Impact Analysis on Throughput on Air Fleet Resources Using Simulation

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ABSTRACT

This paper presents a modeling approach to determine the impact on throughput on air fleet resources on the operation of airports. The primary constraints for this analysis are i) adherence to schedules, ii) optimization of resource utilization and iii) reduction of operational costs. Any plan for an impact analysis on throughput on air fleet resources on the operation of airports has to take into account the air transport specific constraints such as a) combination of automated and manual planning procedures, b) degrees of freedom which make the conduct jobs much more flexible, and c) independent encapsulated service and resource management. These constraints have a huge impact on the architecture of the simulation model. Hence, this paper describe the development of an architectural model for service planning and information gathering necessary for planning the different service activities for resource allocation through the several service providers.

KEYWORDS

Air-fleet resources, operation of airports, general flight management, local service management level, shortage identification, modeling approach.

1. INTRODUCTION

The paper presents an integrative concept for an impact analysis on throughput on air fleet resources for people and cargo on the operation of airports. According to the objective of an integrated valuation and optimization of the transportation resources, the suggested over-all approach concerning the means of transportation resources and the combination of cargo and people have to be adequate. In addition an overall system architecture has to be designed in such a way, that the various level of detail are represented adequately within the modeling approach. Further on it is mandatory to represent the physical key characteristics of the different transport resources, which are needed to assess the economic and environmental impact of a transportation resources in a comparable way.

For all types of influencing variables the transportation resource chain has to be modelled not only from the connection perspective but also as a local mode transportation chain incipient at an arbitrary starting point to any other local achievable position. This view on the air transportation system implies a multilevel and multi-scale transportation graph as basic data structure to work with.

In the past various approaches have been investigated to develop a global methodology to compare air transport resources in complete transportation scenarios. But the design and assessment of the future air traffic system has not only to consider the air side, it also has to bear in mind ground services and ground congestion. Because air transportation in the next century has to be much more convenient, ecological, effective, flexible than today in order to handle the volume of people and cargo that is projected worldwide. To achieve this goal air transportation of people and cargo on the one hand has to be connected with the multiple modes of transportation to improve the existing transportation chains in a more cost effective way. For this reason one need innovative means of tying the existing modalities together and making each one more efficient from a general perspective.

As case study example, in case of cargo intermodal transport, will have to be realized without handling the cargo when changing modes. Hence, intermodal transportation will offer intrinsic possibilities to reduce cargo handling allowing cargo to be transported faster, as well improving security, and may reduce damages and loss. Therefore reduced cost versus over the road trucking is a key benefit for the intercontinental use of intermodal transportation chains.

Referring the foregoing mentioned a general problem of intermodal transportation chains is reducing air and ground congestion which has been identified as a major problem in today's air transportation chains.

The most weakest point for air transportation and air ground handling is ground congestion at airports and/or inadequate availability of resources which can be identified as major shortage events. Assuming that the shortage-analysis deals with the calculation of the adequate availability of resources, the three different cases can be identified::

- **Best Case Analysis**: resources are available and no shortage will appear. This result in a high priced solution for ground handling approach, basically the resources available can't be used in an optimal way, because there are more resource available than necessary.
- **Worst Case Analysis:** resources are not available in the required amount or at the worst only one component is available but several of which are needed. Henceforth shortages will appear. This result in a cheap priced solution for the ground handling approach, basically resources available are not adequate.
- **Real Case Analysis:** real available resources have been taken into account. Basically the solution achievable for the ground handling approach is in between beast case and worst case because the results obtained by the real case analysis are sub-optimal.

Due to complexity and time and cost constraints, identifications of shortages in air transportation resources are not trivial to do. Because identification and elimination of shortages at airports on the one hand deals with discovering dependencies within a sequence of actions, and on the other hand with the dependencies through which the different components are conditional with their related actions. Hence, identifying of shortages at airports is of great value due to its immense impact in determining the throughput on air fleet resources on the operation of airports. Therefore, primary constraints for this throughput analysis are:

i) adherence to schedules,
ii) optimization of resource utilization,
iii) reduction of operational costs.

