MONITORING THE AIRPORT-CDM TURNROUND PROCESS: APPLYING A QUALITATIVE COGNITIVE MODEL BASED ON FIELD OBSERVATIONS

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Abstract

The objective of this study is to better understand the cognitive mechanisms for monitoring the Aircraft Turn-Round Process during normal operation. Networks of participating operators during aircraft turn-round are becoming increasingly large and complex, and so creating unique challenges for human operators who must monitor these networks for reliable and safe operation. The aircraft turn-round as the linking element between the arrival phase and departure phase of flight requires specific decision support for the assignment of a Target Off-Block Time (TOBT) which is an important trigger to inform the Air Traffic Management (ATM) network about an estimate for the completion of the turn-round.

In this study, field observations with focus on cognitive activities were conducted during five different airlines' turn-round operations in situ for a total of approximately 122 hours. Focus was applied on monitoring turn-rounds having only Minimum Turn-Round Time (MTTT) available. This is a novel approach of viewing the turn-round monitoring process since cognitive mechanisms of turn-round controllers have not been identified yet as a contributing factor for TOBT prediction.

The findings indicate that monitoring strategies used by turn-round controllers are different, even through problem settings are similar. While turn-round monitoring and control has traditionally taken place at the aircraft, operators started to move management of the turn-round away from physical location of the aircraft into a control room. However, observations have shown that the predictive capabilities inherent at established ways of turn-round monitoring cannot be transferred into a control room without prior analysis of the monitoring and facilitating activities used by the turn-round controllers. Findings were organized in a qualitative cognitive model originally developed domain specific during operators' monitoring of nuclear power plants.

1 Introduction

Turn-round operation has traditionally been viewed as a standalone process with responsibilities shared between airline and airport. *SESAR Air Traffic Management (ATM)* research however aims at eliminating today's fragmented approach to European air traffic management and synchronising all stakeholders and network resources. Today's' ATM links the arrival phase, turn-round, and departure phase of a flight as one entity, because successive flights depend on each other. The ground process and en route traffic are now considered as part of a time-dependent chain. *Airport Collaborative Decision Making (A-CDM)* is used as the mechanism to integrate aiports into the ATM network. An airport is considered as CDM airport when *A-CDM Information Sharing (ACIS), CDM Turn-Round Process (CTRP), and Variable Taxi Time Calculation (VTTC)* concept elements are applied at the airport [1]. The CTRP describes the flight progress from initial planning until take-off by defined '*milestones*' to allow close monitoring of significant events.

Flight Update Messages (FUMs) and Departure Planning Information (DPI) are in place to inform all participating CDM partners about the flight progress.

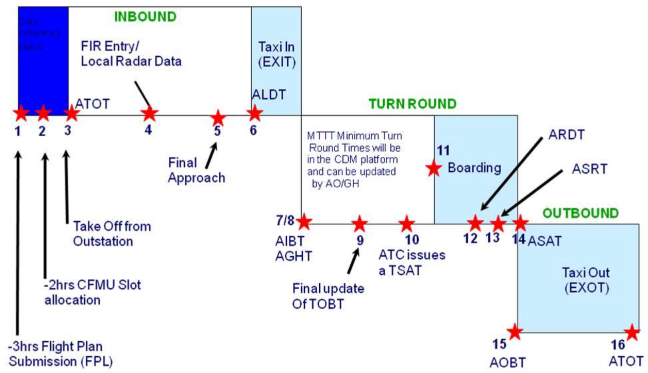

Figure 1: Airport CDM Generic Milestones (Source: EUROCONTROL 2009)

Among the milestones used for monitoring flight progress, the period of flight between milestone 7 (actual in-block time) and milestone 15 (actual aircraft off-blocks) is called *Turn-round.* Monitoring this turn-round phase is a complex task, because situational awareness has to be established across various subsystems of different organizational and operational structures having their own causal and intentional domain constraints. Subsystems are referred as participating partners who include airport operator, airline company, air traffic control, ground handler, and Central Flow Management Unit (CFMU). Additionally, all terminal and ramp processes have operational interdependencies, e.g. processes can normally not be parallelized, as well as legal requirements, e.g. one side of the aircraft has to be clear of obstructions to ensure that fire fighting access is always possible [2]. In order to increase situational awareness during turn-round, a number of agreed trigger events are defined by the A-CDM concept to inform all partners about updates to estimates and/or aircraft turn-round status. A CDM compliance alert will emerge within the Airport CDM Information Sharing Platform (ACISP) in case of disruptions. Any internal or external disruption at these milestones generates an alarm and has to be communicated to all partners in order to maintain situational awareness.

