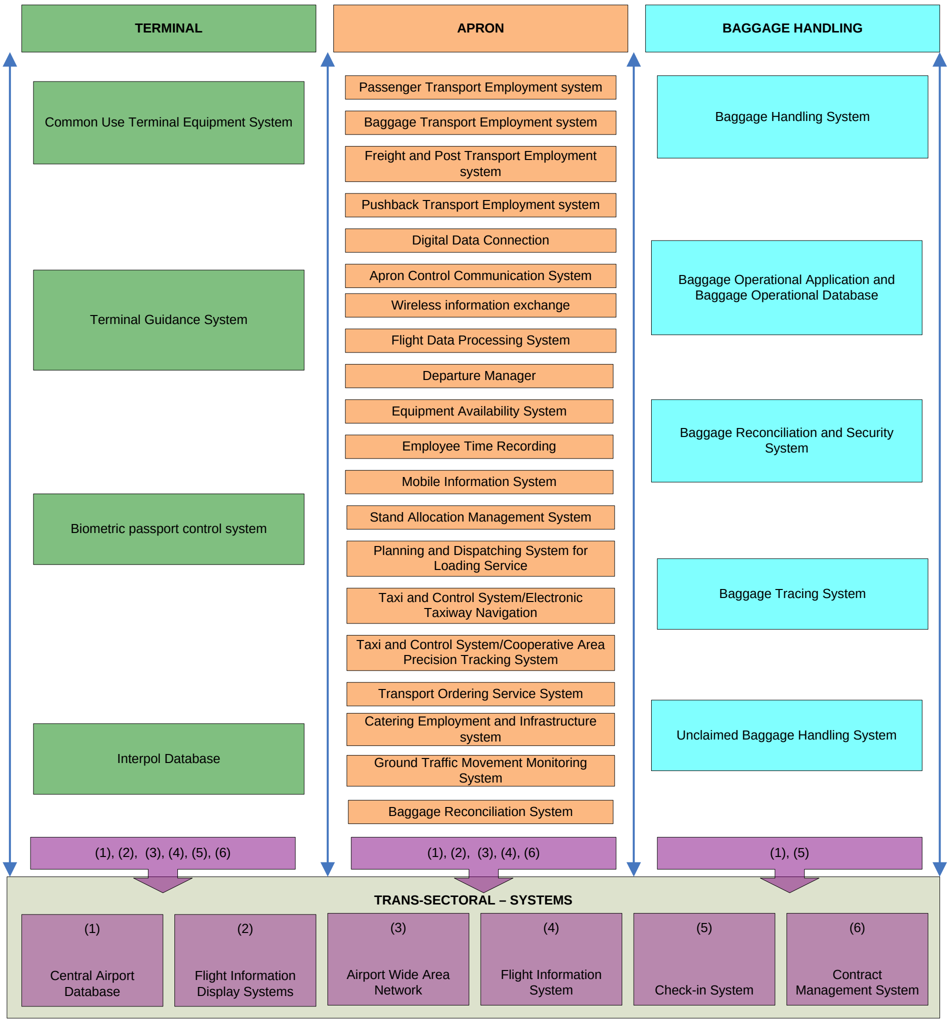

Figure 2: Overview of Airport Information Systems

Within each one of the sectors and their systems, the implementation and infrastructure available can differ based on the technology and operational processes. Computers, telephones and handheld devices can be technical equipment used to access the airport systems, and the data communication protocols and methods can range between voice communications, VOIP, Telex, SITA messages, IP etc. The conceptual maturity in the airport environment also influences the infrastructure needed and the information exchanged/managed. For example, airports which implement A-CDM may have systems allowing for more effective data exchange and system-wide information management between all the relevant parties in the airport environment, therefore bypassing the need for cumbersome trans-sectoral systems.

