THE USE OF MODELS FOR ATM VALIDATION: FROM AIRPORT EXTENSION PROGRAMS TO THE AIR TRANSPORT SYSTEM OF THE FUTURE

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Abstract

Different kinds of models are important to evaluate the benefit of different extension measures like an additional runway, modified procedures (e.g. introduction of controller assistance tools), or even the change of the whole system (e.g. SESAR [1]). This paper provides an overview of the applicability of the different models for the application areas and point out some of the required model extensions for the future.

1 Introduction

This paper gives an overview about today's use of models in ATM research activities. Furthermore it highlights future developments, which will be necessary to validate the ATM system of the future, which are currently under development within the NextGen and SESAR initiatives.

2 Model Overview

In the ATM domain various models are in use, ranging from very simple analytical models to high complex computer based simulation facilities and real testbed like aircraft or airport facilities.
Analytical models are primarily used for strategic decision making or to get a first rough estimation about intended modifications to the system. They are normally dedicated to one or two performance parameter, like capacity or delay. They are easy to use and provide the results within seconds. The disadvantage of these tools is their very global view, which does not allow to access special questions.
Fast time simulation (FTS) models (example see Figure 1) allow a much more detailed view, but require a higher level of input and experienced user. It is possible to focus on unique system

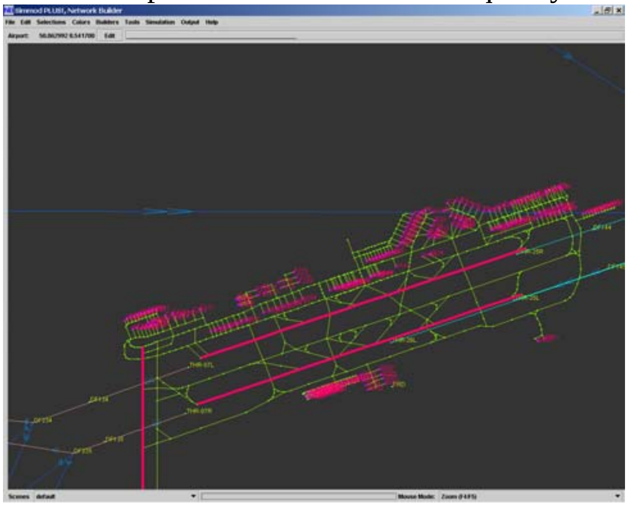

Figure 1: Screen Shot FTS model Simmod

Figure 2: Post processing visualizations tool [2]

features of an ATM-System (e.g. layout of an airport) and evaluate several performance parameters (e.g. capacity, delay, noise, safety). These can be assessed either as direct output from the model or by post-processing tools, which use this output (example see Figure 2). FTS models are primarily used for strategic decision making (see chapter 3) but due to higher computer performance, they are considered more and more also as tactical or pre-tactical tool

The most detailed models are real time simulation models. Usually they are realized as human-in-the-loop (HIL) models. Operators like pilots or controllers act in the same way as in reality. This kind of modeling requires high effort but allows the validation of new concepts, which can be very specific, before implementing them. This kind of simulator is (with limited features) also used for training. There are simulators for the main actors (pilots and controllers) of the ATM system available, i.e. tower, radar and cockpit simulators. In addition for airport collaborative decision making (CDM), an airport control center simulator (ACCES) has been developed (see

Figure 3: AT-One Airport control center simulator

Figure 3). It allows different stakeholders of an airport to access the same information over a central information panel and discuss directly about solving possible problems [3]. Many of these models can be connected to simulate the also the interactions between the actors.

The most expensive, but also most realistic models are real testbeds like aircraft, helicopter or airport facilities (see Figure 4), which are dedicated for research. These testbeds can be integrated in the real time model environment but allow also the validation of prototypes, new

Figure 4: A-SMGCS Testbed at Braunschweig Airport

operations and/or new systems in a real operational environment.

