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Combining Air Traffic Schedule Prognosis and Future Terminal Capacity Analysis

by

Dipl. Ing. Andreas Krolzig

SAT Simulations- und Automations-Technologie GmbH was founded in 1998 out of the CRC – Clean Room Consulting GmbH in Freiburg. In the year 2000 SAT was extended by the SimCorporation in Düsseldorf.

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of Freiburg & Düsseldorf - Germany, was founded in 1998.

SAT GmbH - Business Units

- Airport Logistics
- Supply Chain & Production
- Warehouses & Distribution
- Contact Center & Business Processes

One of our business units is dealing with airport business processes and logistics. During the last years SAT build up its competition in airport business and can come up with a lot of experience in modelling airport processes, terminal-, apron-, and curb-logistics.

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Partners and References

Partnerships in Airport Business

- Deutsche AeroConsult GmbH
  of Frankfurt/Main - Germany
- MEVATEC Corporation
  of Huntsville, Alabama - U.S.A.

References in Airport Business

- Hamburg Airport
- Düsseldorf International
- Munich Airport

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As an example for detailed terminal simulation we will have a closer view to the Hamburg Airport Terminal Simulation Project later on in this presentation.

In developing solutions in tasks of airport business, we are accompanied by strong partners like Mevatec Corporation of Huntsville, Alabama – U.S.A. and Deutsche AeroConsult GmbH of Frankfurt, Germany.

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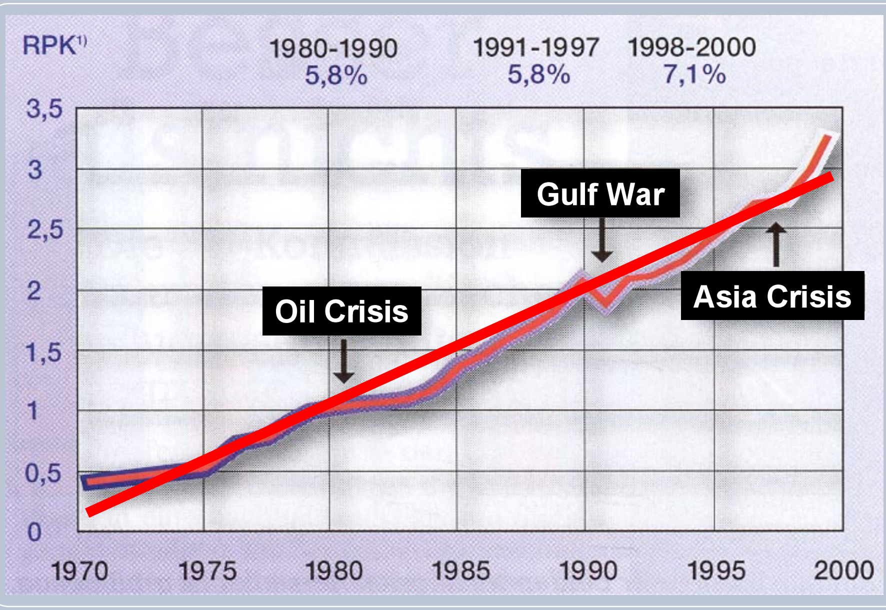
Development of Air-traffic World-wide



Aero International, № 11 - Nov. 2001 (page 45)

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For the moment air-traffic development world-wide is stagnating and in some regions even decreasing. Those setbacks are not new for international air-traffic. For example the oil crisis in the beginning of the 1980s, the gulf war 1991 or the Asia crisis a few years ago were responsible for temporary declines in civil aviation.

There is no chance to forecast extraordinary political events or catastrophes like the events of September, 11th. Those scenarios can not be the basis for long- or medium-term planning and they will not interrupt the general trend of increasing air-traffic world-wide. Maybe the time horizon for airports reaching their operational limits is pushed out, but the limits will be reached for sure. Questions for resource capacity and optimised operations will still be actual.

How is air-traffic growing? How will the need of operational resources develop? And can the anticipated Passenger Service Level in the future be guaranteed?

These are some of the fundamental questions for every airport extension program.

No planning engineer, no project manager, who does not have the wish to take a ride in Herbert George Wells' "Time Machine".

How easy it would be to plan, to decide what should be realised and constructed right on time. This option is science fiction and will be forever.

But there are two possible ways to go ahead with this deficiency. The first and of course most efficient approach is to create the future by your own - the problem: everyone is trying to do so and everyone for his own specific targets. The conglomerate of all intentions for each field of interest will be a general trend for the future development.

So the second attempt to get an impression of the future and to be prepared for future demands is to take the trend and forecast the possible development, respecting all terms of influence.

What does it mean for airport affairs?

The basic information required is the flight schedule with its effects on the daily airport operations, as well as on future scenarios. The flight schedule sets the frame for the most important decisions in airport development concerning

- Airport Expansion Projects,
- Business Plans,
- Operations Planning and
- Personnel Policies for all departments.

Airport authorities are not able to take decisive influence on the structure of future air-traffic. Airport operations only can react to the development to satisfy the requests of airlines and passengers.

Therefore, it is more important to know how the future will look like. Together with Deutsche AeroConsult, SAT created the Airport Simulation Manager.

The essence of the following presentation is, to introduce the idea of combining air-traffic schedule prognosis - as a static analytical method for development planning and creation of a basis for further investigation - and future terminal capacity analysis in a dynamic approach, using the efficiency of the simulation tool ARENATM.

I would like to describe the background needed for an applicable forecast of future flight schedules, the steps of extension to create a useable input for a simulation analysis and last but not least the benefits of the simulation results describing the requirements of resources and operations planning for the future.

Today's planning procedures are extremely time-consuming and demand a lot of human resources to develop a detailed future flight schedule for the airport under consideration. It is nearly impossible to create a whole group of schedule scenarios varying the parameters of influence and the expansion rate within an acceptable time-frame.

The Schedule Expansion Module derives a future flight schedule of the respective airport for a definable forecast volume automatically.

It bases on the idea, that a future flight schedule will have a close connection to the structure of the current flight schedule combined with the definition of a future trend.

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Input of Basic Reference Flight Schedule

- Flight Time (STD / STA)
- Flight Direction (Inbound/Outbound)
- Airline
- Flight Number
- Type of Aircraft
- Origin
- Destination
- Stopovers
- Flight Day

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The current flight schedule structure is given by a basic reference flight plan, which would be normally the last schedule in use of the respective airport. To find the easiest way to implement the data, the information from the reference schedule is reduced to the absolute minimum, as there are the flight time and direction, the flight number including the airline code and the route number, the type of aircraft, the origin and destination with the stopovers, and if the read-in basic reference flight schedule consists of more than one day, the marker for the flight day.

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Extend Basic Flight Schedule - Background Tables

- Airports world-wide
- Geography and Administration
- Airlines world-wide
- Aircraft types & Aircraft fleets
- Airport specific Factors and Rates

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These data are the basis for the analysis of the current flight schedule structure. In addition some more information - general and airport specific - are needed to describe the scenario comprehensively. For this duty the Airport Simulation Manager contains a group of background data tables to extend the basic flight schedule automatically.

This means, that the most relevant additional information for the future flight schedule will be generated within the system without detailed manual input.

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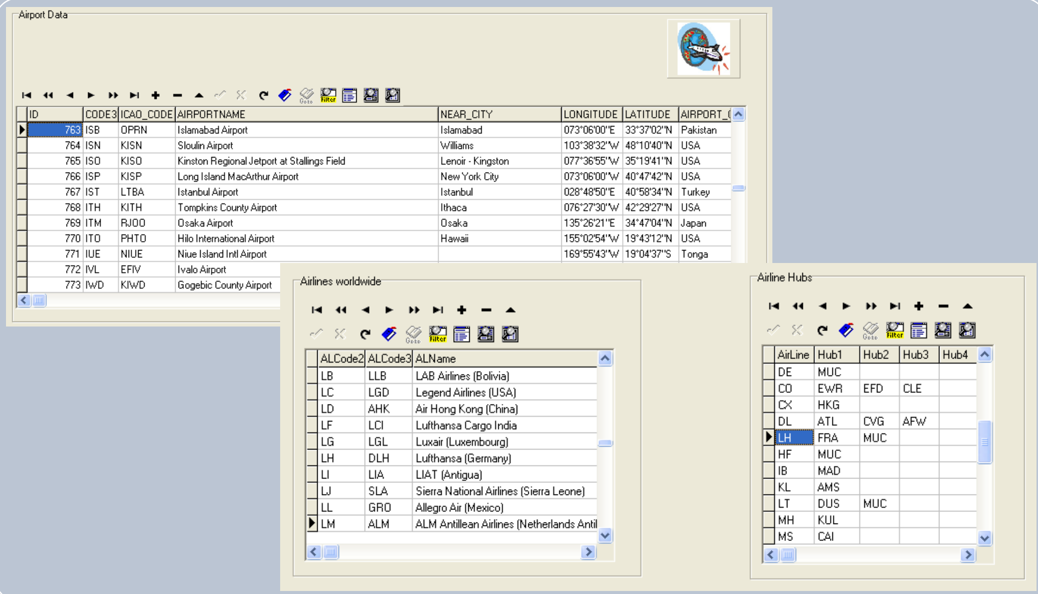
Background Data - Airports & Airlines World-Wide



