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SUPPORTING CO-OPERATIVE WORK IN APRON CONTROL AND RESOURCE MANAGEMENT OFFICES ON AIRPORTS

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ABSTRACT

A high demand exists to increase the efficiency of present airport ground facilities and the co-ordination of traffic and services. The Traffic Office plays a crucial role in managing the airport. The main tasks of the Traffic Office is management of equipment, services, and resources based on the flight schedule and resolving conflicts arising from deviations from the schedule. A new tool will support information exchange between Traffic Office and other facilities on the airport.

KEYWORDS

Airport ground operations, co-operative work

INTRODUCTION

As the demand for air transportation is constantly increasing, we approach capacity limits in the air as well as on the ground. Especially in Central Europe, ground space at airports is limited as operating hours are. The public often rejects against plans of extension of airport operations in space or time. Therefore, a high demand exists to increase the efficiency of present airport ground facilities and the co-ordination of traffic and services. Today, the Traffic Office (*Verkehrszentrale*) of an airport provides ground-handling co-ordination and resource management as well as control of apron traffic.

While air traffic control controls airspace and runways, space for parking and servicing aircraft is under control of the airport owner. Co-ordinating ground handling operations is highly co-operative work between few people in the Traffic Office and several ground service providers on the apron (airside) and in the terminal (landside). These service providers are mainly private companies providing baggage and cargo handling, cleaning, catering, fuelling, security, and passenger services. However, also government agencies (customs, immigration, health services, and boarder police) are involved.

In a currently ongoing project, we evaluate support for this co-operative work. The project started with task analyses in Traffic Offices on two medium-size German airports and provided a description of the work in these offices as managing information flow. We further designed and evaluated a tool for supporting this work. In the final project phase, we are going to extend this tool to handle information flow, to support task assignments, and to track execution of tasks. An additional demand for re-organisation of ground services is forced by new European Union regulations. These demand to open airports to several different external service providers where in the past the airport operator alone provided all ground handling services and equipment. Consequently, the new system will also implement means of negotiating with different providers of similar services, transferring and tracking orders, and ensuring timely service. An important source of information is the direct view on the apron. Thus, for the final evaluation, the project also includes an airport simulation on a virtual reality system.

APRON OPERATIONS MANAGEMENT

Task Analyses

Regarding the growing complexity of workplaces and supporting technology, the individual worker (the *operator*) looses the ability to build or configure his own workplace. It became the task of others, to design workplaces and supporting machinery in hard- and software. Designing workplaces and structuring work temporal and organisational for other people is a demanding task of high responsibility. Today, not a single person can handle this any longer, but groups of engineers, computer scientists, psychologists, human factors experts, and, finally, representatives from the future operators work together - the *designers*. The group of designers as a whole needs general knowledge and domain-specific knowledge and must be able to communicate knowledge and findings within the group.

General knowledge is necessary about the human in general, its physical and cognitive capabilities and constraints as well as on the tools and procedures available for the design process. A designer should have this knowledge available as a pre-requisite to fulfil his job - or to involve more expert in the design task.

Domain-specific knowledge relates to the objects to handle and their properties, rules and guidelines to follow, limitations in space and time. It is also necessary to know about the individual background, education, training, and knowledge of the operator or group of operators involved with the task. Domain-specific knowledge needs to be acquired when starting a design task in a new domain. Our preferred instrument for gaining this knowledge are task analyses.

Means to communicate results and findings among a group of design experts must be established. Based on previous experience we would propose using the DIADEM methodology for software specification (Borys, Tiemann 1997). However, deep use of such formalisms would not be appropriate for a small-scale project. Additionally, after hierarchically breaking down the overall task into smaller sub-tasks, DIADEM concentrates on dynamics of interaction when performing one single sub-task. The core of the work we observed was supervising several sub-tasks (aircraft turnarounds) in parallel, and collecting and distributing information. Thus, in contrast to interaction graphs we depicted information flow passing the Traffic Office.