Henceforth, any plan for an impact analysis on the throughput on air fleet resources on the operation of airports deal at least with the identification of shortages, but has to take into account air transport specific constraints. These constraints result from the:

a) combination of automated and manual planning procedures,
b) several degrees of freedom to make conducting jobs much more flexible,
c) independent encapsulated service and resource management features,

which finally have huge consequences on the architecture of the developed simulation model. For example, in time access on flight information data, partition of handling through several service providers, reliable data sets for availability of the several services are mandatory assumptions to accomplish an impact analysis on throughput on air fleet resources on the operation of airports.

Based on the foregoing mentioned constraints, particularly c), as part of this paper we developed a workflow architecture where service planning is done at the so called General Flight Management Level (GFM) and the information necessary for this planning dependent on the several service activities belong to the subjacent so called Local Service Management Level (LSM), as shown in Figure 1. The LSMs in this architecture are responsible for the resource allocation from the service provider.

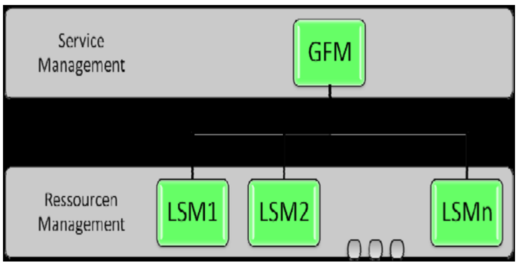

Fig. 1.: Architectural simulation model concept showing the General Flight Management Level (GFM) and the Local Service Management Level (LSM).

Planning at the GFM level is carried out through a dynamic feed back optimization component as well as through a manual graphical user interface which allow interaction with the simulation runs for optimization of the throughput on air fleet resources on the operation of airports.

Moreover this paper include in the following sections the development of the workflow based simulation model, the experiments done to evaluate the impact on throughput on air fleet resources on the operation of airports, and an analysis of the results and conclusions.

Planning at the GFM level occur a dynamic feedback optimization method (Wittmann, 2008), but also a manually interaction through a graphic user interface (GUI). This GUI is described in the following section 2.

2. GRAPHIC USER INTERFACE DESIGN

The primary design constraint for the foregoing mentioned GUI is based on a workflow dependent approach. The workflow approach can be realized based on a so called standard workflow, as shown in Figure 2, which show the respective generic services and the relative times stamps, as well as based on a so called specific workflow, as shown in Figure 3, which embed the respective set of services in relation with the respective flight number.

Workflow

- **SetOfAllServices**
  each element contain the following information:
  - **ServiceName**
  - **Processing Time**
  - **StartTime**
  - **Rules**
    after: typelist
    parallel: typelist
    before: typelist
  - **ServiceGroup**

Fig.2.: Standard workflow approach for GUI

Specific Workflow

- **FlightNumber**
- **GateNumber**
- **SetOfServices**
  subset of set out of workflow
  for StartTime and Ready Time a pop:
  A EarliestServiceStartTime
  B Latest ServiceReadyTime
  C EstimatedServiceStartTime
  D EstinmatedServiceReadyTime

Fig.3.: Specific workflow approach for GUI

The GUI in Figure 2 show the bulk of assigned services (*SetOfAllServices*) offered during flight handling. For explicit identification reason each service is characterized by its individual name (*ServiceName*), the length of execution (*ProcessingTime*), a relatively denoted start- and end time (*StartTime*; *ReadyTime*) and specific rules (*Rules*), for the control of the various dependencies. Moreover the several services are grouped through an additional parameter (*ServiceGroup*) to assure a clear arrangement in case of a visual planning.

The dependency rules of the workflow approach for visual planning are denoted in so called *afterlists* with the respective forerunner service. In general it can be seen from Figure 4, that for the configuration of the necessary dependency structure it is irrelevant whether or not each service is stated as forerunner (*after*), or follower (*before*) or both together

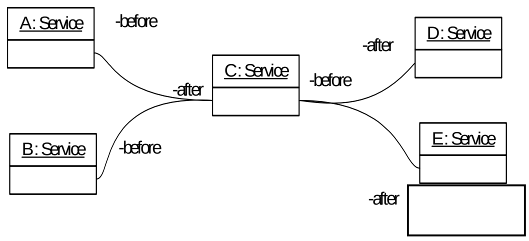

Fig.4.: Workflow approach for before and after statements

The flight dependent arrival and departure times for the several flights, which are be on hand as scheduled or estimated, are transferred in case of the specific workflow concept, shown in Figure 3. The transferred data are allocated as flight number (*FlightNumber*) and act as key for an explicitly assignment of a flight.