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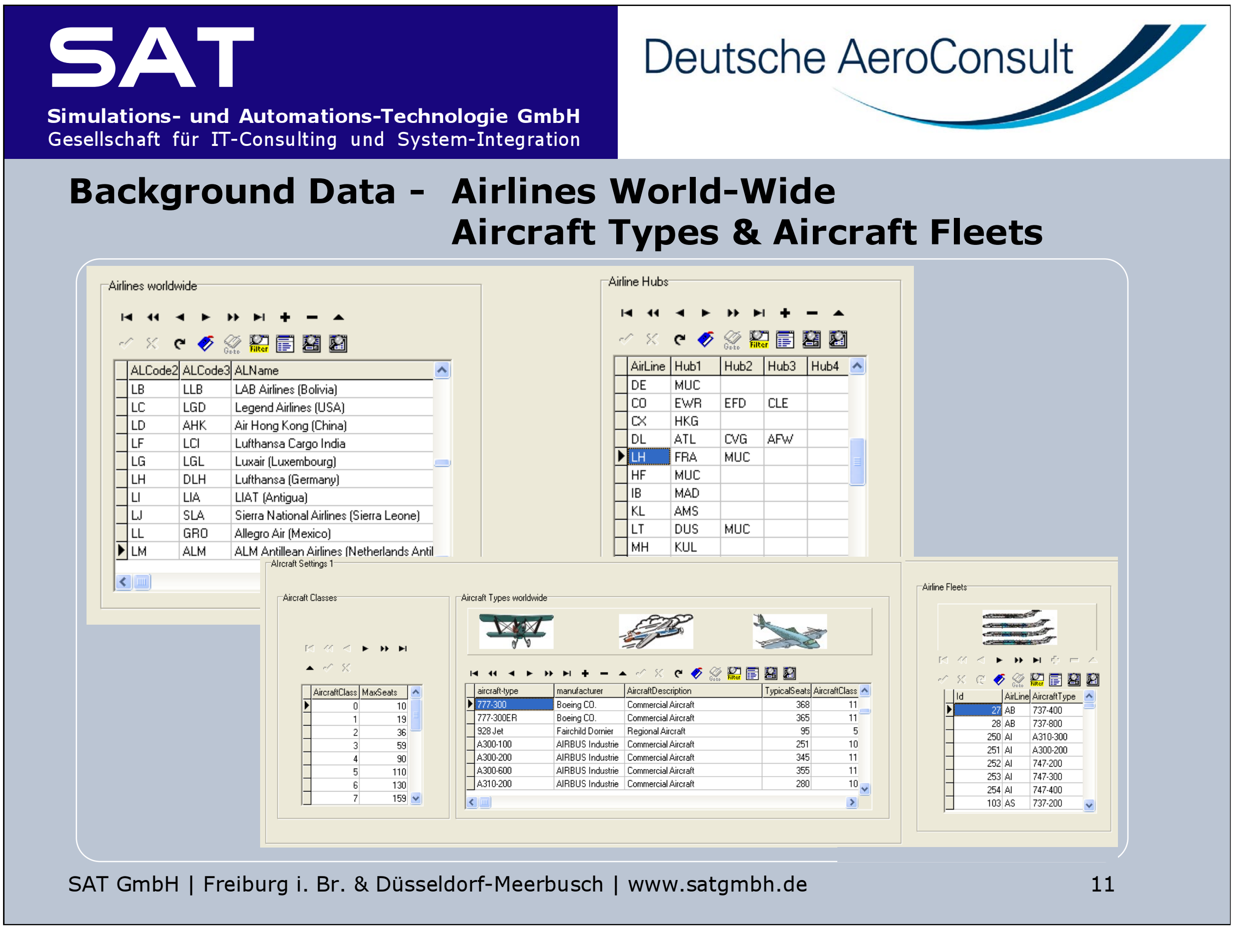
Pre-defined tables give information about the trigger values for short, medium and long range flights, the relationship between country and continent, as well as the possible membership in an Administration Zone.



For the consideration of the aircraft size and fleet development in the future flight schedule, the types of aircraft are categorised in classes. The fleet structures of the implemented airlines are listed. All those data are pre-defined, but can be easily modified by the customer.

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Data Processing to Extended Flight Schedule

- Flight type
- Flight area category
- Flight distance category
- Aircraft class
- Passengers expected
- Baggage expected
- Escort expected
- Checkin type
- Administration Zone
- Hub flight marker
- various airport specific information

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The extended flight schedule contains of course all information of the basic flight schedule and it is supplemented with data calculated from the background tables as there are:

- Flight type
- Flight area category
- Flight distance category
- Aircraft class
- Passengers expected
- Baggage expected
- Escort expected
- Check-in type
- Administration Zone
- Hub flight marker

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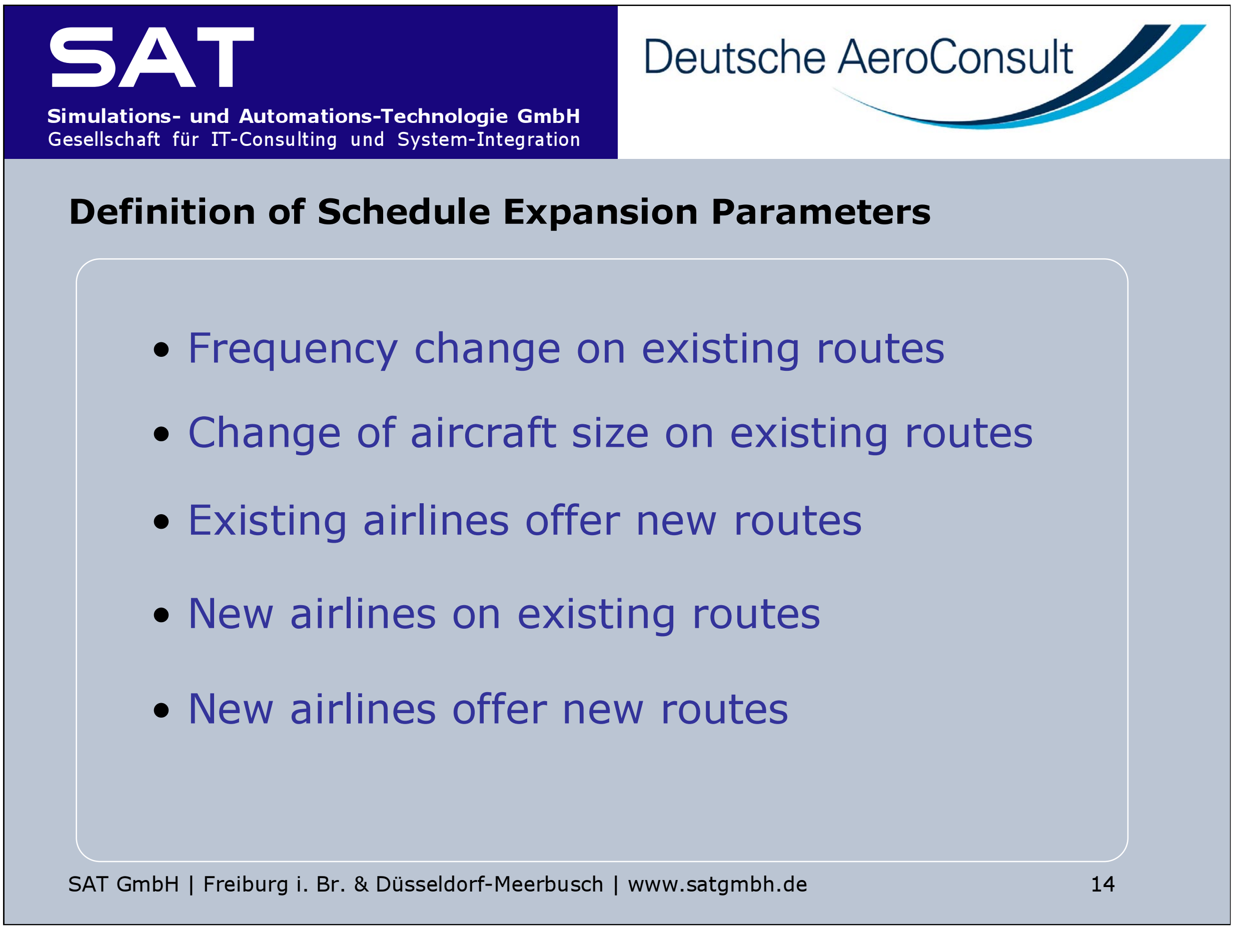
Analysing the Schedule Structure

- traffic peak hours
- distribution of business and tourism flights
- aircraftmix
- distribution of short/medium/long range flights
- frequency of flights
- composition of airline structure

The schedule structure is analysed regarding to the traffic development over the day, especially through the peak hours - these times will be the most inquired slots in the future as well. The distribution of business and tourism flights are registered, because of considerable differences in passenger behaviours. The distribution of long-, medium- and short-range flights, the average fleet size and the composition of airlines at the airport are working as indicators for the global orientation of the respective airport. More specific are the findings about the frequency on the routes.

The creation of schedules bases on this analysis, the analysed structure will be combined with the user-described trend for future flight schedules.



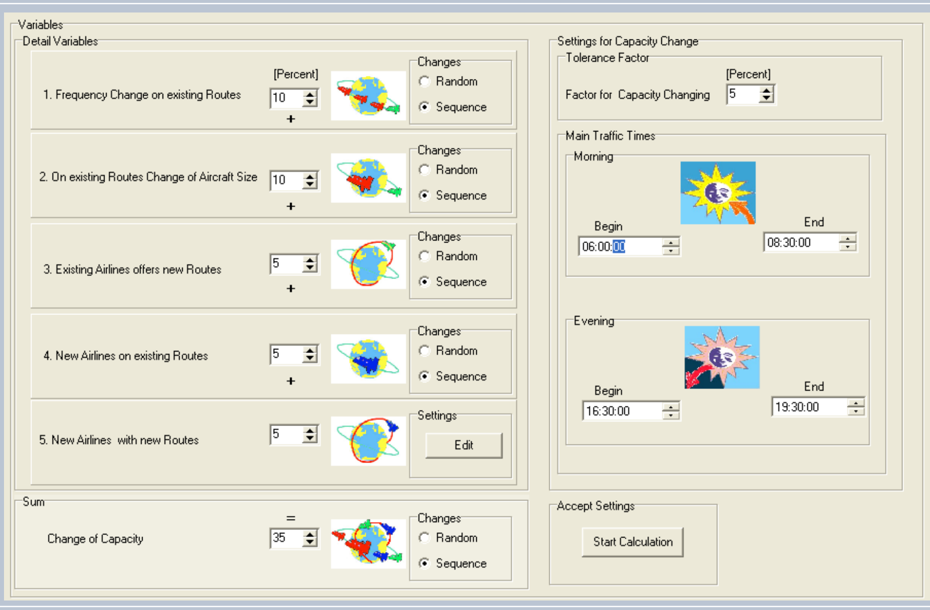
So the forecasted schedule will be a consequent development of the specific air-traffic situation at the anticipated airport with respect to possible future influences.