However, due to the complexity, size, speed, and functionality of the ATM network between all airport partners during this turn-round phase, it is important to understand *how* operators monitor the turn-round operation, the *challenges* they face for the monitoring task, and the *tools* they use for monitoring. Designers can use this information for creating interfaces that enhance not only monitoring the operation, but also alleviating information overload, integrating or highlighting required information, decreasing response time, and thereby increasing efficiency. Failures during turn-round monitoring can result in insufficient situational awareness with consequences on TOBT reliability.

2Motivation

2.1 Role and Benefit of TOBT Accuracy for the ATM Network

Within A-CDM, *Target Off-Block Time (TOBT)* represents the time that an airline or handling agent estimates an aircraft to be ready, all doors closed, boarding bridge removed, push back vehicle available, and ready to start up or push back immediately upon reception of clearance from air traffic control [3]. It is issued by the airline or handling agent and is an important trigger to all partners for the departure management. Based on the TOBT, *Air Traffic Flow Management (ATFM)* slot delay, and the traffic situation, ATC issues a *Target Start-up Approval Time (TSAT)* to inform the flight crew and all partners about the time when the aircraft can expect start up and/or pushback approval. A key requirement for TOBT assignment is accuracy, because a reliable TOBT allows ATC to reduce time buffers within the CTRP for the TSAT assignment, and as a consequence, the *Target Take-of Time* (*TTOT*) gets more predictable. Also network benefits can be expected, if number of airports adopting the A-CDM approach increases: A study has shown that a wider implementation of A-CDM could increase sector capacity, reduce en-route delays, and reduce number of regulated flights [4].

2.2 Problems for Achieving an Accurate and Reliable TOBT

TOBT can be assigned using different strategies: Either TOBT prediction is based on *all* available information identified via *measured process times, resource availability,* and *other operational information* shared with actors or partners required for sequential turn-round events, or only the *pre-determined value* of the MTTT as defined by the airlines is used as a reference.
For today's TOBT assignment, the predetermined value of the *MTTT* is used, if length of turn-round is a factor; when operational information is available or resource constraints are known, turn-round controller estimates the duration of the CTRP. It is questioned however that this practice has the potential to deliver the TOBT accuracy required by the airport partners, because accuracy depends heavily on sufficient and reliable information provided by *all* participating partners: TOBT needs to be updated, if only *one* turn-round process is delayed during the *critical path* of sequential turn-round processes with only MTTT available. While a number of turn-round processes can be executed in *parallel*, the critical path emerges from the *sequential* sub-processes, where a delay propagates across the CTRP and affects the TOBT. Therefore, not only close monitoring of this critical path is required, but also predictions are required for each single process, because TOBT accuracy heavily depends on exact prediction of *all* sequential sub-processes.

3 Field Study Method

The aim of this study is to identify the influences of turn-round monitoring on TOBT accuracy. Therefore, field observations were conducted in situ for a total of approximately 122 hours at operation centres of airlines like Air France, British Airways, KLM, and Lufthansa German Airlines during turn-round controllers' TOBT assignment.
According Su et al [5], visualisation, situational awareness, proactive/reactive monitoring, and interactive capabilities are the four core elements necessary for effective human monitoring of complex systems. If one of these elements is missing, decision making will always involve handling uncertainties. The control room observations at the airline operation centres were carried out with focus on these core elements.
Turn-round operation is getting increasingly complex, because of interdependencies between third party ground handling service providers, the number of participating parties for each turn-round, size and dimension of airport, and decreasing time available for each individual turn-round. How the quality of these networks is monitored by human operators has not only a great impact on the efficiency of the turn-round operation, but also flight punctuality and passenger satisfaction are depending on a reliable turn-round process.
The method used for analysis was evolving from this given situation. Observations preferably with minimal interruption to activities under observation were carried out with following questions as key drivers:

- What are the different modes used for monitoring the turn-round?
- What are the cognitive challenges for turn-round monitoring?
- What are the strategies used by turn-round controllers for monitoring the turn-round?