Regarding integration of the TITAN ConOps within the current airport environment, TITAN's intention is to be an information broker residing between the originators and the users of information, with respect to the turnaround process. Ideally this means the elimination of "trans-sectoral systems" for those involved in the turnaround process, and replacing the trans-sectoral systems with the TITAN ConOps Titan Information Sharing (TIS). The information required for TIS would need to be extracted from the existing systems for use in TIS, and any updates from TIS to other information systems may also require update access. The additional target milestones specific for the turnaround are isolated locally to the TIS, removing any coupling between additional systems milestone requirements and those which are local to the TITAN ConOps. Allowing subscription to TIS data for the main actors (those operating within the Terminal, Apron and Baggage Handling) means that actors across sectors can have updated information from each sector, based on their data access subscription. This premise applies whether trans-sectoral systems are in use at an airport, or whether a more sophisticated system-wide information management approach is taken.

TITAN will not need a full integration of SWIM to implement the ConOps, as the data required for the TIS can be taken from the current information pool and picked to fulfill the TIS data requirements. However, the ability for data from each one of the available airport systems to be brought into the TIS is critical for the TITAN ConOps to be successfully integrated in the airport environment. The principle of information handling in TITAN is predicated on all critical information of concern to the turnaround being shared on a system-wide basis in accordance with the agreed rules and security provisions in the airport environment. The totality of the shared information in TIS is made available to authorised users without them having to know where the information is actually located. The TITAN information environment is globally interoperable with other similar information environments, especially those at the airport, as well as legacy aeronautical information services via the use of appropriate data exchange models and common services.

2.2.8.9 AOC Systems

Airline Operational Control Centres are used by airlines as a means to regulate customer and disruption management as part of their airline operations. The AOC also has functions and divisions for long-term, midterm planning and execution on the day of operation which includes flight following and flight planning, maintenance control, crew and fleet planning. Irrespective of whether an airline operates as a non-scheduled or scheduled carrier, an international, domestic, regional or private operator, success depends upon having complete, positive operational control over their flight operations. The AOC task is to execute the scheduled plan to the best of its availability; however, the AOC also extends much further from sole "day of operations" management to plan and assist in all relevant activities to satisfy the business needs of the airline.

Within the AOC, functional groups exist with varying responsibilities and activities to assist aircraft processes. Table 1 provides an overview of the groups and activities within the AOC:

Functional Group	AOC Function/s
Operations Support	• *Airport analysis* • *Navigation data* • *NOTAM management* • *Post Flight Reporting* • *Training*

	• *Communications* • *Customer Data Service* • *Weather Services*
Operations Coordination	• *ATC* • *Aircraft Movement Control*
Operations Control	• *Flight Dispatch (Chief Dispatchers, Flight Dispatchers, ATC Coordinators)* • *Crew Briefing* • *Flight Planning* • *Weight and Balance Planning* • *Cargo, Load Control*
Crew Scheduling & Tracking	• *Crew Management* • *Crew Portal* • *Crew Tracking*
Maintenance Planning and Control	• *Maintenance Control* • *Long term maintenance planning*
Marketing Planning	• *Passenger services* • *Reservations* • *Schedule planning* • *Airport services*

Table 1: Overview of the Core Service Units within the AOC

Each one of the groups requires systems to facilitate its operations. The core systems accessed within the AOC environment can be loosely categorized as:

- Movement Control
- Flight Planning
- Flight Following
- Crew Management
- Load Planning
- Communications (messages, Radio, Phone Conferencing)
- Operations Analysis

To integrate with the actors who are not solely dedicated to interacting within the airline, access to external systems and interfaces can reach areas such as Slot Management, Maintenance Control, Reservations, Departure Control, Cargo and ATC.