The preparation of the *task analysis* followed the usual way: At first, we selected suitable airports. These should be of a medium size, i.e., sufficiently large to offer all aspects of work in apron operations, but sufficiently small that we can learn about their specific organisation in a suitable time. Contact was established beginning from the top, with airport management and department managers. During a first half-day visit we explained our project, our expectations and the methodology we planned to use. In both cases we learned about the current problems, the organisational structure, work organisation, and were taken for a tour behind the scenes.

Finally we observed work in the two Traffic Offices each for two days and on each day we were able to see two different shifts at work. The workload showed peaks in the morning and the afternoon, where we were more observing. During off-peak hours, we conducted several interviews to get deeper information on work procedures. To support a suitable simulation for our experiments, we also took time lines of events. During one hour, we recorded flight number, time (with approximately 10 seconds resolution) and type of every interaction of the Traffic Office with aircraft or ramp.

Traffic Operations

The area under control of the Traffic Office has two sides. One is the *airside* with gates or remote parking positions, ramp and apron with different service equipment, and taxiways. The other is the terminal or *landside* with public transport terminals, car parking, public and shopping areas, counters for ticketing and check-in, baggage reception and delivery, government controls and security checks, waiting rooms and transit areas.

The main tasks of the Traffic Offices are management of equipment, services, and resources, apron control, and event recording. It co-ordinates all activities on the apron taking into account the flight schedule, special requests of airport customers, and safety requirements. Each operator of the small group working together is able to work on all different subtasks.

Work in the Traffic Office has different time horizons. Work starts long ahead the actual day with the semi-annual preplanning focussing on several consecutive months and ends with solving actual conflicts on a minute-to-minute basis. This continuous work on multiple parallel threads that are not separable from each other is the main concern of the project. Each thread is one aircraft turnaround, which interacts with several other threads that are close in space and time. Few people (around three) handle several threads (up to 20) in parallel. Threads interact in time for separation in-flight, for landing and departure, interact in space when using runways, taxiways, or apron positions and compete for resources when handled on ground. Interaction may lead to conflicts that should be avoided already in the pre-planning phase. However, when the pre-planned threads (aircraft turnarounds) do not adhere to the schedule new conflicts may arise that need to be solved during the continuous traffic operations.

The work is characterised by information exchange, using speech over telephone lines and radio links and access to written information using databases of flight schedules and recorded events.

Focussing on information exchange as one main task of the office, task analyses showed that this business is often accompanied by re-gaining, re-assessing, re-coding, and re-entering information that is already available in another format in another source. It was also evident that the same information, e.g., allocation of apron position to an aircraft out-of-schedule, needs to be transmitted several times to different receivers like the aircraft, its airline, the service providers, and passengers. Doing so, different channels (radio, telephone, voice announcement, public displays) and different codes (ATC English, internal slang, German; UTC and local time) are used.

Consequently, one part of the project was the design, implementation, and experimental evaluation of a prototype tool supporting information exchange between the Apron Control, ramp services, and ressource allocation. Extending the results gained from task analyses of current systems, we also take into account the open competition between service providers forces by new European regulation.

Before developing new means of support for co-operative work in the Traffic Office, it was necessary to acquire knowledge on how people currently conduct apron operations. Opposed to air traffic control, ground operations are not based on a strict and internationally defined set of rules, standard procedures and terms. We found that work was organised around the demands of the task and on different airports, results are different, depending on the general culture and historical development of work on this airport.

Pre-Planning

International airlines and air traffic control agencies negotiate every half-year about ATC slots for use of airport runways and terminal airspace in the so-called *slot conference*, resulting in co-ordinated flight plans for one summer or winter season. Based thereon, the first step in planning ground operations is the design of the local seasonal flight plan. This does not only list scheduled times for landing and departure of every flight in the season that are published in the official timetable. It also assigns runways, parking or gate positions and ground equipment on the airside as well as check-in counters, waiting rooms, baggage delivery areas, and gates for passengers of each flight on the landside. *Resource Planning Systems* support work in this stage. However, these systems only store and manage results in database tables, they are not able to resolve conflicts. Also, pre-planning was - on airports we visited- no co-operative work, but performed by one single person.