These trends are described by the following five terms of influence:

- Frequency change on existing routes
- Change of aircraft size on existing routes
- Existing airlines offer new routes
- New airlines on existing routes
- New airlines offer new routes

The valence of each item has to be defined individually depending on the value setting. So all possible trends for the future can be described as a combination of those terms of influence.

Definition of Schedule Expansion Parameters

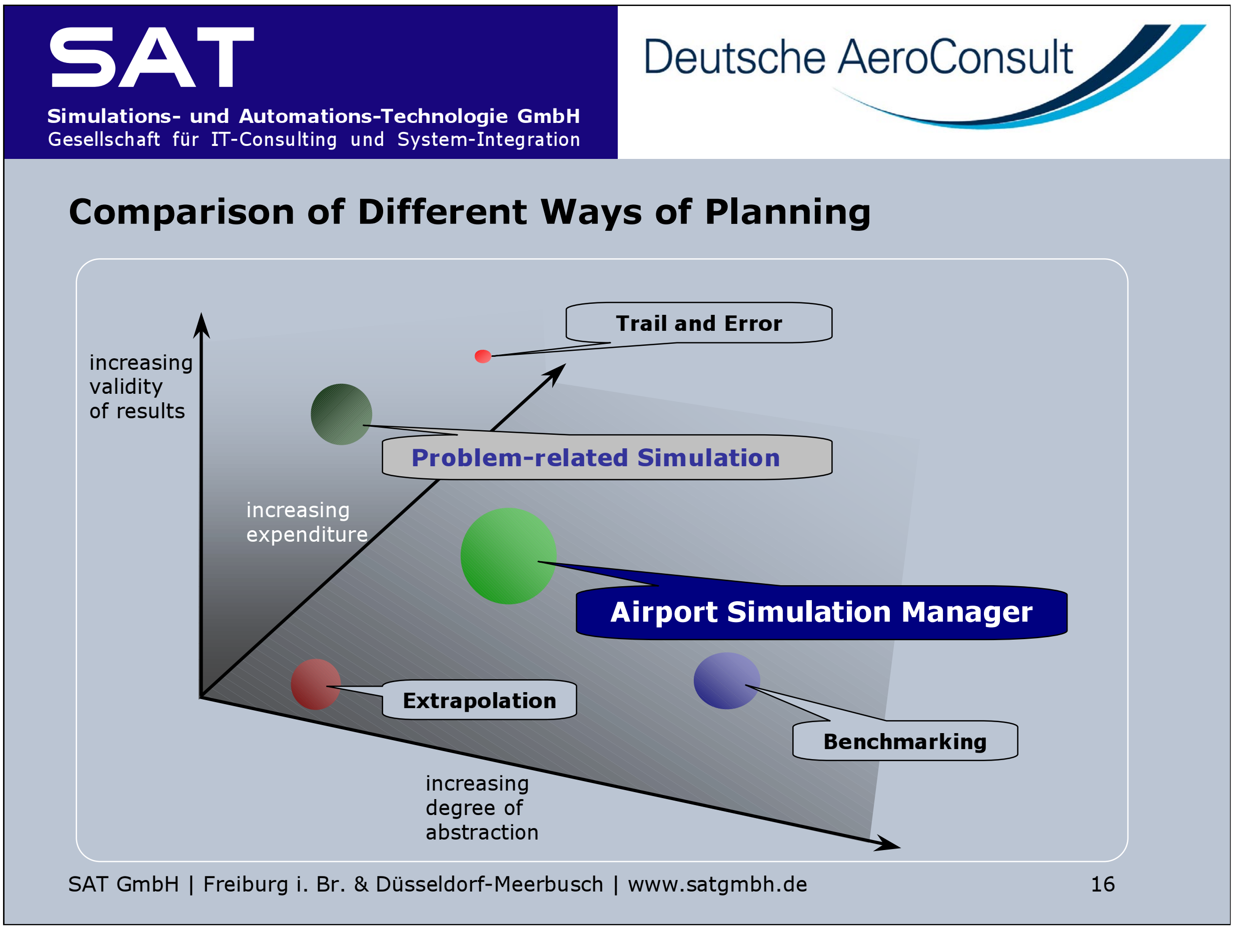


The sum of these values determines the extension volume for the future flight schedule. User-defined rules and airport specifics can be integrated easily regarding aircraft size development, traffic extension in the main traffic hours and flight range distribution.

Following the definitions and extension rules the flight schedule can be forecasted.

The future flight schedule can now be used as input for further analysis.

The knowledge about the air-traffic development and to dispose of a possible future flight schedule are fundamental - especially for developing business plans, but taken for their own, this information is no answer to the question concerning future operational requirements at the airport.



Some approaches to analyse the effects of changing traffic loads on airport operations should be discussed briefly, with emphasis on expenditure, the validity of the results and the possibility of transfer to the specific airport situation.

'Trial and Error' seems to be the worst method concerning prospective planning - expensive, inflexible, unprofessional and time-consuming and not really a high sophisticated approach!

The anticipated need of resources in the future often is calculated by taking the experience of the past and projecting it on the future tasks. Those forecasts are neither valid nor secure and normally do not allow sophisticated capacity analysis either. Generally, the more the extrapolated data - representing the basis for all planning decisions - are beyond the actual situation, the more the results will be invalid!

'Benchmarking' - a large-scale way to get general data for a specific problem without being able to control the own development of success, perfect to find the own position in competition - not the best method for finding the way for the future!

The most reliable results will be created by using simulation technologies. Two complementary level of detail in simulation will be presented here.

On the one hand the Layout- and Concept-Level, as it is realised in a tool like the Airport Simulation Manager and on the other hand the more detailed approach for Process- and Operations-Planning of a problem-related simulation introduced by the example of the Terminalsimulation at Hamburg Airport.

In the following both strategies should be described and discussed pointing out their strong points and specifications.

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Airport Settings - System Adjustment

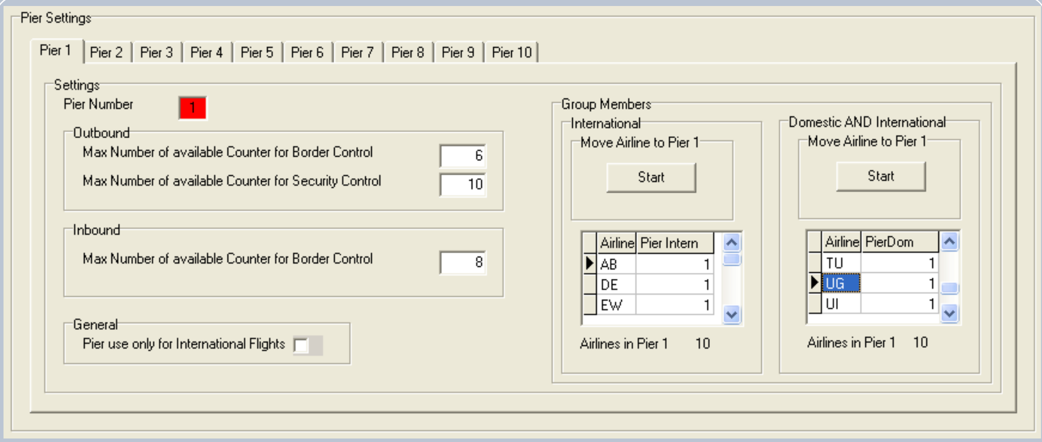
- Architectural Adjustment
- Logistic Adjustment
- Organisational Adjustment
- Operational Adjustment

Concerning the required simulation input the Airport Simulation Manager as well as a Problem-related Simulation tool have to be adjusted to the airport specifications. The main difference between both systems is the quality and quantity of input data required.