In terms of TITAN integration within the AOC, TITAN will affect all those who require information about the aircraft whereabouts and the progress of the turnaround. It is not foreseen that TITAN will be required to integrate with the AOC services outside of the “day of operations” environment. However, the increased predictability of the turnaround process from the benefits of TITAN may be able to assist in the external planning and analysis tasks for the airline. With regard to the daily operations of the Airline, the integration requirements of the TITAN ConOps for the Airline environment are similar to the integration requirements of the airport environment. The AOC, especially those working in Operations Control, would benefit from having access to information in TIS, and some systems used in the AOC may benefit from updated information that is available from the TIS. The TITAN target milestones specific to the aircraft turnaround are locally specific to the TIS, therefore the critical airline milestone information can be separated and analysed for deviations that may endanger the reaching of the operational target milestones. Having this information decoupled from the other airline systems may also be useful for the airline as it gives flexibility to define other milestones or target activities that may not be central to the turnaround, but still have an effect on the operations.

The TITAN ConOps gives flexibility to the AOC to decide whether to apply the entire TITAN concept, or only parts which are of most interest to the airline’s individual operations.

2.2.8.10 Handling Agent Systems

Ground handling companies are using DCS (Departure Control System) and BRS (Baggage Reconciliation System) for automated passenger and baggage check-in at the airport. The DCS can be connected to an airline’s CRS (Computer Reservation System) thus enabling the identification, update and storage of passengers’ status in the PNR (Passenger Name Record).

The DCS handles all the basic operations required for passenger and baggage handling, such as:

- PNL/ADL message input
- Flight management
- Passenger check-in including seating
- Baggage registration
- Access baggage control
- Boarding control
- Flight closure reporting
- Post flight messaging

The BRS provides positive reconciliation matching checked baggage with the correct flight to meet with today’s security standards for international travel. In the event that baggage has to be offloaded, the baggage numbers are identified and transferred to the baggage loading scanners. After the pieces have been pulled, the database is updated accordingly.

CUTE (Common Use Terminal Equipment) is a common software, hardware and network airport solution that enables airlines and handling agents to access their own applications from workstations and printers shared by all users.

Another important system of the handling agent is the ‘Weight and Balance’ system, which can be connected to the DCS. Its aim is to analyse if the aircraft with the actual load is at or below the allowable limit(s) and whether its centre of gravity is within the proper range and whether both remains so during the duration of the flight.

Handling agents are also using software for contract management, service recording and billing.

Information from TITAN can help integrating data of different systems used by handling agents in real time thus enabling better situational awareness and enhancing the quality of the decisions taken. Decisions taken based on precise and timely information will result in better quality and faster disturbance resolution thus enhancing efficiency and productivity

2.2.8.11 Other partner Systems

One of the new features brought by TITAN is the ability to connect new partners (particularly on the landside) into the collaborative decision-making environment who have not taken part in CDM before. This complicates matters in as much as their data protocols may or may not be compatible with those used by TITAN and/or A-CDM. On the other hand, many organizations use various web-based applications where compatibility can be established relatively easily.

The range of potential partner systems is very wide, from transport companies via road maintenance and traffic control to city hotels or even the airport parking garages. In this respect the integration of TITAN means primarily coming to an agreement on what information they are able and willing to provide and what information they would like to have.

Only loosely coupled solutions are acceptable here to avoid the logistical problems that may arise from system changes undertaken in organizations too far removed from the core CDM environment.

2.2.8.12 Passenger Security Systems

In the time-frame considered by TITAN, the methods of security checking will continue to rely on discreet check-points and hence the potential for congestion will continue to exist. It is not foreseen that the scanning devices themselves will ever exchange information with TITAN, however, automatic or manual inputs to indicate a congestion situation to the passenger flow information service (PFIS) will be required. It is also possible that the passage of individual passengers will be recorded and the information shared to enable the proper tracing of missing passengers and to have a complete picture of the passenger flow. This may be of particular interest at airports where the new, risk-based screening policy is used, as different passengers will pass through security at different speeds and hence the use of average values is not appropriate or information about queues may need to be interpreted differently.

2.2.8.13 Information Technology Security

The TITAN environment must be properly protected against malicious intent both internally and externally. This is especially important in respect of the new, external partners.

Access to information must be strictly controlled and in particular, information of a competition or security sensitive nature must be protected so that only those partners/persons specifically authorised may access it.