Several restrictions apply when assigning resources to aircraft, airlines, or flights. For aircraft, mainly physical dimensions restrict use of docking positions and equipment. In addition, assigning two aircraft to adjacent positions need to take into account size of both aircraft including safety margins. Several aspects of a flight influence assigning resources for passengers. Separate handling is necessary depending on origin or destination, e.g., domestic, Schengen states[1], other European Union, other international. Another aspect is the expected number of passengers on this flight, which may not correlate with aircraft size. Finally, people working in flight planning business know of specific behaviour of passengers that influences use of resources. We learned that business flights (more experience in flying) board and de-board faster than holiday flights (more baggage), passengers to specific destinations are accompanied by more non-flying relatives than others. Finally, the airlines are the immediate customers of the airports. Thus, demands like separate counters and waiting areas or specific gate positions close to visitors' terrace may be followed based on the commercial importance of an airline. We mention all these restrictions here in

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[1] No boarder controls between those states of the European Union that signed the *Schengen Treaty*.

combination with preparing the seasonal flight plan. However, most of them will also be followed in the steps from planned flight to actual operations.

Operation by Information Management

Modifications of the flight plan are possible until the planing for one specific day ends in the night before and the operational phase begins. At this time, responsibility is transferred to the Traffic office. The work of the Traffic Office for the actual day can be characterised as (1) *gathering information* on deviations from the pre-planned schedule, (2) *solving conflicts* arising from deviations while regarding restrictions mentioned above, resulting in new plans, and (3) *distributing information* on new plans to all stations concerned.

Information is available from several sources in different modes. The AIMS synthetic radar display provides the most important information on inbound aircraft. From aircraft position, remaining time to arrival can be estimated. An important trigger is the ten-miles-out position: Ground crews are informed, when an aircraft passes this line. (Pre-planning has secured that ground crews and equipment are available.) Slight deviations from schedule and from the planned landing sequence can be estimated from the display. The schedule itself is available as the flight plan database and shown as spreadsheet tables on two flight plan displays (inbound and outbound). About 25 table rows show one flight each, columns show –among other information– scheduled, estimated and actual times. Information on greater deviations is given by telephone and fax messages. Besides all electronic equipment, for aircraft on ground most information is received by direct (or camera) vision. Operators know what equipment in which state of aircraft servicing is necessary and can estimate how long services will take based on the type and number of equipment or vehicles still present around the aircraft. During our observations we noted questions passed between operators whether baggage loading completed, passenger steps still present or doors closed, and, finally, whether the aircraft beacon is already flashing. This will signal that the aircraft is ready for starting engines and will clear its position immediately.

Positions, preferably at a gate, at least on the apron are the most precious resources of an airport. Thus, **conflict resolution** concentrates on finding alternate positions for an aircraft falling out of the pre-planned sequence. Changing a gate position will have consequences on passenger flow regarding waiting and transit areas. Changing an apron position will only influence distribution of equipment and passenger transport. Apron positions often act as buffers when gate positions are unavailable. For every change, the restrictions mentioned above apply. Technical support is provided only by displays showing positions vs. time diagrams, indicating assignments of positions to flights at different times. Whether a position will suit a specific aircraft type or baggage delivery will follow customs needs for a specific flight is checked manually. Therefore, modifications are made only when necessary. If delays are within a few minutes, some conflicts are resolved by slowing taxi speed of the next aircraft assigned to this position or asking ramp personal to speed up operation. However, for security reasons, airports react quite sensitive to disturbances. In one of our visits we experienced that a complete terminal was closed for the public after discovering a single left bag on the ramp. In all cases where modifications to the schedule are necessary, they need to be communicated to all persons involved.