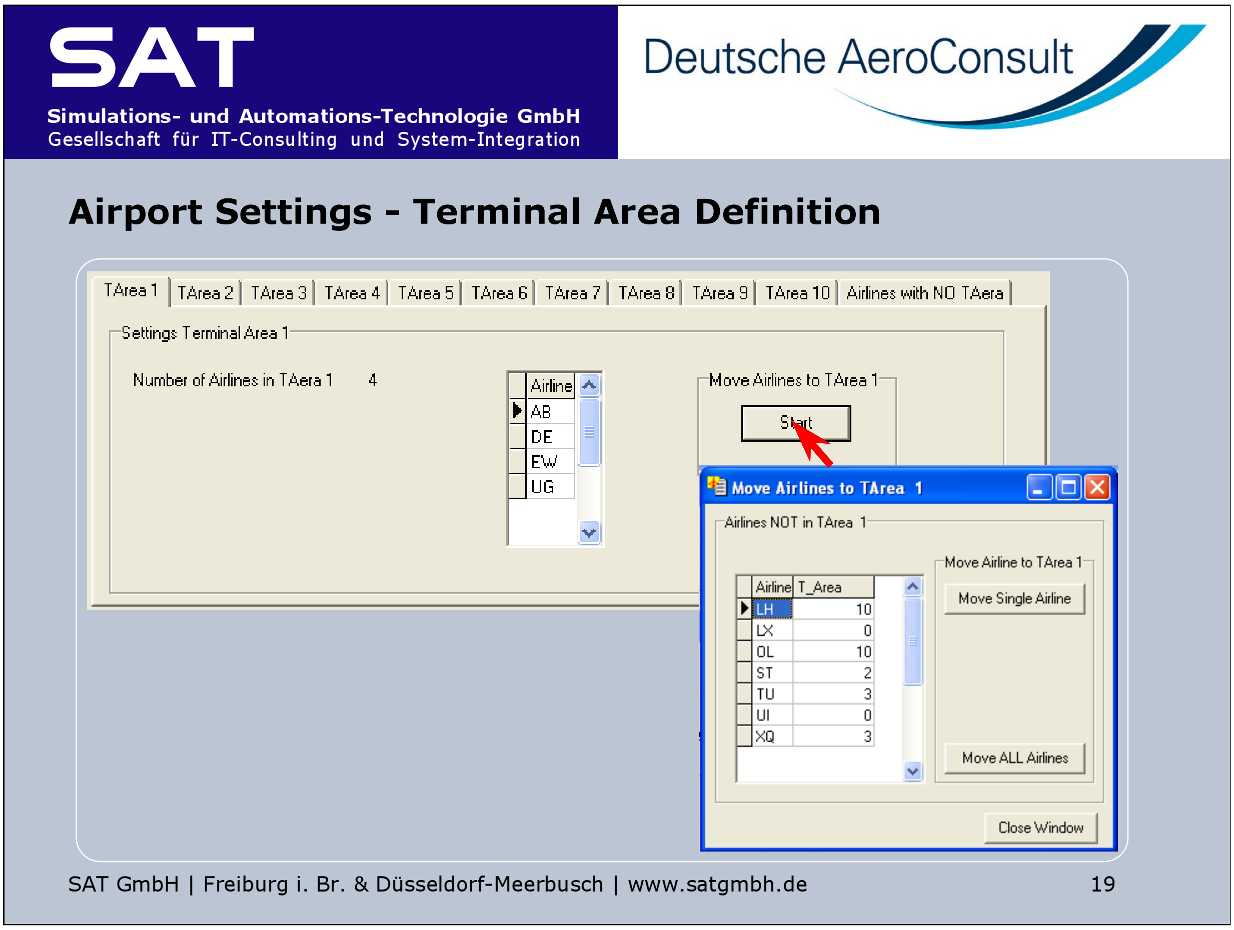
The Airport Simulation Manager needs basically all specific settings of the anticipated airport. For a structured description it can be split into four categories:

- Architectural Adjustment
- Logistic Adjustment
- Organisational Adjustment
- Operational Adjustment

Airport Settings - Definition of Pier Settings



The Architectural Adjustment contains a description of the most fundamental airport layout, as there are the number of piers, the availability of resources like check-in and security counter, ticket counter and immigrations. All resources have to be set for each particular part of the airport. This means for example, that resources of piers, like immigrations for in- and outbound traffic as well as security counter, must be set individually.



The airport utilisation is described in the Logistic Adjustment, which is managed by assigning airlines to specific parts of the airport like piers or terminal areas.

Airlines using an assigned pier are defined and listed in interactive tables.

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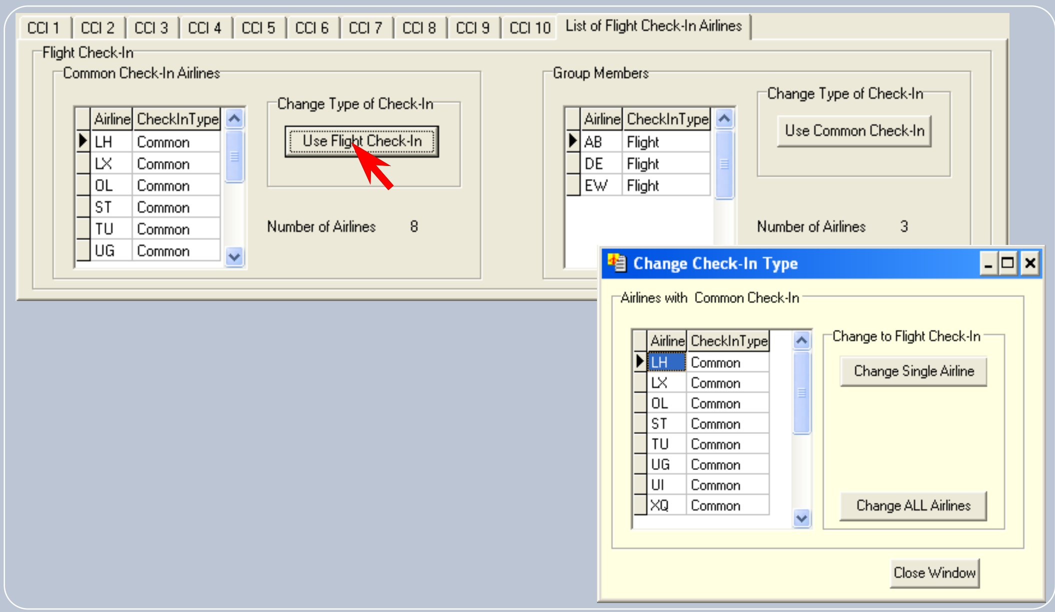
Airport Settings - Definition of Flight Checkin



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The commitment of handling specifications are part of the Organisational Adjustment. The definition of common check-in groups and airlines handling their flights individually must be prepared.

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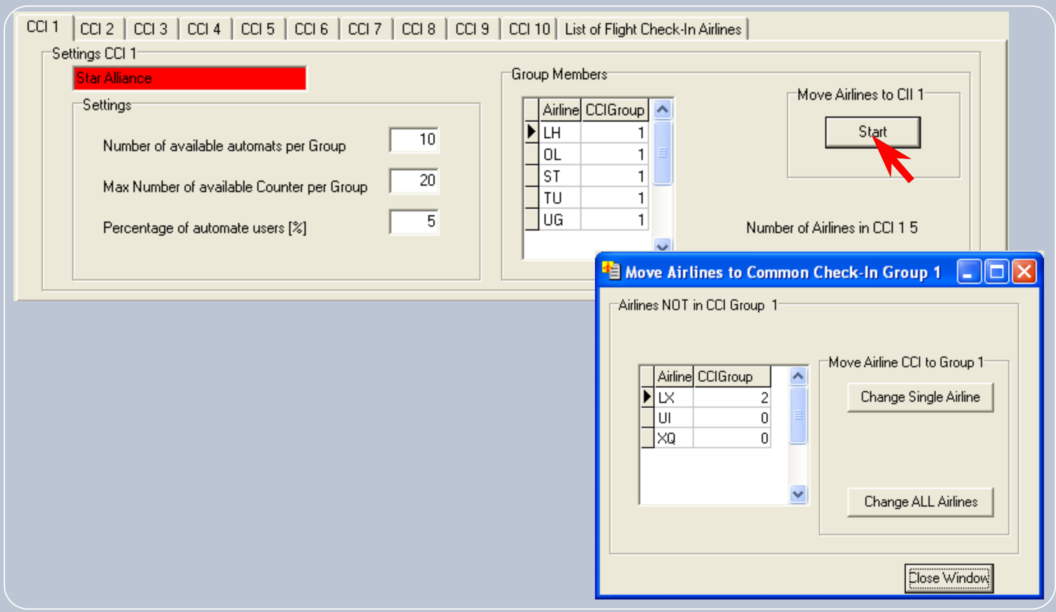
Airport Settings - Definition of Common Checkin Groups



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The common check-in groups will be defined by assigning the respective airlines to the chosen group.

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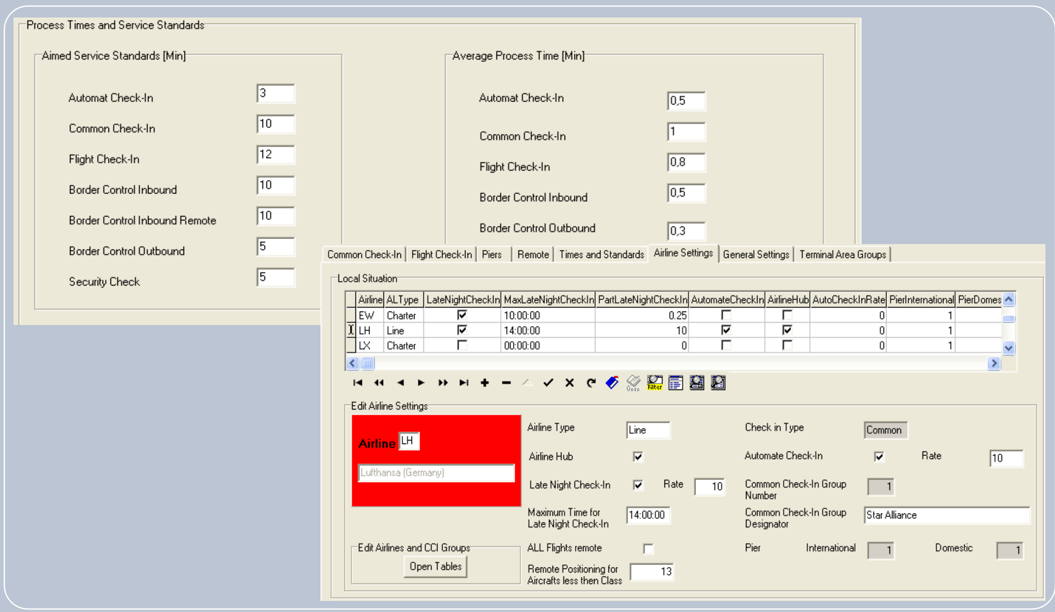
Airport Settings - Process Times and Service Standards Airlines Characteristics



The Operational Adjustment defines the process times as well as the aimed passenger service standards. The anticipated service standards describe the quality of passenger convenience at the airport. The average process times for each type of handling resource will be defined separately - within the simulation these times will be varied automatically for each entity. Not only airport specifications have to described, but also airline characteristics being relevant for the simulation must be defined.