A system for administering partner requests for participation and information must be set up and operated by a trusted organization.

It must be kept in mind that the A-CDM environment in which TITAN is implemented may already have some of the required IT security protocols in place. However, these are not likely to extend to the new, land-side partners.

2.2.8.14 Safety

The operation of TITAN does not have a direct influence on aviation safety. It must however satisfy all applicable safety requirements set against supporting equipment as defined by the appropriate authorities.

3. PLAN FOR INTEGRATION WITH THE BUSINESS TRAJECTORY

3.1 Understanding the Business Trajectory and its lifecycle

The business trajectory is a trajectory which expresses the business intentions of the user with the minimum number of constraints. It includes both ground and airborne segments of the aircraft operation (gate-to-gate) and is built from the airline wishes, and updated with the most timely and accurate data available (FOC, FMS, etc.).

In fact, the business trajectory goes through three distinct phases of development. It starts with what is commonly referred to as the business development trajectory. This is created during the planning process of an airspace user and may in fact appear years or months before the planned date of flight. At some point the planned trajectory becomes firm enough so that it is worthwhile to check it against the plans and capabilities of the air traffic management system and it is therefore published by the airline concerned. This action makes the trajectory visible to other users enabling them to take account of its existence while the “owner” of the trajectory is able to get feedback on the impact of their, so called, Shared Business Trajectory (SBT). Strategic-level collaborative action on these shared trajectories is undertaken to agree early modifications if necessary to balance demand and capacity. This is an iterative process and the shared business trajectory may undergo several changes as time passes. As the time of operation approaches, the trajectory is published as part of the actual flight plan and it is now called the Reference Business Trajectory (RBT). This is the trajectory the airline agrees to fly and the air navigation services agree to facilitate. Of course the reference business trajectory may also change over time to reflect tactical clearances or other changes that may become necessary, e.g. to avoid weather.

It is still under discussion within SESAR, but it is expected that the definition of the business trajectory will make it clear that this is something we consider gate-to-gate but we have already said that a given airframe continues to have a trajectory even when it is stationary at the gate or at a parking position. What is more, this trajectory continues to evolve but only in the time dimension and not the spatial dimensions. It consumes resources and has costs associated with resource usage at all times.

The business trajectory has two important features attached to it. These are the airframe identification and the flight identification (the two may be identical). Of these two, the trajectory will always have an airframe associated with it. Then parts of the trajectory will be named also… The name is of course the flight identification. So, an aircraft identified as OO-YKR (which is the aircraft registration but each airframe is also foreseen by a tail-number that is used to uniquely identify it in, for instance, flight plans) may at one point in time be performing SN9534, and hence the business trajectory concerned will be OO-YKR (or tail number)/SN9534. A few hours later we may have a business trajectory that is OO-YKR/SN2332. Same aircraft, different flight. When OO-YKR is at the airport for an overnight stop, there is still a trajectory OO-YKR but there is no associated flight identification. Air traffic management (ATM) may not care much about this portion of the trajectory but for the airline and those performing maintenance, cleaning etc. it is vital to know when the trajectory evolving in 4 dimensions (in this case OO-YKR) stops evolving in space exactly when the airframe is coming to rest at its designated parking position so that work may start on it and when the trajectory is supposed to start evolving in space again. They have to complete all the work before the trajectory is planned to start evolving also in the spatial dimension.

The situation is very similar to what happens during the turnaround except for the fact that there the consecutive (time) portions of the business trajectory get assigned a flight identification in a back-to-back manner.

3.2 TITAN in the light of the Business Trajectory

The nature of the business trajectory as described above is very important both conceptually and in practice if we want to understand the relationship between it and TITAN. Each instantiation of TITAN will need to be aware of each business trajectory and its time and space evolution for which the TITAN services are planned to be applied.