3. VISUALIZATION

The visualization concept has to fulfill the specific user requirements which deal with the service management approach allowing the user a clear allocation of actions. These requirements can be expressed as a three phase concept of the service management approach. Phase one offer the user to view and to deal with the whole standard workflow approach, which is shown in Figure 1. The restriction of phase one is its limitation onto the two dimensions service and time. In contrast in phase two the user is able to undertake individual adaptations for the respective flights such as arrival time scheduled and arrival time estimated, etc. Hence, the dimension flight is add to the two previous dimensions service and time. Finally the third phase has to show the actually daily episodes of activities. This episodes are updated hourly to afford an actual during the day view which show the current state of eradication.

In general phase too covers, except a few exceptions all phases, which are in relation to services and flights. For flights Figure 5 show the data model for a simulation case study example.

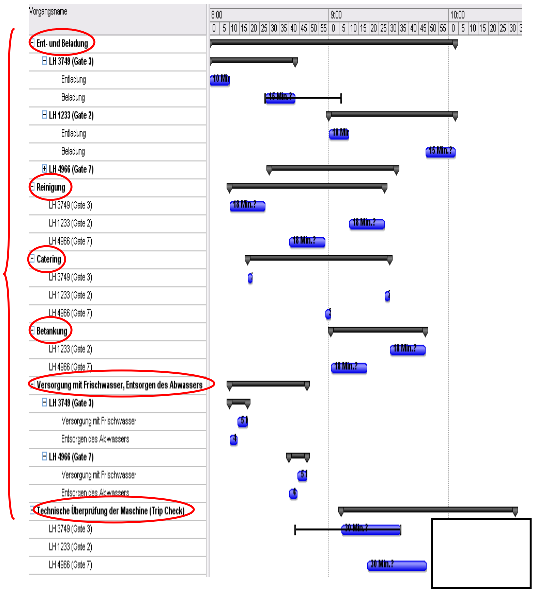

Fig.5.: Data model for phase two visualization approach, dimension flight

4. SIMULATION SOFTWARE

The implementation of the foregoing described visualization phase concept shall be done based on commercial available software packages. For this purpose a list of references was developed, shown in Figure 6, based on the essential requirements as well as on nice to have add on. .The essential requirements are valuated due to their pros and cons and potential identified problems. Problems are defined as fundamental, which are so far as they are unsolved will not allow a rational use of the software. The results are shown in Figure 6 on page 5 of this paper.

5. CONCLUSION

The impact analysis on throughput on air fleet resources project described is in its initial phase. However, the intention of this paper is to give a comprehensive overview over the problem and the methodological approach to its solution

6. REFERENCES

1. MS Project Professional 2007: MSDN Academic Alliance Software-Center (IWI Hamburg)
2. GanttProject 2.0.9: http://downloads.sourceforge.net/ganttproject/ganttproject-2.0.9.zip?download
3. SERENA OpenProj 1.4: http://sourceforge.net/project/showfiles.php?group_id=199315
4. Gantt Chart for Workgroup 1.7 (Demo): http://www.orgbusiness.com/download/ORGSetup.exe
5. Ground Handling System (GHS) http://www.topsystem.de/de/luftverkehr/ghs_ground_handler.htm
6. proveo Airport Visualiser http://www.proveo.de/products.do