Our Solution

Airport Simulation Manager

Simulation Module

In a real system run both categories of information, the background data especially for the development of the flight schedule and the definitions for simulation are processed together, combining and adding the findings. Most of the simulation settings appear in the presented future flight schedule as additional information like check-in group, arrival- or departure pier, etc.. For the following simulation the database provides a data-set containing all relevant steering and input data. The simulation run starts automatically, without any further manual definition or programming.

The Simulation Module considers every single passenger as an independent entity, taking into account the specific attributes and successions of handling processes in temporary interdependence to each other. It reflects the user-defined architectural, organisational and operational structures at the airport.

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The Simulation Run - Discrete Event Simulator *ARENA ™*

- passenger arrival
- ticketing
- passenger and baggage checkin
- security check
- immigration (in- and outbound)
- boarding
- passenger arrival (inbound)
- baggage claim
- leaving the airport

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The simulation depicts the passenger handling process in and through the airport terminal for in- and outbound traffic:

From the appearance of passenger in the terminal, depending on the flight time and the personal behaviour, over the ticketing, the passenger and baggage check-in, the security check and immigration to the boarding. And for the inbound: From the passenger arrival, over the baggage claim to the leaving of the airport.

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The Simulation Run - Utilisation of Resources

- Analysing the evaluation of the dynamic resource load
- Presenting the effect on airport operations
- Describing the status of passenger convenience

The Airport Simulation Manager analyses the dynamic demand for resources for the passenger handling.

The main topics of the simulation are the evaluation of the dynamic resource load and the effect on airport operations as well as passenger convenience.

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The Simulation Run - Resources and Service Level

- Up to the pre-defined upper limit of resource availability the system provides the needed number of facilities automatically
- Reaching the limit the results will show the decreasing service standard and customer convenience

The Airport Simulation Manager analyses the need for resource availability in the passenger handling process. This means, that the system will not act with the real utilisation of discrete existing and scheduled resources, but calculates the demand of resources to guarantee an aimed passenger service standard.

Up to the pre-defined upper limit of resource availability for a particular part of the terminal or a specific group of resources the system provides the needed number of facilities automatically, keeping the defined Service Level within an interval of 10% with respect to the anticipated Service Standards. Reaching the limit the results will show the decreasing service standard and customer convenience.

By means of the flexibility of the user-defined system adjustment, with respect to resource utilisation analysis the system can represent current resource availabilities as well as possible future scenarios.

The Airport Simulation Manager cuts out any animation. The integrated abstraction of utilisation of resources and routes takes the general coherence into account, but makes the system independent from detailed resource schedules and architectural layouts.

This provides the possibility to take the benefits of simulation even in a project status or for future scenarios, in which detailed information are not available.

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Output of Simulation Results

- Passenger Development
- Baggage Load
- Demand for Resources
- Passenger Service Level
- Airport Operations Functionality

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The generated results are presented in graphs describing the dynamic development usually over the time, differentiated for particular defined parts of the airport.

The system performs various information concerning the development of passenger figures in different areas and the anticipated baggage load. The demands for resources - like check-in counter and check-in automats, security counter, immigrations, gates and some more - are documented, combined with the development of the passenger service level of the respected resource.

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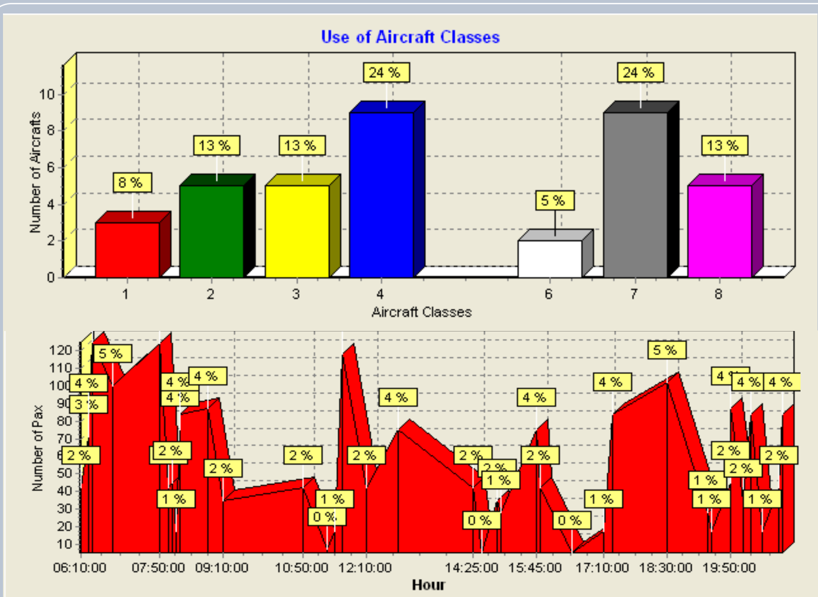
Presentation of Results - Graphics and Tables



Examples of prepared result graphics

The results allow a total overview about the airport operations functionality.

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Hamburg Airport

Process- and Operations Planning Simulation System

Terminalsimulation Hamburg Airport

Hamburg Airport

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To get the chance to see how an animation of an airport terminal simulation can look like and what benefits and differences a specific problem-related simulation system in opposite to the presented Layout-simulation tool has, the example of Hamburg Airport will be described briefly.

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Hamburg Airport

Requirements - Terminalsimulation Hamburg Airport

- Verify the future Airport Extension Planning
- Optimising the Operational Processes
- Simplify Data Processing for Input Data
- Implement flexible Resources
- Integrate virtual Resources
- Implement 100% Hold Baggage Screening
- Flexible and automatic Passenger Routing
- System supported Result Analysis

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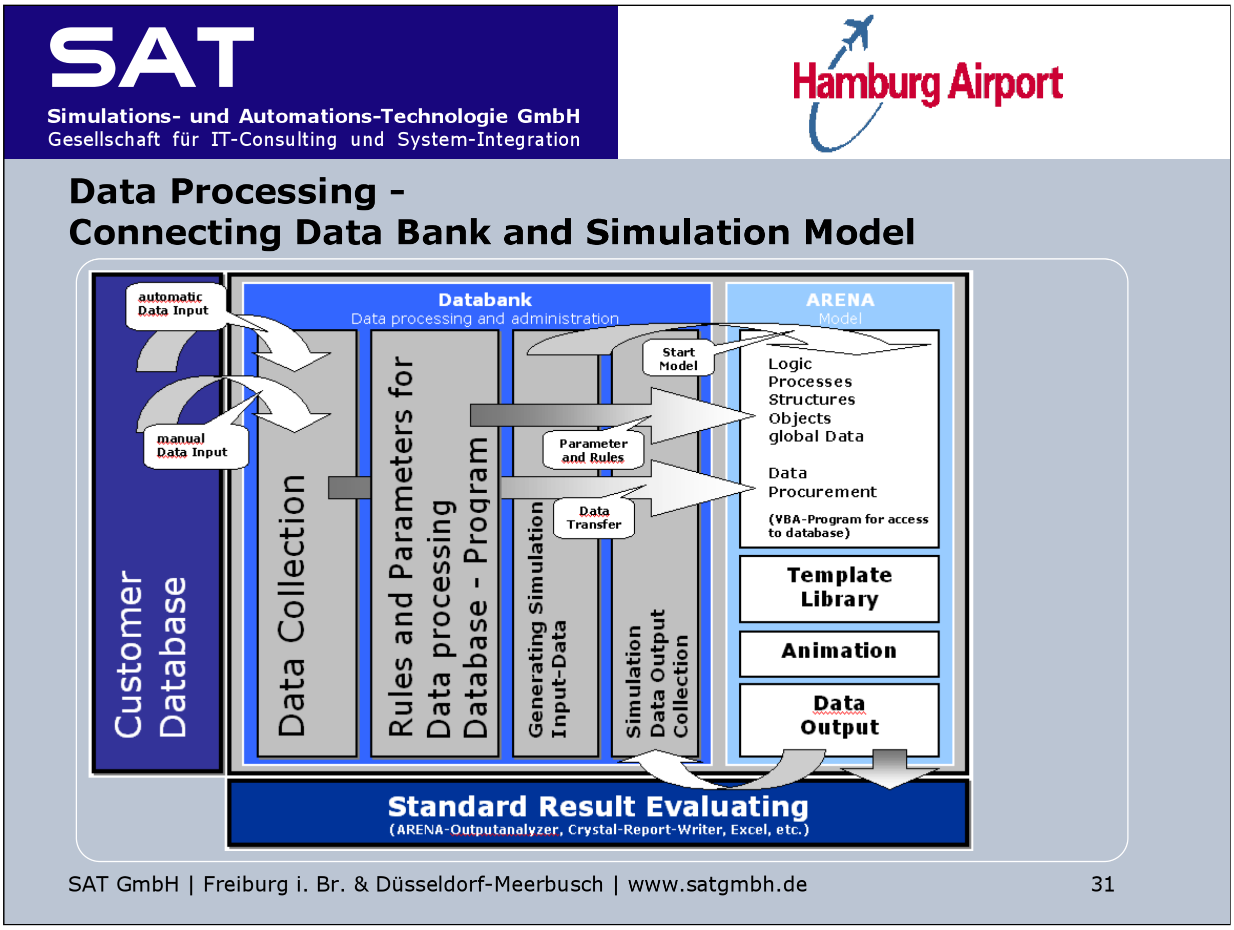
Hamburg Airport Authorities want to create a comprehensive Simulation system for the description of passenger terminal processes for the whole airport. The target for Hamburg Airport is to have a tool for the future extension planning and for optimising the operational processes to increase the passenger convenience.

The data processing for input data should be handled easily for the customer.

Resources in the model have to be flexible in use. Virtual resources should be integrated and switched on or off user-defined. The system has to implement the new concept of 100% hold baggage screening. The routing of the entities must be flexible and the passengers should be directed automatically on their ways through the terminal. For the simulation results the database provides a system supported result analysis.