To organize the findings from the observations, a model analogous Vicente [22] was applied that is able to capture the cognitive, monitoring, and the facilitating activities of the turn-round controller.

4 Results

4.1 Different Modes of Turn-Round Monitoring

In general, two different modes of monitoring were observed:

- *Direct mode turn-round management (DTM):* a turn-round manager gets assigned for an individual flight and is then physically present *at the aircraft* where he directly controls turn-round processes. He can either coordinate the turn-round processes based on the requirements of the airline, his own experiences and knowledge-based mental strategies, or only react on arising problems.

- *Remote Turn-Round Management (RTM)*: turn-round manager controls turn-round *from remote operation centre* via automated received data and inputs from different agents, e.g. pilots, loaders, flight manager. This approach is less personnel intensive and increasingly used by airlines.

4.2 Cognitive Challenges for Turn-Round Monitoring

A number of challenges for turn-round monitoring arise due to *cognitive* demands while on-task. Examples include:

- Monitoring requires visual sampling and selective attention due to time constraints and information overload.

- Data exchange between partners across functions has to be established throughout distributed locations and also via different modes.

- During peak hours, interferences are initiated from multiple sides: telephone, supervisor, colleagues, incoming ACARS messages, or requests via radio. Prioritising and selective problem solving skills are required.

- Insufficient data from turn-round service providers or about the aircraft turn-round status

- Situational awareness depends on ability of turn-round manager to use the tools, data and displays given for the creation of a mental strategy.

- Information representation on displays itself is often the cause of a problem.

- False or too late alarms created on displays.

- Data overload requiring data filtering versus problems through insufficient data

- Network data or status information of sub-processes from all participating actors are not automatically shared

- Proactive versus reactive monitoring: controllers today have to track turn-round in real-time, react on alarms created by the system, or answer interactions created by participating actors.

4.3 Strategies used by Controllers for Monitoring

Airline companies provide working strategies and modes for monitoring turn-round flows to the controllers. The turn-round controllers themselves again adopt *own* strategies for monitoring the turn-round depending on the given working procedures, situations, knowledge, and tools available. However, it has never been demonstrated which strategy used by the airlines results in the most reliable turn-round processes in order to make TOBT prediction as accurate as possible.

The major cognitive concepts used by turn-round controllers are

‘Situational Model’ Driven Monitoring’

One major finding of the observation was to see that regardless of the mode of turn-round control or the tools available, turn-round controllers were trying to build and maintain their *own* situational model which in turn directed their attention and set their expectations during monitoring activities. This situational model however was extremely differing depending on the *mode* of turn-round control: For example the turn-round controllers at the aircraft could already anticipate arising problems with de-boarding or loading and as a consequence initiated required actions proactively. Turn-round controllers at remote positions had to be updated about such situations by ramp agent or the pilots in order to establish the required situational awareness.

The interesting fact however about these observed ways of turn-round management is the difference between DTM and RTM which emerges through the technologies and the cognitive driven behaviour. While during DTM turn-round controllers use their eyes to observe events which may require predictive analysis of the situation, turn-round controllers at the operation centres have to rely on the information displayed at their monitors, the incoming calls from actors at the terminal or the ramp, and the cameras towards the aircraft parking positions. This induces to infer that in the operation centre predictive behaviour onto turn-round processes taking place at the aircraft cannot be applied like it is used on the ramp because of the missing information visually perceived by the ramp agent. Situational analysis is therefore only possible based on information received via *own* creation of interference or interferences received from *others* where interferences are seen as cooperative ways of creating human-human interactions [18]. This simple example is interesting because it shows that the task goals are the same in all modes of turn-round monitoring, but the *situational* manifestations between the monitoring locations of direct and remote shaped the *behavioural* manifestations of turn-round control between proactive at the ramp and reactionary at remote.

‘Rule- and Knowledge Driven’ Monitoring’

It was observed during DTM that turn-round controllers usually engage in rule- and knowledge-driven monitoring of the processes at the ramp for estimation of the TOBT. Rather than merely reacting to stimuli from processes failures, turn-round controllers seek out specific information of the current, but often unfamiliar situation. Examples of this type of behaviour include:

- Already before the aircraft arrives at parking position, turn-round controller re-confirms with participating actors availability of personnel and required equipment.