3 Airport Extension Programs

The first step in a validation chain can often be made by using an analytical model. One example can be the airport capacity extension. Obviously, the highest increase can be gained through an additional runway. Due to environmental constrains this option is often either impossible or hard to realize. A very detailed analysis is required to justify this kind

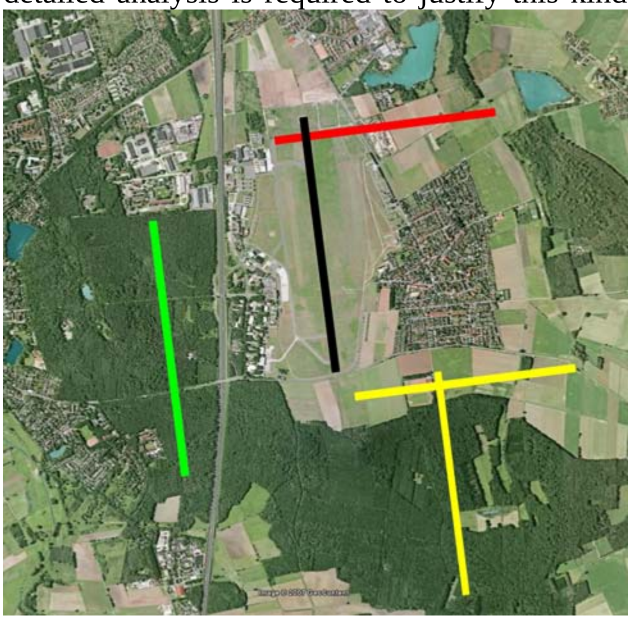

Figure 5: Possible runway locations (extr. from Google Earth)

of expansion. In a first step, possible runway locations are identified. Limiting factors are for example the available area, population densities and the predominant wind direction. In the hypothetical example (see Figure 5) an existing single runway airport (black runway) should be extended by a second runway. Possible options are displayed in green, yellow and red. By using an analytical tool (e.g. FAA airfield capacity model) the saturation capacity of these runway options can be calculated. Using the rule of thumb that the practical capacity is in the range of 80% to 90% of this saturation capacity the runway options can be ranked regarding their capacity demand of the extension program. In the example, the green runway will fulfill the required demand, while the red one won't. The yellow runways have to be further evaluated to make a decision about their capacity.
Further evaluation in this example can be achieved with fast time simulation (FTS) models (e.g. Simmod, TAAM, or Airtop). By simulating the runway capacity only, i.e. without implementing the exact airspace structure and taxiway system, the practical capacity of each runway layout can be calculated. However, due to the fact that a simulation is much more time-consuming than an analytical calculation this is usually done only for a limited number of runway layouts. This is done by an incremental increase of the movements while monitoring the average delay. In our example it is assumed that both yellow runways fulfil the desired capacity demand. With these results the effects of specific schedules as well as of the taxiway and airspace topology can be analyzed in more detail.

4 ATM System of the future

Analytical and simulation models are primarily used to analyze capacity or environmental impact on a global basis. A more sophisticated type of modeling is often needed for in depth analysis of the operational aspects of new concepts of operation. This is the domain of real time simulation with human-in-the-loop procedures. As mentioned above (see chapter 2) for each domain a special kind of simulator exists:

- Radar simulation (ATMOS – Air Traffic Management and Operations Simulator): Modeling the working station of an en-route or TMA controller. It can, for example, be used for the evaluation of new ATC support tools.
- Tower simulation (ATS – Apron and Tower Simulator): Modeling the tower environment to evaluate the effects of new procedures on the airfield (e.g. dual threshold operations).
- Cockpit simulator (GECO – Generic experimental cockpit): Modeling the cockpit of an aircraft. It can, for example, be used to evaluate new kinds of displays.
- Airport Control Center Simulator (ACCES): Modeling an airport control center, where all stakeholders participate in a CDM process to allow a total airport management (TAM).
- In-flight simulator (Airbus A320 – ATRA): The most realistic kind of simulation in ATM is the use of an aircraft to evaluate future concepts like simulating the behavior of an UAV in controlled airspace.