To handle the large amount of detailed information most of the data reduction is fully automated or system supported once again in a database. SAT GmbH found a solution for the problem by using a specifically developed Access Database, which prepares the animation of the result data as well.

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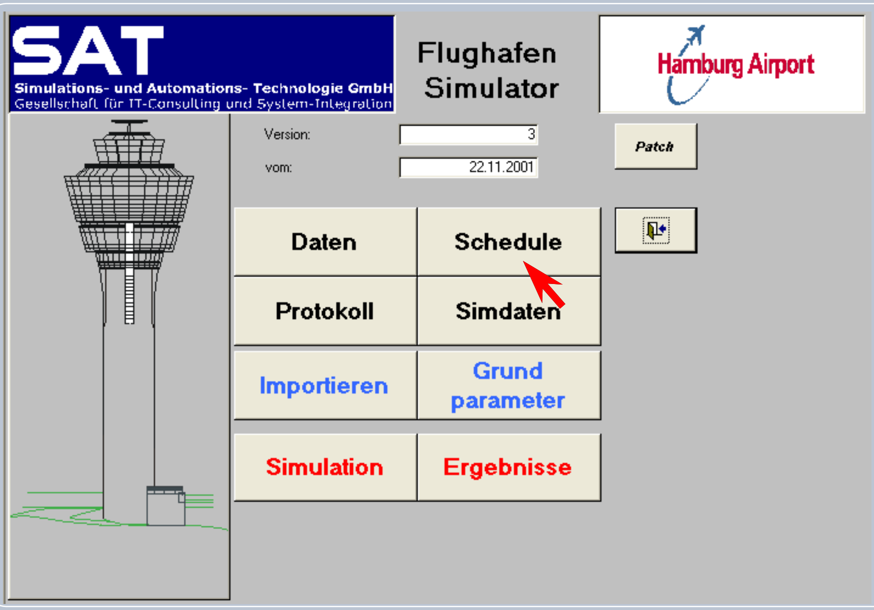
Hamburg Airport

Data Bank Structure - User Interface



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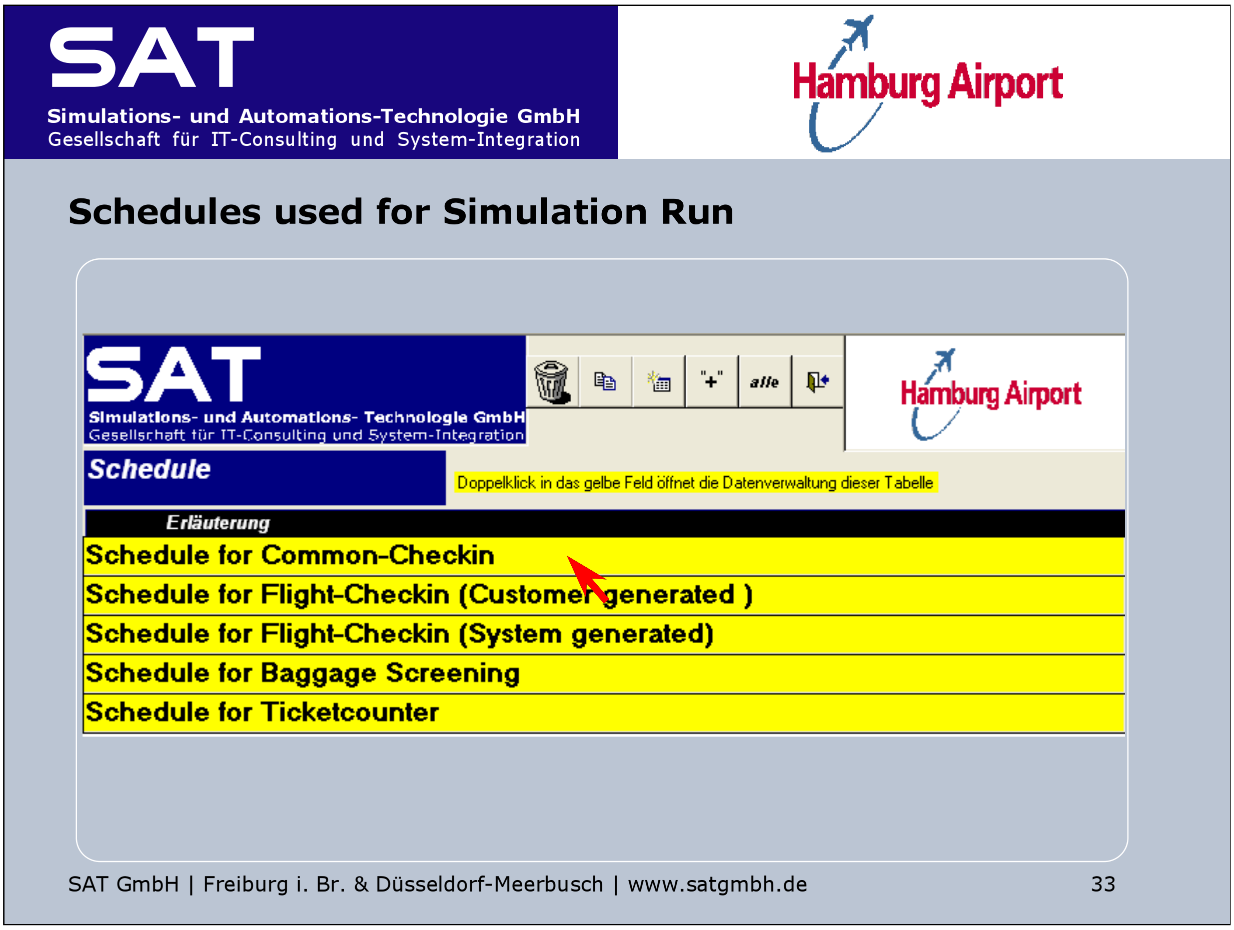
A fast walk through to the structure of this database to demonstrate some selected features will give a first impression and points out the differences of required input data between both complimentary systems.



All integrated resources and facilities here have to be scheduled, this applies to

the passenger check-in - for common and flight check-in, the airline ticketing and the 100% - Baggage Screening Facilities as well as for the security counter and immigrations.

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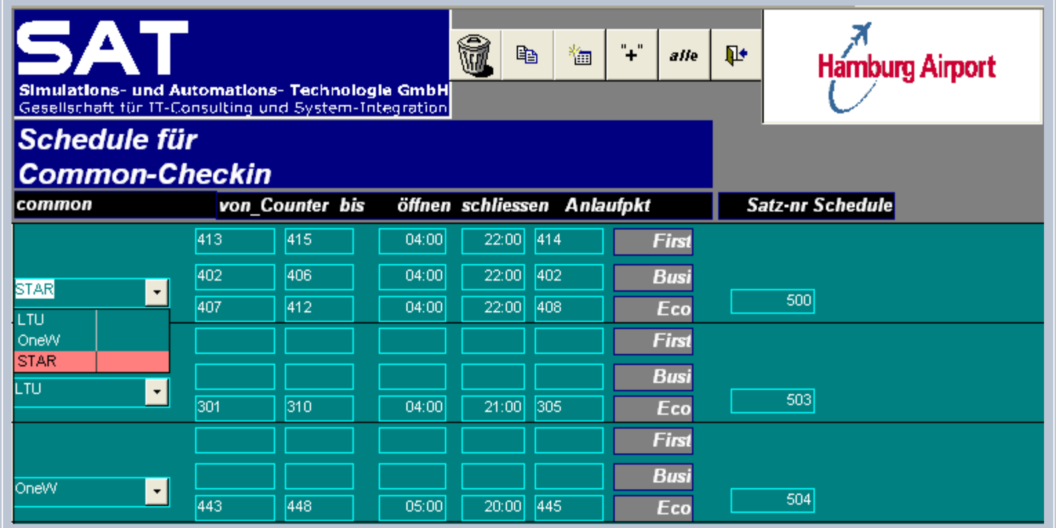
Data Input - Schedule for Common Checkin



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Each Common Check-in Group (for example Star Alliance, One World, ...) has got its own schedule. The frequency of modifications is unlimited.

The schedule depends on two categories of information, the check-in classes and the definition of location and time, as there are the first and last counter, the opening and closing time.

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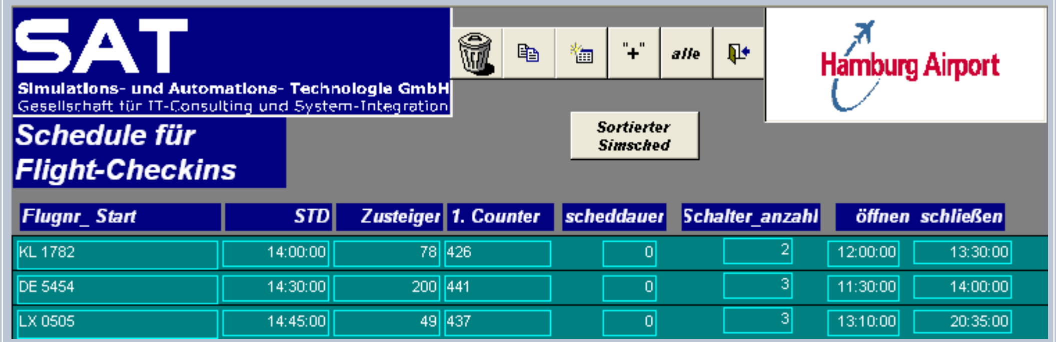
Data Input - Schedule for Flight Checkin



Flugnr_ Start	STD	Zusteiger	1. Counter	scheddauer	Schalter_anzahl	öffnen	schließen
KL 1782	14:00:00	78	426	0	2	12:00:00	13:30:00
DE 5454	14:30:00	200	441	0	3	11:30:00	14:00:00
LX 0505	14:45:00	49	437	0	3	13:10:00	20:35:00