As mentioned previously, following the ATM shift to trajectory-based operations air transport is considered as a continuous process with a sequence of arrival, turnaround, departure and en-route events in aircraft progression. In this context the airport should be considered as another “sector” through which the aircraft passes when executing its business trajectory that describes place and time of each waypoint covering the aircraft operations of an entire day and not only one cycle of it. The business trajectories go beyond the turnaround of an aircraft, rendering it an integral trajectory part.

The business trajectory concept requires that airspace/airport users are able to agree the detailed trajectory directly with service providers involved in facilitating the flight through the specific airspaces/airports concerned. After initial planning (agreement between users and providers) each RBT needs continuous supervision until its final point ensuring its evolution in a data sharing environment performed through Collaborative Decision Making (CDM) (business trajectory management). Detailed positional information for the aircraft throughout the flight are exchanged with all service providers on the route, as well as ascent and descent paths and times are agreed with departure and arrival airports in advance. ATM operations can be automated to a greater extent with data exchanged directly between the airborne and ground systems. Eventually, the sharing of all trajectory information in real time requires the network management functionality provided by System Wide Information Management (SWIM) of the SESAR concept.

Aircraft turnaround, considered as an integral part of the aircraft business trajectory taking into account also the relevant landside processes and based on the principles of CDM and SWIM, comprises the sequence of ground operations required to service the aircraft from in-block time to off-block time. TITAN concept encompasses these ground operations including also those external services, which have a direct influence on it, as well as processes not (fully) considered by CDM. The precise definition of a rolling trajectory counts on balanced and coordinated plans from all stakeholders well in advance to set relevant 4D positions correctly. This planning task is structured by the TITAN Information Model and facilitated by end-user applications making use of the information available from TITAN.

TITAN intends to deliver additional benefits to those available from CDM for SESAR project addressing landside processes not covered by it. To achieves this TITAN builds on a net-centric design principle, using trajectory-based operations as the means to integrate airports into the ATM network for achieving a seamless environment of operations, defining services that act on the processes that are the subject of analysis and making use of CDM and SWIM principles. This approach is aligned to that used in SESAR, but limited to turnaround operations.

Trajectory management processes also apply to the ground segment of the trajectories in order to avoid any disruption that may take place within the airport. That means that a trajectory is also required for the ground segment. Through a collaborative planning process, airport stakeholders could perform the airport-related activities on time without causing any impact on the trajectory and what is more important, without causing any effect on the whole network. One single business trajectory may cover one, two or more flights, considered as cycles of the same trajectory. Any disruption to the ground segment could affect the following cycles of the business trajectory, in its air or ground segments.

TITAN will deal essentially only with the most up to date version of the business trajectory (i.e. the Reference Business Trajectory – RBT) and will also “see” subsequent trajectories as being tied together via the airframe identification. The various parts of those trajectories are all bound by time limits as well as physical limits and the TITAN services are in fact synchronised to those limits. In other words, the processes which use the services have to be completed in such a way that the RBT is not distorted by an out of synch process or failing service. In case that TITAN discovers a situation that would result in a distortion of the RBT appropriate warnings are issued. We must keep in mind that the latest version of the RBT is the result of a long process of coordination with air traffic management and activities like the turnaround should in principle never interfere with the results of the coordination. Or, if the interference is not avoidable, the effect must be known well in advance and to a high degree of accuracy (this is predictability).

The operation of TITAN is really a series of judgments on the extent of the distortion of the RBT, including, as the case may be, portions of the trajectory that in fact bear a different flight identification (subsequent flights).

Summarizing, TITAN and the business trajectory concept should be considered as tightly combined. TITAN concept focuses on an integral part of the business trajectory: the trajectory that includes also all processes taking place during aircraft turnaround on airport. Turnaround forms an integrated part of the ground segment and therefore part of the business trajectory. TITAN aims at assuring common situational awareness and trajectory information sharing during aircraft turnaround based on CDM and SWIM principles of SESAR. In that way TITAN enables the incorporation of the airport segment (together with airport access infrastructure) into the ATM network and of the turnaround into the business trajectory. By that means all aircraft turnaround information can be efficiently distributed into the ATM network of SESAR that consolidates aircraft en-route phase and aircraft turnaround phase (at the airport) into one single 4D trajectory.