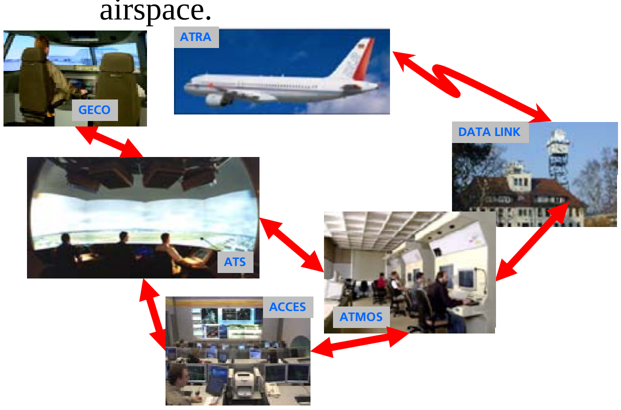

Figure 6: Example of a possible model chain at AT-One

However, all of these described models can only be used to analyze very specific parts of the air traffic management domain. For the evaluation of a complete new concept of operation like SESAR or NextGen a network of all these

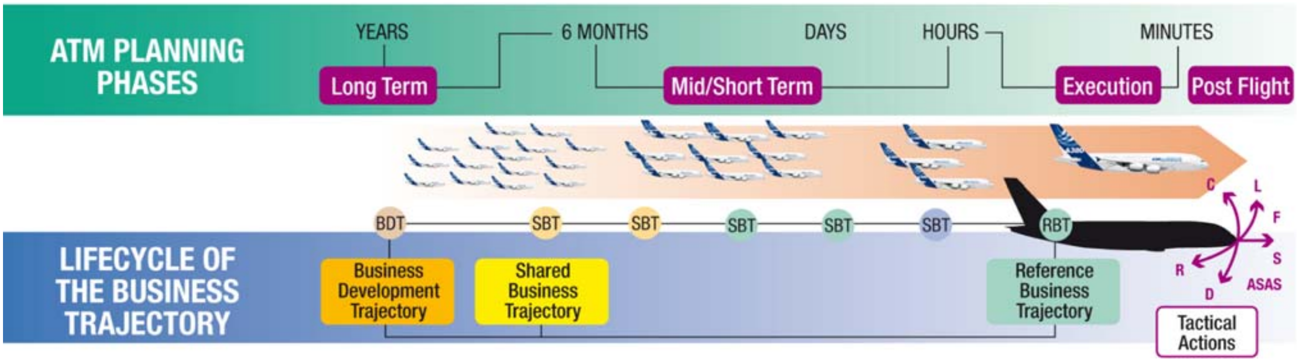

Figure 7: SESAR Business trajectory lifecycle [1]

models with open interfaces is beneficial. By means of a network a complete gate to gate (or en-route to en-route) operation can be simulated in detail to evaluate the interdependencies between the different flight and control procedures and different players in this air transport chain.
But this model chain is only the first step to validate all aspects of the future ATM system. New ideas are necessary for several aspects of the system.
Taking a look at the lifecycle of a business trajectory (see figure 7), it is obvious that a new approach for simulating the process from the business development trajectory (BDT) over the different version of the shared business trajectory (SBT) to the reference business trajectory (RBT) is needed. An embedded fast time simulation could be a new approach here, meaning that real time and fast time simulation models act together in that way, that results of fast time simulation runs determine the behavior of the real time simulation model. To facilitate this approach not only process descriptions but also detailed interface specifications are required. These will be the next steps in building up the new validation environment by changing the pattern of utilization from a single or serial connection use to a complex model network.
Another approach to model for this kind of process is the development of gaming exercises, which allow jumping in time during human in the loop simulations. This approach is based also on a network or connection of existing simulation facilities.

5 Summary

Within ATM, modeling is a proven methodology for evaluating and analyzing systems or determining their performance. In the past single models focusing on one specific domain or simple model chains were used. Due to the high complexity of the ATM-systems of the future (compare NextGen or SESAR) this approach is not sufficient any more. Instead a network of models, making use of the strength of the different kind of models, is proposed to build the validation platform of the future.

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