- Not only normal turn-round processes were coordinated, but also special ground handling issues were prepared with confirmation calls to participating actors. If a problem was arising during pre-arrival phase, a possible solution was already analysed to avoid failures during the critical chain.

- Problems forwarded from pilots after landing were analysed directly after AOBT.

- Actual passenger numbers and aircraft loading status are used to make estimates of boarding/de-boarding times.

Therefore it is proposed to engage in further analysis about the possibility to establish proactive behaviour observed during DTM also at remote operation centre.

It is hypothesized that reliable TOBT prediction during RTM also depends on the *number* of turn-rounds which the turn-round controller has to monitor simultaneously. Especially if unanticipated events are encountered during critical path of turn-round processes, there is not sufficient time is in hand to prepare each individual turn-round proactively.

But also advantages could be observed during RTM management due to the tools and information sources available at the operation centre which allows turn-round controllers to use other forms of monitoring through activities they are able to apply via the technologies and information sources at the working position. This allowed controllers to adopt strategies like:

- Proactive telephone calls: Turn-round controllers using the direct-dial functions of their telephones to check with actors at the ramp about status of personnel and equipment

- Reducing MTTT: It is in the interest of the airlines to reduce MTTT even further, if AIBT is delayed more than *Scheduled Off-Block Time (SOBT) – MTTT*, and as a consequence, a departure delay has to be encountered. To avoid delays from getting too large, turn-round controllers are using two different strategies: either they reduce the MTTT by applying a special turn-round procedure e.g. increase support via additional ground personnel, or they only reduce the MTTT by a certain value without taking any other information or factors into account.

- Creating indicators or alarms: Turn-round controllers can choose display settings and tools depending on their own preferences. The strategies used here depend also on the knowledge level of controller and the ability to extract information as required.

  The most interesting observation was the difference in creating an overview of displayed information which turn-round controllers were using for day-to-day monitoring: While some controllers are dedicated to display each turn-round event as a *detailed depiction* of all turn-round processes, others were using a more *flight status oriented* tool where all monitored flights are visible at the same time on a time axis. The detailed turn-round depiction allows following up each turn-round process in real-time, while the flight status oriented tool depicts only an overview about all monitored flights. This tool however requires additional information of the turn-round status to allow real-time monitoring of the critical turn-round chain.

- Setting Rules: The adopted strategies used also depend on the rules and policies defined by the individual airline. Most prominent example is the definition of the duration of a MTTT: For the same type of aircraft, comparable type of turn-round and size of airport, MTTT during one turn-round differed up to 20 minutes. Other rules set by the airlines include the amount of turn-rounds monitored in parallel, where differences of up to 10 turn-rounds were observed.

- Creating external reminders for monitoring: to reduce demand on their memory, turn-round controllers frequently use scratch pads and lists with all assigned turn-rounds.

- Shifting turn-rounds: During peak hours, turn-round control does not allow leaving working position and observed work demand is very high. To allow breaks or during schedule changes due to weather, turn-round controllers can shift assigned turn-rounds to other back-up controllers having capacity to handle additional turn-rounds.

- Employ additional turn-round controllers: some airlines observed have dedicated personnel available during peak hours allowing controllers to maintain the same amount turn-rounds for monitoring, even during high traffic demand. These ‘spare’ controllers can either handle excess traffic or turn-rounds with high monitoring demand due to extra service requirements.

4.4 Developing a Qualitative Cognitive Model of Turn-Round Monitoring

A theoretical model analogous Vicente [17], was used in order to organize the findings from the observations at the airlines' control rooms. Vicente et al developed this model domain specific during operators' monitoring of a nuclear power plant under normal operation. However, according Vicente, the qualitative cognitive model of operator monitoring can be generalized across other domains, because of the general types of activities and cognitive functions used when monitoring complex dynamic systems.

The model includes four major elements: *initiating events, cognitive activities, facilitating activities*, and *monitoring activities*.