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Referenzliste			MS Project Professional 2007	GanttProject 2.0.9	SERENA OpenProj 1.4	Gantt Chart for Workgroup 1.7
Workflow		relative Zeitachse	×	× (müsste impl.)	× (müsste impl.)	×
	Attributes	ServiceName	✓	✓	✓	✓
		ProcessingTime	✓	× (nur ganze Tage)	✓	×
		StartTime (relativ)	×	× (müsste impl.)	× (müsste impl.)	×
		ReadyTime (relativ)	×	× (müsste impl.)	× (müsste impl.)	×
		Rules (after)	✓	✓	✓	✓ (FS/SS/FF/SF)
		ServiceGroup	✓ (PSP-Code)	✓	✓ (PSP-Code)	×
		Gantt (einfach)	✓	✓	✓	✓
		Abhängigkeiten darstellbar	✓	✓	✓	✓
		Informationen an Balken	✓	✓	× (müsste impl.)	✓ (über Rollover-Sprechblase)
spezifischer Workflow		absolute Zeitachse	✓	✓	✓	✓
	Key-Attr.	FlightNumber	✓	✓	✓	✓ (über Trick: Flight als Res.)
	Arrival (Attributes)	ArrivalTimeScheduled	O (nur über Notlösung)	× (müsste impl.)	× (müsste impl.)	×
		ArrivalTimeEstimated	O (nur über Notlösung)	× (müsste impl.)	× (müsste impl.)	×
	Departure (Attributes)	DepartureTimeScheduled	O (nur über Notlösung)	× (müsste impl.)	× (müsste impl.)	×
		DepartureTimeEstimated	O (nur über Notlösung)	× (müsste impl.)	× (müsste impl.)	×
	spez. WF (Attributes)	ServiceName	✓	✓	✓	✓
		ProcessingTime	✓	× (nur ganze Tage)	✓	×
		EarliestServiceStartTime	✓	× (nur ganze Tage)	✓	✓
		LatestServiceReadyTime	✓	× (nur ganze Tage)	✓	✓
		Rules (after)	✓	✓	✓	✓ (FS/SS/FF/SF)
		ServiceGroup	✓ (PSP-Code)	✓	✓ (PSP-Code)	×
		Gantt (mit Intervalerweiterung)	✓	× (müsste impl.)	× (müsste impl.)	×
		Abhängigkeiten darstellbar	✓	✓	✓	✓
		Informationen an Balken	✓	✓	× (müsste impl.)	✓ (über Rollover-Sprechblase)
		mehrere Flugzeuge möglich	✓	✓	✓	✓ (über Trick: Flight als Res.)
tatsächlicher Workflow		spez. WF ohne Intervalle	O (s.o.)	× (s.o.)	× (s.o.)	× (s.o.)
		Standlaufleiste	✓	✓	O (mit Bug)	✓
		alle WFs gleichzeitig darstellbar	✓ (jeweils eigenes Fenster)	× (müsste impl.)	× (müsste impl.)	✓ (jeweils unters. Ressourcen)
		Zoom auf Minuten-Ebene	✓	× (müsste impl.)	× (müsste impl.)	O (nur eingeschränkt)
Vorteile			+viele Exportm. zu MS Office +weit verbreiteter Standard für Projektplanung +stabiles System +keine Bugs entdeckt +leichtes Gruppieren der Services über PSP-Code	+Open Source +Java-Programm +stabiles System +keine Bugs entdeckt	+Open Source +Java-Programm +stabiles System +leichtes Gruppieren der Services über PSP-Code +Import von MS Project Files (eingeschränkt)	+Preis ($59.95 orgbusiness.com) +stabiles System +keine Bugs entdeckt +Unterscheidung der Abhängigkeiten nach (FS/SS/FF/SF) +Daten werden in eine Datenbank verwaltet (FDB)
Nachteile			-A/D-Linien nur über Notlösung -für unser Problem etwas überladen -Preis (Ø 1.136,73 EUR idealo.de)		-für unser Problem etwas überladen	-Zoom auf Minten-Ebene nur eingeschränkt
Probleme			*keine relative Zeitbetrachtung	*keine relative Zeitbetrachtung *keine A/D-Linien *keine Grenz-Intervalle im Gantt darstellbar *WFs *nicht* gleichzeitig darstellbar *Zoom *nicht* auf Minuten-Ebene *kleinste Zeiteinheit ist ein Tag	*keine relative Zeitbetrachtung *keine A/D-Linien *keine Grenz-Intervalle im Gantt darstellbar *WFs *nicht* gleichzeitig darstellbar *Zoom *nicht* auf Minuten-Ebene *keine Möglichkeit für Informationen an Balken *viele Bugs bei der Interaktivität	*keine relative Zeitbetrachtung *keine A/D-Linien *keine Grenz-Intervalle im Gantt darstellbar *keine ProcessingTime *keine Möglichkeit zur Service-Gruppierung

Fig. 6: Software reference list with pros and cons