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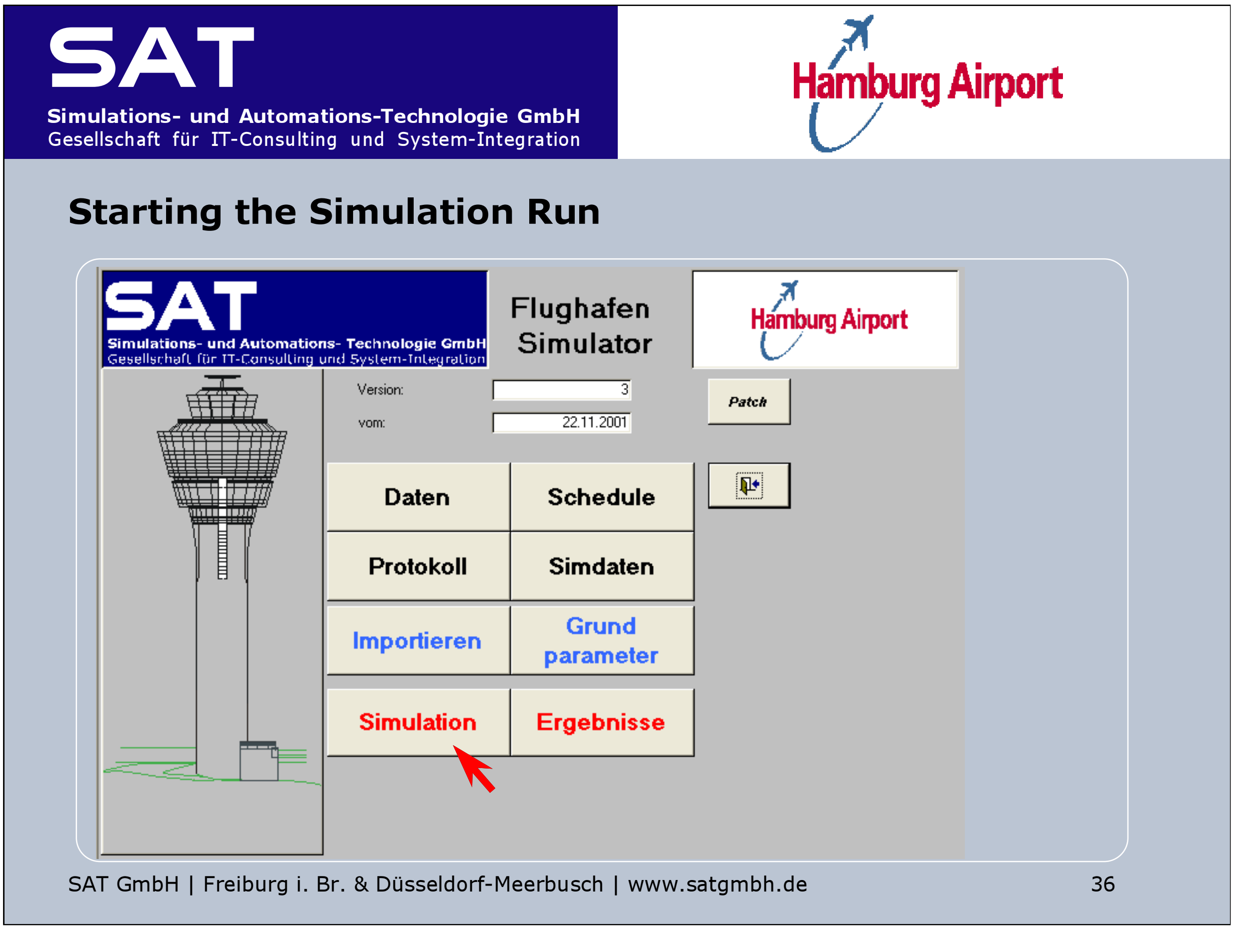
The Flight Check-in schedule receives its data from the customer database. The schedule is generated automatically - using the rules, described in the data bank.

In the same way - user-defined or rule-based - the availability and utilisation of all resources have to be defined in detail.



All background tables, definitions and parameters lead in addition to the considered flight schedule into a fully described operational air-traffic scenario for the respected airport. Also the flight schedule generated by the Airport Simulation Manager can be used to feed this terminal simulation, if the detailed information described above is available for those schedules.

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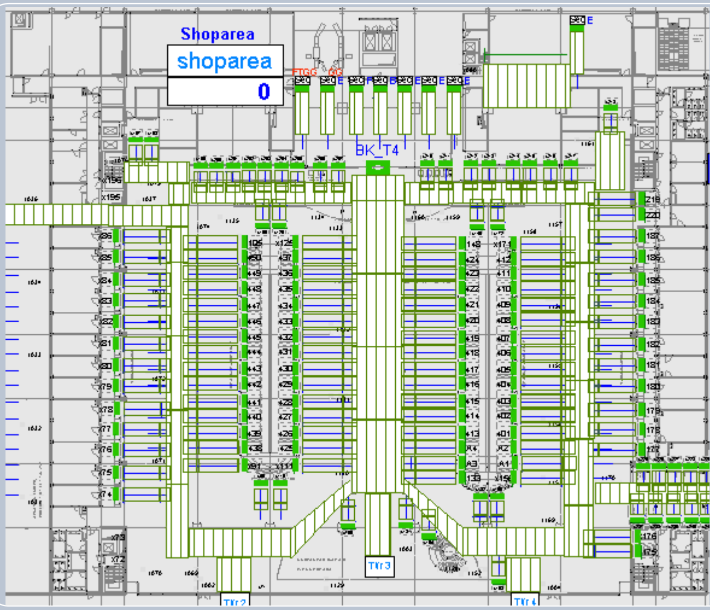
Overview - Terminal Simulation Hamburg Airport



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The simulation model represents the airport layout and process structures.

Resources and traffic areas are pre-defined, the flight and resources schedules are read in automatically, the passenger-entities and characteristics are created and the airport terminal processes are modelled in detail.

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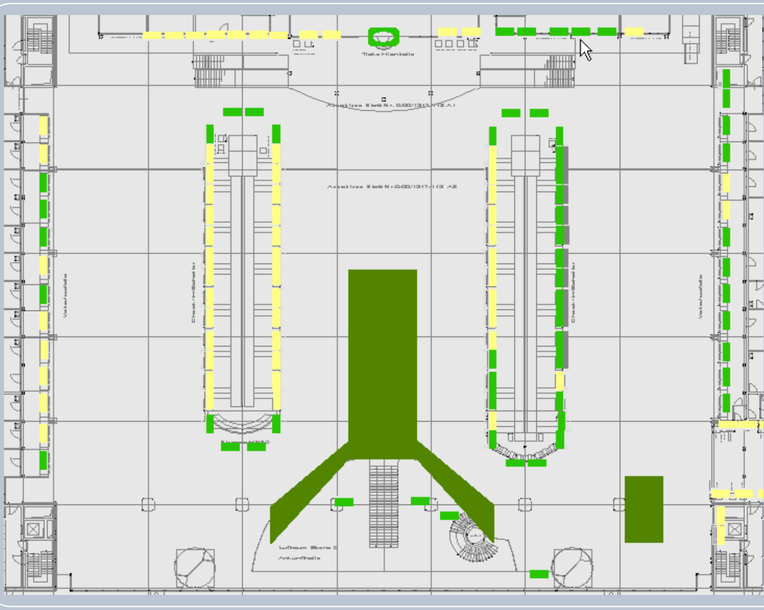
Finding the Way through the Terminal



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Each entity takes the most common route to reach its next point of process. The passenger routing is designed to be variable and dynamic. It follows the specific process requirements of every single entity, as there are the remaining time to Scheduled Time of Departure or the availability of resources.

The walking speed of each individual passenger is influenced by two circumstances. First the personal situation - maybe the passenger is carrying baggage or bulky luggage - and second the walking speed is influenced by the actual traffic situation of the used traffic areas.

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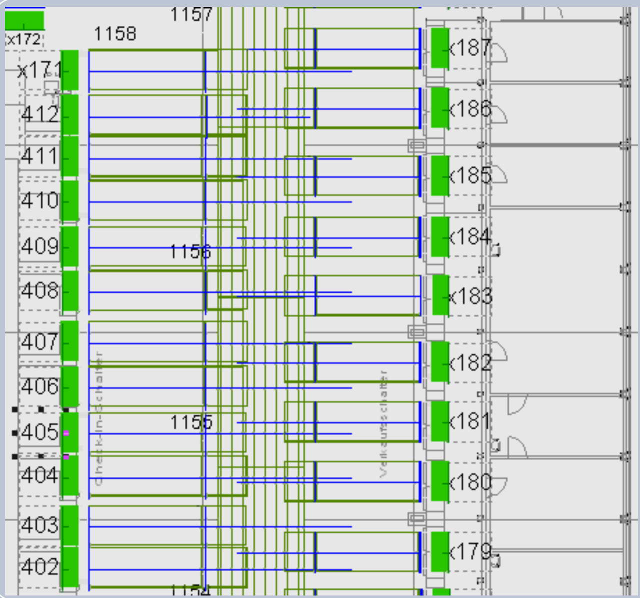
Defining Resources