Information distribution again uses different channels and modes. The most important tool is the flight plan database. The Traffic Office is able to write changes to the database, other clients have read access to the database. However, there are no automatic alerts on changes, thus, major modifications need to be announced by telephone or radio lines. Although the Traffic Office has the final authority for assignments, it depends also on nationality and verve of an airline whether changes are accepted or need additional personal negotiation.

Consequently, the support system concentrates on information access, distribution, and tracking of information flow. A first prototype was already evaluated, modifications for a final prototype are in progress and an evaluating experiment is planned.

FIRST PROTOTYPE

The basic motivation of the first prototype was to proof that in the context of the Traffic Office, communication can be handled properly with a computer based solution. Such a solution should replace the usage of the variety of communication means to a great extent.

An important guideline during development was to keep the software simple and intiutive. The staff at the Traffic Office uses already different computer systems. Each of these systems runs with very complex (and sometimes "buggy") software, making it not easy to operate it. As we did not want to make this situation even worse, the new communication system about to develop has to be reliable, predictable and understandable to the staff. A good method to achieve such a system is to keep it simple (Cooper, 1999): We concentrated on the tasks the user want to do with the communication system. Obviously, things like setting option dialogs, confirm questions not understandable by the user or click on a "Ok" button of a error message do not help the users to achieve their goals. With this in mind, we developed the first prototype of AirPortCom, as we named the communication system.

Features

Like in an e-mail application, the users of AirPortCom can send and receive messages. This is the main purpose of the program. A message in AirPortCom contains these elements:

- Time: The time this message was sent.
- Urgency: The user can mark a message as "urgent". AirPortCom highlights such messages
- "To" and "from": Receiver and sender of the message.
- Reference: Indicates to which flight or gate this message refers to
- Read: Shows whether the message was read already
- Text: Plain text the sender can enter.

AirPortCom assists the user during creation and handling of the messages, e.g. there are templates for standard (frequently used) messages. With a template, the user just has to add the reference and fill possible spaces in the text.

AirPortCom knows all possible receivers, so there is no need to learn e-mail addresses. In addition, a user cannot enter an invalid e-mail address, as the user just chooses from a list of receivers.

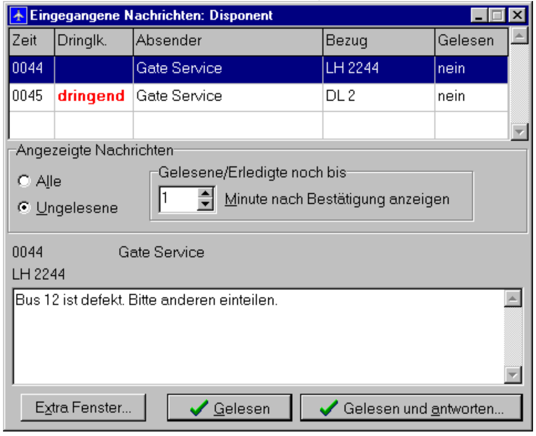
For the reference, AirPortCom maintains a list of flight numbers (like “BA 475”) the user can choose from. With this, the references always look the same. Alternatively, the user always can enter free text for the reference.

It is vitally important for the sender to know whether a message has been read already or not: If a message was not read for a longer time, the sender may want to use alternative means for contacting the receiver, like telephone or VHF radio. Therefore, the receiver has to mark every message he read as “read”. By doing so, the sender is well informed about the status of every message sent. As long as the receiver has not read a message, the sender can cancel it. Of course, the receiver of a cancelled message does not need to mark it as read.

Under no circumstances, a user needs to delete a message. There is no handling of messages besides marking them as read. Instead, AirPortCom hides these messages after a certain time. The user can change this time easily. However, it is always possible to show every message, whether it has been read or not.