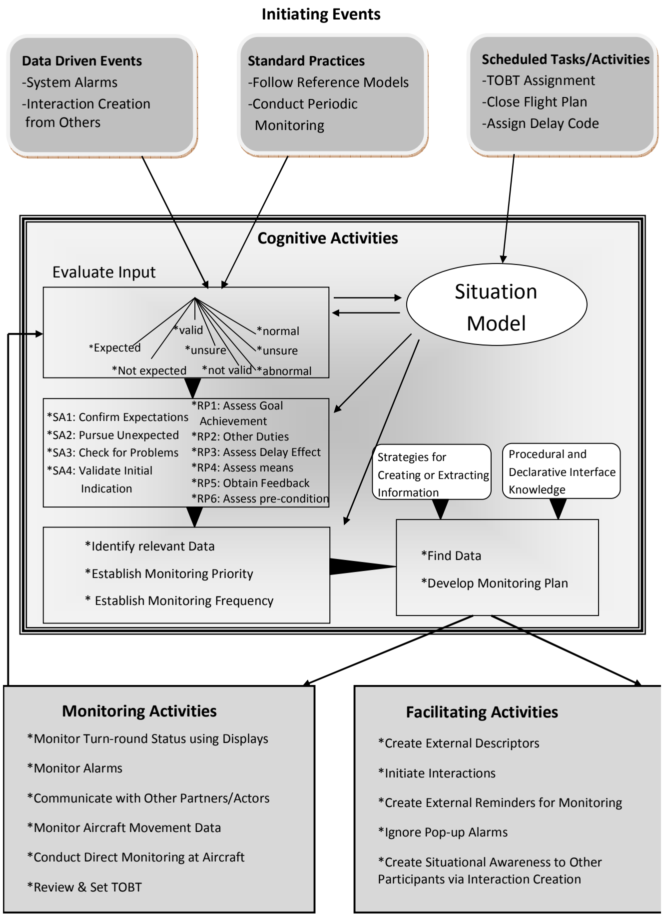

Figure 2 Turn-round Controller Monitoring Model (Source: Own Observation Data analogous Vicente, 2009)

First, the events were identified which trigger to *initiate* monitoring. The model identifies three types of triggers that initiate monitoring:

- *Data-driven events:* not actively sought by operators, but rather prompted by changes in the environment, e.g. alarms by the system, interaction creation from system or other partners/ actors.
- *Standard controller practices, policies, or procedures:* events in this category are designed to ensure controllers periodical and knowledge-driven working practices.
- *Scheduled tasks and activities:* have to be carried out during normal shifts, e.g. close the flights after monitoring is completed

Most of the triggers result from periodical events, e.g. flight movement messages, but also many triggers relate to specific events, e.g. incoming calls from participating actors. Alarms automatically created through the monitoring system, e.g. late crew arrival or turn-round process start delays usually are not used as triggers for monitoring events. Once monitoring is initiated, it may result in a specific path of actions and coordination with other airport partners or actors. Also multiple initiating events may be in effect at the same time, requiring the controller to time-share several activities, especially during time-constrained turn-round situations.

The initiating events result in *cognitive activities* of the turn-round controllers. These are formed and influenced by *interactions* with control room interfaces/ other personnel, or *knowledge* which is owned by the respective turn-round controller. The major element that drives cognitive activities however is the situational model which is developed by the controller as an incomplete mental representation that integrates the controller's current understanding of functional turn-round aspects, and the automated control system. Applying this situational model to turn-round monitoring, it captures a number of general cognitive activities:

- Controllers' knowledge of the turn-round physical processes, their characteristics and interfaces;

- Supports controller in developing a cause-and-effect relationship for analysis of turn-round failures and participating actors' process delays;

- Supports controller to integrate separate received or automatic created data for accounting of all data;

- Supports controller to develop a turn-round description that captures a process state at a higher level than individual actor perception;

- It allows the controllers to create a mental simulation of the turn-round to anticipate future states of turn-rounds, or evaluate turn-round performance under various configurations.

According Vicente, training and experience allows controllers to evolve their inherent mental model to a somewhat idealized turn-round design and a better reflection on the actual operation, and the situational model being used for turn-round monitoring can so be adjusted.