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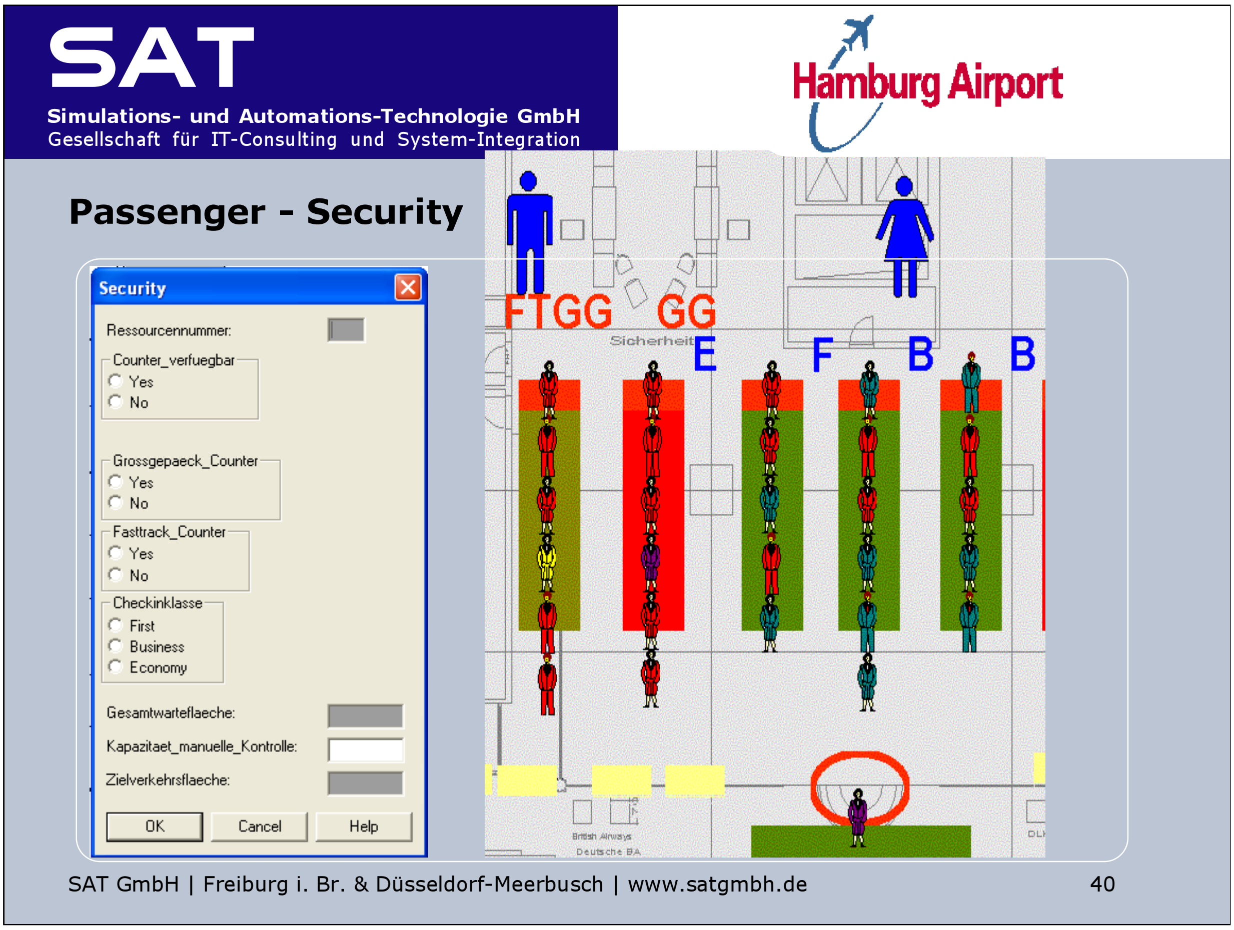
One of the demands of the projects was the flexibility of resources to keep the flexibility of the model without the necessity of reorganisation of the programming. Integrated resources are flexible to use as check-in counters, check-in automats, bulky luggage counters or ticket counters. Or they could temporarily fade out of the model.

All possible types of resources must be defined in detail in a dialog window, regarding capacity and assigned waiting areas.



Beside the flexible resources there are 'Special Duty Resources', for example the Passenger Security.

Each Security Counter will be described in detail. Restrictions in use can be considered, for example a special Counter able to check large-sized baggage, or a counter reserved for urgent passengers only. Counters can be reserved for single travel classes as well.

The integrated security logic considers a two stage detection system:

First step is an automatic detection system (the Screening Frame) and - if the screening result is positive - followed by the manual body screening distinguished in independent male and female control zones. The rate of manual body screening is customer defined. Both stages have their specific process times.

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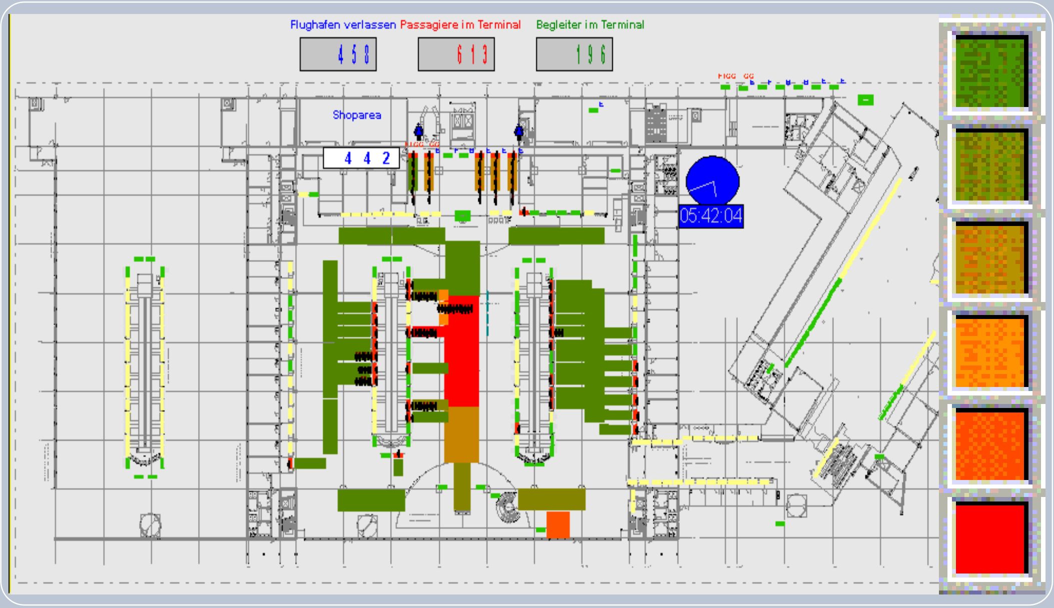
Passenger Checkin - Animation



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All animated areas in the model are showing the actual degree of Service Level.

The Passenger Service Level is described in six steps, from

'GREEN' - standing for a high standard of service,

'ORANGE' - defining a medium service quality, down to

'RED' - for a not acceptable Service Level.

Areas belonging together are grouped automatically and will be shown in the same status code. The trigger values for switching to the next service level are customer defined.

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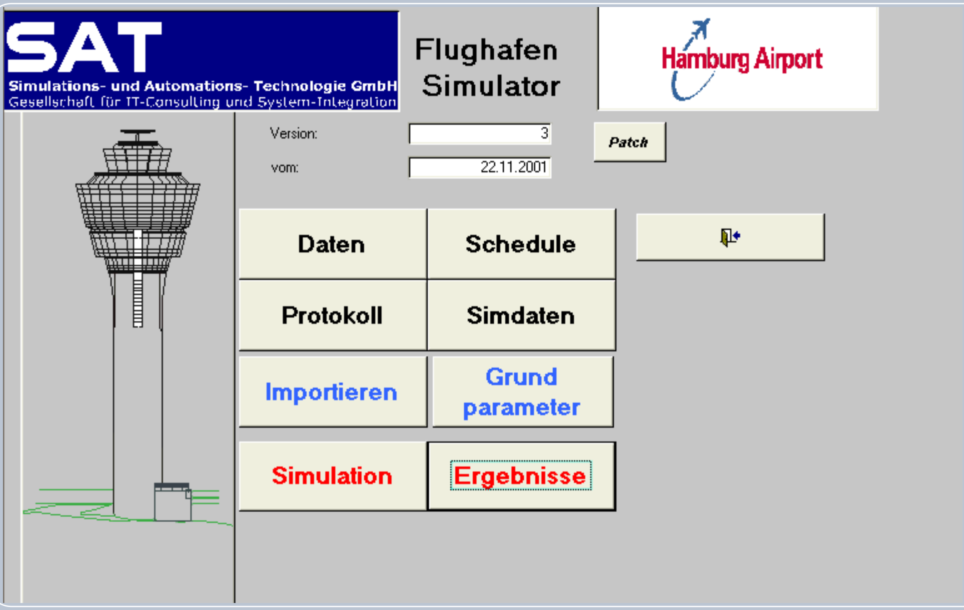
Analysing the Simulation - Results



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42 The simulation provides results for an evaluation of a status quo existing in the system - it could describe a real and current layout, but also future planning. Time-slot pattern for a detailed result write out are user definable. The results are collected as structured data in the database, where the result data will be analysed and prepared. The results are presented in the form of interactive tables and finally the pre-defined graphics are generated automatically.

It is apparent that in comparison to the Airport Simulation Manager the results are more detailed, because of the realised connection between specific located resources, their utilisation and measured dynamic figures of waiting time and service level.

Based on those automatically performed results the customer is able to draw his conclusions and make decisions for future development. The forecasted solutions can be verified, considering new parameter settings in a further simulation run.

Not in any case it is necessary or possible to have such a detailed view to the problem. Often the available information are scanty, so that there is a need for an abstract calculating system, which is able to generate valid results for the support of future planning decisions.

As you have seen in the presentation the main benefits of simulation in airport planning are:

- detailed problem analysis,
- Valid Determination of Requirement,
- Optimised Resource Utilisation,
- Innovative Solution Approaches,
- Creative Planning,
- Increased Decision Security, and of cause
- Cost Reduction in Planning, Construction and Operations.

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Contact - For further information please contact:

Thank you for your interest!

SAT GmbH
Badenweiler Strasse 4
79115 Freiburg
Germany

phone +49 / 7614 - 7997911
fax +49 / 7614 - 7997999
www.satgmbh.de

Deutsche AeroConsult
Frankfurt Airport
Area South / Bldg. 664
60549 Frankfurt
Germany

phone +49 / 69 - 697690
fax +49 / 69 - 69769300
www.daco.de