3.3 Representing the Business Trajectory in TITAN

The ground segment of the business trajectory includes any process taking place between landing and take-off time for each cycle of the trajectory. The turnaround process is currently seen as a summary of activities necessary to finish the inbound flight and prepare the start of the outbound flight; coordinate the technical treatment of the aircraft to assure readiness for the next flight. During turnaround, milestones track the progress of the turnaround process and the impact of events on later parts of the trajectory can be established at an early stage.

Stakeholders involved in the turnaround sub-processes should be part of the CDM process and should share the same information with the rest of the actors involved in the trajectory management; i.e. information about passenger/baggage-related activities that take place on the airport landside can be used to plan the start/end time of passenger boarding and baggage loading. Furthermore, information from the previous departure airport or the next destination airport can improve the coordination of aircraft turnaround activities.

TITAN shall be aware of the philosophy around the turnaround: from the Actual Landing Time (ALDT) to the Actual Take-Off Time (ATOT) the aircraft does not leave the business trajectory, in fact the movement on the surface has been also agreed among all partners. Moreover, during turnaround process, aircraft still follows the business trajectory in a position where coordinates are fixed but time is running. Any incident affecting the ground trajectory will result in an update as if the aircraft was airborne.

As TITAN focuses on the ground segment of the business trajectory transition points from/to trajectory segments preceding and following the ground segment (turnaround at the airport) are planned for ensuring continuous information flow throughout the business trajectory using aircraft turnaround as a reference time period:

- Proceeding to the airport

  The (destination) airport, considered as active member of the ATM network taking part in the information exchange necessary for the management of the business trajectory, should receive real-time information about spatial and temporal position of the aircraft within the business trajectory in order to be able to plan resource allocation for subsequently serving it or resource reallocation in case (un)expected disruptions occur taking into account their impact on other business (ground) trajectories. Destination airport should get i.e. information about estimated landing time of an aircraft that should optimally match the scheduled one as already planned during the planning phase of the particular business trajectory.

- Being served at the airport (aircraft turnaround)

  At this stage the airport plays the role of the information provider to the network. Real time information (actual time values) about milestones from aircraft touchdown till aircraft in-block, during turnaround and from aircraft off-block till aircraft take-off should be provided through with each other collaborating information platforms of TITAN and airport CDM, connected and interacting with SWIM. The monitoring of the aircraft turnaround process and the transmission of information regarding scheduled/estimated/target/actual start/end times of specified milestones are necessary for assuring the efficient turnaround completion or in case of (un)expected disruption for estimating delays as well as their impact on following phases of the current trajectory (i.e. arrival at the next destination airport) or other trajectories (delay propagation phenomena). During this business trajectory phase each airport stakeholder feeds their information into the system and the airport builds the Airport Operations Plan (AOP). The Airport Operations Center (APOC) manages this (or in fact in some cases even several) AOPs feeding in turn the Network Operations Plan (NOP) with information that has an impact on the ATM Network as a whole.

- Leaving the airport

  During the previous stage of the ground trajectory information exchange enables the estimation of the aircraft take-off time that is necessary for the monitoring or adjustment of the following phases of the business trajectory. After successful outbound flight preparation the airport is considered as departure airport and it should provide real-time information about the time the aircraft exits its control sector for enabling definition of the spatial and temporal position of the aircraft within the business trajectory in order to be able to plan allocation of resources in following business trajectory sectors (en-route or next destination airport) or resource reallocation in case (un)expected disruptions occur taking into account their impact on other business (ground) trajectories. Departure airport (or the airline) should provide i.e. information about actual take-off time of an aircraft that should optimally match the scheduled one as already planned during the planning phase of the particular business trajectory.