AirPortCom uses a window for the list of the messages received and another window for the list of the messages sent. Having two windows, the user does not need to navigate to the lists. The picture below shows the window with the incoming messages. The list is on the upper part of the window. Below the list, the user can set the options for displaying the messages. Below the options, AirPortCom displays the message currently selected in the list. With the buttons, the user can mark this message as read and answer this message.

Picture 1: Recveived messages in AirPortCom



Zeit	Dringlk.	Absender	Bezug	Gelesen
0044		Gate Service	LH 2244	nein
0045	dringend	Gate Service	DL 2	nein

○ Alle
● Ungelesene

Gelesene/Erledigte noch bis: 1 Minute nach Bestätigung anzeigen

0044 Gate Service
LH 2244

Bus 12 ist defekt. Bitte anderen einteilen.

The user can resize the height of window. By doing this, the list shows more or less messages.

In addition, the user can create an extra window for each message received, using it as a reminder on the screen.

Finally, AirPortCom provides a window showing information about alternative ways to contact other users, like telephone number, VHF channel, etc.

AirPortCom supports both mouse (with wheel) and keyboard operation, allowing the user to follow personal preferences.

Software architecture

Each subscriber of the communication structure build by AirPortCom uses the same program. All settings, like identification of the user, possible receivers, etc. are set by configuration files. At no time, the user has something to do with it. There is no “Options” menu at all.

AirPortCom uses a central database for storing and exchanging the messages. Every instance of AirPortCom stores and retrieves the messages from here, there is no direct communication between the instances of AirPortCom. Using this concept, only the system hosting the database has to be always active. A failure of one computer does not block or even irritate any of the others. No messages like "could not reach station..." ever pops up. If a system failed, the user of this system simply could not mark messages as read, which is enough information for the sender. In such a case, alternative means of communication has to be used (telephone, VHF radios, etc.). Obviously, it is important to have such a redundant backup system to handle situations like this properly.

Experimental evaluation

We expected that all subjects could perform their tasks and the system was able to handle communication. To proof this, we set up a experiment. The experiment was centered around the Traffic Office. This means that the other subjects (Gate Service and Passenger Transport) have almost nothing to do except answering and confirming messages they received.

Scenario

For the experiment, we created a scenario to support the subjects with a context of their work. In the scenario, a simulated minor airport (one runway, 8 gate positions and 16 apron (remote) park positions) has to be "operated". In the experiment, we introduced three simulated tasks: Gate Service, passenger transport and Traffic Office. As the experiment was centered around the Traffic Office, the other two simulated tasks has been created just for communication with the Traffic Office.

The task of the Gate Service is to connect the passenger bridges to arriving aircraft and to disconnect them from departing aircrafts. To do this, the Gate Service has to be informed about any incoming and outgoing aircrafts. On the other hand, the Gate Service has to inform the Traffic Office about any occurring problems, e.g. a bridge out-of-order. We introduced such an event in the scenario to make the task of the Traffic Office more complex.

On a real airport, the passenger transport uses busses to carry passengers from and to the aircrafts at the apron positions. To do this, the Traffic Office has to inform the Passenger Transport about any arriving or departing aircraft at an apron position.

The most important task was of course to operate the Traffic Office. In this scenario, the Traffic Office was responsible for

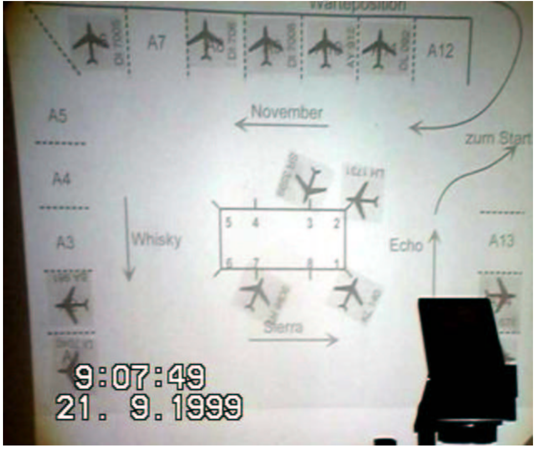
- Apron control. In this case, this is limited to provide taxi instructions to the "aircrafts".
- Ressource planning. We provided the personal with a flight plan and a preplanned assignment of the gates and apron positions. In the scenario, Traffic Office had to resolve arising conflicts caused by delayed flights blocking a few positions and a bridge out-of-order.
- Communicate with the Gate Service and Passenger Transport.