At a higher level of description, all controllers' cognitive activities can be split into situation assessment and response planning. However, situation assessment refers to the process of 'constructing an explanation to account for observations' and studies show that operators actively develop a coherent understanding of the current state [19]. This in turn emphasizes the need to provide reliable indications for situation assessment. Any failure to provide essential turn-round data from participating actors may stall the assessment process due to missing key indicator. During turn-round, controllers not only monitor, but often proactively retrieve information required for situation assessment via automated systems or interaction creation. However, the constrained time available during turn-round often does not allow controllers to get updates as necessary. Different types of situation assessment (SA) were identified:

- *Confirm expectations about the flight/turn-round progress (SA1):* based on the given data, e.g. Flight Update Messages (FUMs) or movement messages, controllers develop expectations about actual in-block or off-block time. Based on these expectations, turn-round controllers develop strategies as a response to the actual situation. During this arrival phase of flight, monitoring the status of the flight serves either to maintain current strategy or adapt it to actual situation.

- *Pursue unexpected situations (SA2):* a controller often encounters situations which are not expected, but response is required, e.g. aircraft change, crew change. In these cases, the controller will actively direct monitoring to identify complementary data that might help him to better respond to the unexpected situation.

- *Check for problems considered to be likely (SA3):* the controller is best placed to identify problems which are likely to arise during turn-round. The controller understands that certain processes create the potential for particular problems to be solved, e.g. coordination of sequential processes within the critical chain. He needs to be vigilant to such problems.

- *Validate initial indications (SA4):* in general, control room and interface technologies are not perfectly reliable and also do not always provide an appropriate visualisation of the situation. Therefore, controllers are often unwilling to trust received information, but have to validate the information via creation of interactions (e.g. phone, ACARS, radio).

After assessment of the actual turn-round situation, a response is usually required. This involves decision making about necessary course of action. In general response planning involves identifying goals, generating, evaluating, and selecting response plan that best meets the goals identified [22]. Since there are only a few formal written procedures that guide response, controllers use their *own* assessment of the situation and evaluate whether the actions they are taking can achieve their goals. This may include deviation from formal procedures. Five types of actions/monitoring were identified that support response planning (RP).

- *Assess goal achievement (RP1):* controllers' actions are taken in order to achieve airline operators' goal. However, current procedures within A-CDM require to weight operators' interests against ATM network benefits.

- *Other duties while on-task (RP2)*: turn-round control entails a variety of situations: while some turn-rounds require only little attention, others are time-constrained (e.g. if MTTT or even less due to arrival delays) and having high monitoring demand. During these situations, controllers initiate interactions proactively with other airport partners or actors for duties like information forwarding, e.g. inform ramp agents about direct transfer of passengers, follow up late crew arrivals, identify solutions to resource constraints or adaption to reference turn-round models.

- *Assess potential delay effects of contemplated actions (RP3)*: a key activity of controllers is ensuring that their activities and the activities of other airport partners and actors do not produce a delay, or if unavoidable, ensure that the delay remains as small as possible. While airlines have established reference models for standard turn-round flows, controllers are often faced with events resulting from uncontrollable variables in the environment or variables identified late. This requires adapting the reference turn-round flow to the actual situation with necessary assignment of IATA delay codes to actors causing the deviation from standard procedures.

- *Assess means for achieving goals (RP4)*: As a consequence of a turn-round process delay, the controller needs to consider that the CTRP could fail and an alternative process would be required (e.g. aircraft change or flight cancellation). Thus active monitoring is needed to support the evaluation of resource availability. Due to the large number of actors and partners involved, this remains a difficult task.

- *Obtain feedback on actions (RP5)*: after completion of turn-round, controller needs to obtain feedback about how the processes were carried out. This is usually obtained actively; in some cases actors call.

- *Assess pre-condition for action (RP6):* for all sequential turn-round processes, a certain pre-condition is necessary for the next step of turn-round (sequential turn-round processes). This requires that the controller actively monitors status of turn-round and informs partners or actors if problems arise at a certain stage. Due to the high workload which is required therefore, response planning RP6 takes place only marginally.