Any information exchange described above relies on CDM and SWIM principles. CDM concept comes real through SWIM that involves all stakeholders aiming at allowing seamless information interchange for improved decision-making and the capability of finding the most appropriate source of information. Through SWIM, all air transport partners will contemporaneously have the same and for their own business needs the appropriate and relevant operational picture. The entrance/exit points to/from airport control sector constitute points of intersection between the airborne and the ground segment of the business trajectory where the roles of information receiver/provider get inversed; the airport becomes information provider. The efficient communication between all collaborating systems (TITAN, CDM, and SWIM) is a nonnegotiable prerequisite.

3.4 Main interactions between TITAN and the Business Trajectory

TITAN focuses on the ground segment of the business trajectory facilitating all processes taking place during aircraft turnaround within the time frame from aircraft landing till aircraft take-off at/from an airport. All stakeholders being involved in aircraft turnaround or indirectly affecting it (airport, airline, ground handling, airport ATC, external actors such as transportation system provides/supervisors facilitating airport access) have to participate in the continuous information exchange process facilitated by TITAN that is interacting with CDM and SWIM system integrating the airport into the ATM network/business trajectory.

According to the previous segmentation of information flow for the time window shortly before/after approaching/leaving an airport, we still consider the aircraft turnaround as a reference time period. TITAN, focusing on the “ground” segment of the aircraft business trajectory, interacts with the “airborne” one and contributes to keeping information flow between both segments consistent and continuous by providing enhanced key information into the ATM network necessary for its efficient operation (seen as “matching together the correct missing pieces of a puzzle”). Although the focus remains on the turnaround process, TITAN does not focus only on sub-processes and milestones taking place solely during the turnaround, but also on sub-processes and milestones beginning/ending before/after turnaround having though a direct impact on it and subsequently on following segments of the considered trajectory. In other words, TITAN informs about the evolution of any procedure in time, whose successful completion is required for the successful completion of the aircraft turnaround process; such processes take place on ground shortly before/after aircraft stay at the airport. For example, passenger and baggage check-in, passenger security control or checked-in baggage sorting and security screening are only some of the procedures that begin before aircraft landing at the airport but are considered as necessary for the efficient aircraft turnaround (that takes place between aircraft in-block and off-block times).

In that context, TITAN interaction with business trajectory is necessary as it should be considered as integral part of the business trajectory management. In order to enable business trajectory monitoring to see if implementation matches planning (and there is enough time in advance to mitigate negative impact of (un)expected disruptions), the provision of data related to the ground segment of the trajectory is also necessary. Given the fact that stakeholders interacting with TITAN during aircraft turnaround get information necessary for the allocation of their resources provided through TITAN and fed into it through its interaction with CDM and SWIM, TITAN interaction with business trajectory constitutes provision of information about time of completion of particular milestones, necessary for tracking the progress of the turnaround process. As many TITAN milestones (better seen as warnings supplementing existing CDM milestones) serve better internal monitoring of the turnaround process and are not necessarily fed into the ATM network, TITAN provides the network with information about milestones principally covered by CDM, contributing though to improved estimation of their completion time through the above mentioned supplementary milestones/warnings. For the better monitoring/management of the business trajectory TITAN shall provide information i.e. on following milestones:

- aircraft actual in/off-block time (incl. final update of aircraft target off-block time)
- Ground handling actual start/end time (the second milestone coincides with actual "aircraft ready" time)
- Boarding actual start time
- aircraft start-up request/approval time (incl. target time)

Supplementary (control) information could also be provided, i.e. check-in close time, completion time of de-boarding, baggage unloading, de-icing etc. In the context of monitoring a flight all along its planned and approved business trajectory any information (basic or supplementary) on predefined milestones should be provided; this is of crucial importance mainly for the aircraft operator. However, such information should be reduced up to the most necessary in order to prevent information overload in the case of the ATM network.

Summarizing, TITAN interaction with the business trajectory is realized to the extent to which TITAN facilitates turnaround monitoring and management by successfully providing any information necessary for tracking the progress of any process relevant to the ground segment of the trajectory and by that means the active integration of the airport into the ATM network.