Procedure

The duration of the experiment was 30 minutes. After introducing the subjects into their tasks, we did a test run of 10 minutes to ensure that everybody knows what to do.

In a questionaire following the experiment, we asked among others for estimated work load of the subjects, performance and the degree of satisfaction with AirPortCom. In addition, we asked if the subjects like to have alternative means for communication, like a telephone.

Picture 2: Simulated airport scenario



During the experiment, AirPortCom generated a log of all communication.

Results

During the experiment, the “staff” handled 14 incoming and 12 outgoing aircraft. The Traffic Office had to reassign the position of 4 incoming aircraft due to delays and a bridge out-of-order. The Traffic Office resolved all problems quickly and properly, so there was no additional delay caused by the staff.

Picture 3: Discussion after experiment

As a main result, no message got lost and all messages had been answered promptly. Not surprisingly, the Traffic Office has had the highest work load during the experiment. On the opposite, the two other “workers” had almost nothing to do except confirming the incoming messages from the Traffic Office.

Finally, all the subjects proposed to add a aural notification when a new message arrived.

FINAL PROTOTYPE

After the successful test of the first prototype, we are going to develop a final prototype of AirPortCom.

In addition to the features of the first prototype, we will add an aural notification if a new message arrives. As a new feature, we will include support for handling and supervising the competition between service providers (see below).

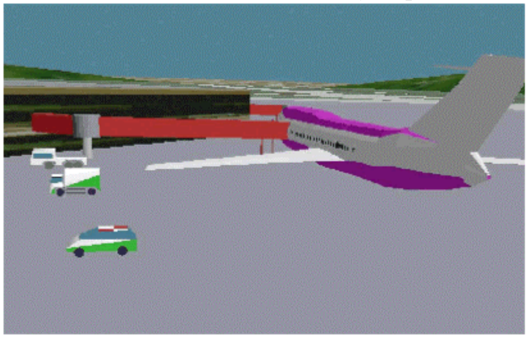
Experimental evaluation

As well as AirPortCom itself, we will improve the experiment for evaluating the software. Unlike in the first experiment, we will assign some tasks to the other subjects (those not in the Traffic Office). By this, we want to expose them to a greater workload than in the first experiment. Therefore, the Gate Service will have to operate a simulated passenger bridge to perform a real docking manoeuvre.

Like in the first experiment, we will implement the Traffic Office, the Gate Service and the Passenger Transport. This time, however, we will simulate competition on the airport by two providers doing Passenger Transport (thus, a total of four subjects will join the experiment).

The Passenger Transport providers now have to acquire transport contracts and perform them by planning routes of their busses. A online auctioning system will handle the granting of the passenger transport contracts. As an additional benefit, with the competition elements included in the experiment layout, we are able to gather information whether such an online contract auction may be useful or not.

Picture 4: VR simulation of airport



Finally, we plan to use a virtual reality system for generating a virtual view of the apron of the airport. This seems to be useful as we found in our task analyses that the staff of the Traffic Office gathers a reasonably part of information about the state of the airport simply by looking out of the window. By doing this, the staff get a rapid overlook of the progress of handling the aircraft.

Results of the experiment will be published in the project report end of 2000.

CONCLUSIONS

In task analyses, we found that the main task of the Traffic Office is management of equipment, services, and ressources based on the flight schedule and resolving conflicts arising from deviations from the schedule. Most work is performed in distributing information on changes to existing schedules. We designed a tool supporting information exchange and allocation of services. This will be evaluated in a forthcoming experiment.

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