5 Discussion

The most important findings from observations of today's turn-round management can be confined to two factors: (1) procedural differences between traditional DTM monitoring and current approach towards RTM, and (2) the strategies of turn-round controllers for creating or extracting information.
Procedural differences between traditional DTM and today's RTM are relatively straightforward. During traditional DTM, the turn-round controller identifies required information via a *rule- or knowledge-driven* form of monitoring turn-round events. Data is directly identified at action level and used for developing a proactive strategy. Reliable TOBT prediction is based on the experience of the controller and only possible after the aircraft has arrived at the parking position and doors opened. Turn-round controller enters the aircraft, assesses visually and with confirmation of flight crew the time

required for turn-round and then initiates appropriate actions for the required turn-round processes. He continuously monitors current turn-round status and updates all actors involved, taking the given situation into account, e.g. number of passengers, baggage or specials. This approach is *rule-and knowledge-driven* because TOBT accuracy depends on ability of turn-round controller to estimate process time required for all processes along the critical chain even for unfamiliar situations. It is also the most appreciated form of turn-round control for flight crew members, because all operational requirements are handled by the controller and crew members can focus on their own duties.

During RTM however, turn-round monitoring is more *data-driven* and depends on the information available via tools and telephone. Turn-round controllers have to rely on displayed information or updates via voice contacts in order to create situational awareness. The difficulty for the controller here is that he has to monitor several turn-round simultaneously and often time available does not allow capturing all required information which are necessary to estimate a TOBT based on *all* given situational constraints. As a consequence only simplified strategies, like '*TOBT = AIBT + MTTT – 5 minutes*' are used. Updates to TOBT require interaction creation from participating actors and data exchange. Therefore, this approach is *data-driven*, because it depends on data made available to the turn-round controller; any proactive strategy depends on this information. However, it should be analysed how information available at the aircraft can be forwarded to the controller via automated procedures.

It is also questioned that it is possible to achieve the mutual trust required for the exchange of all required information in order to make reliable TOBT with presently applied way of *delay assignment (IATA Delay Codes)*. Since the turn-round controller has to assign the delay via a code to the function, which *he* estimates being responsible for the delay, actors or operators involved at action level will not be keen to share data revealing their failures. This delay assignment procedure is often even combined with a bonus-malus procedure where actors identified being responsible for the delay, have to expect even financial penalties. Therefore, problems with service delivery will not be communicated automatically to the turn-round controller with the consequence that he is unable to make reliable TOBT predictions.

6 Conclusion & Implication for Turn-Round Monitoring

Turn-round *management* is largely influenced by *strategies of turn-round controllers* that they apply for the coordination of turn-round processes and the *availability of resources* necessary for predicting the TOBT.

Turn-round *strategies themselves* are not only determined by individual controllers' knowledge-, rule-, or skill-based behaviour, but also the *mode* of turn-round monitoring that airlines have established depending on their requirements. Thereby reference models are used to define the milestones of the turn-round and process times required for the overall CTRP.

Concluding from the results of the observations in various airline operators' control rooms, it is argued that available data for the controller are insufficient to make reliable TOBT predictions: missing inputs from participating actors, poor monitoring capabilities, and unavailability of predictive turn-round information results in TOBT estimates which allow only assessment of a TOBT rather than reliable TOBT decision making based on facts. Since turn-round controllers at the aircraft engage in knowledge-based mental strategies during turn-round control, turn-round monitoring at remote airline control centre requires a comprehensive anticipation of controllers' monitoring needs, the creation of interfaces that systematically support remote monitoring, and the provision of tools capable to make reliable TOBT predictions.

A number of implications for TOBT assignment could be identified:

1. Before changing established ways of turn-round monitoring, e.g. from DTM to RTM, decision makers from airlines

should *recognize the facilitating activities* with the inherent predictive capabilities used by DTM controllers. It is necessary to comprehensively anticipate turn-round controllers' monitoring needs and create interfaces that systematically support such monitoring with reliable TOBT prediction rather than just expect controllers adapting to a situation with poor data available.

2. As a step towards the design of monitoring and communication tools with functionalities required by controllers, valuable information can be collected by *observing the facilitating activities* in which turn-round controllers are currently engaged during DTM and RTM under consideration of *cognitive* aspects.

3. As a further step in this direction, the available tools for RTM need to be better understood in order to allow facilitating activities with *predictive* behaviour.

4. More attention should also be paid to *basic human factor issues* in the design of such supporting tools since control issues and responsibility sharing are involved.

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