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Concept and prototype of a ground handling vehicle management system

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Abstract— **As airports are being identified as the bottleneck of the future ATM system, optimised airport processes have a significant influence on the overall ATM system. Comprehensive research in the field of the surface movement and scheduling of aircraft has led to technology and support systems that are in place at various airports worldwide. In contrast the coordination and optimisation of service vehicles on the aprons were investigated only insignificantly.**

Within two projects at the Airport Research Facility Hamburg a concept for managing the process of the luggage transport to and from the aircraft was developed. The concept is based on experiences from A-SMGCS research and implements a complete data link process as a replacement of the actual voice solution. Furthermore a first prototype of a support system was developed, implemented and technically tested at the airport. Live connection to operational systems like A-SMGCS and Airport database enabled the use of real data and first shadow mode trials.

Keywords-airport, surface, scheduling, service vehicles, a-smgcs, decision support, optimization, vehicle routing, data link, vehicle management

I. Introduction

After a period of stagnation and decrease, mainly because of external factors as financial crisis, air traffic is growing again. Today's „Mid-Size-Airports", are one of the main areas of the increasing air traffic. Because of comprehensive development and integration of new concepts and technologies in the en-route environment, it is anticipated, that now airports becoming the bottlenecks of the future air transport system. The construction of new infrastructure is often not possible because of missing building areas, especially in Europe. In parallel to the restricted physical expansion programs of airports, which are also extremely time-consuming and costly, the most efficient usage of the available resources is of utmost importance to handle the growing number of movements with available resources.

For a long time the large number of vehicles on the apron was not considered to be part of this process. Concentrating on the airside coordination of aircraft movements the phase of the turn-around itself was not incorporated in the optimization of airport processes.

Based on experiences of the implementation and use of Advanced Surface Movement Guidance and Control Systems (A-SMGCS) an approach to incorporate vehicles operating on the movement area of an airport was taken. During various national projects an operational concept was developed and tested in a first step. Keeping in mind, that technology used in aircraft is not suitable to be installed in a very large number of vehicles a new way of technical realization was worked out.

II. Background

The concept of Advanced Surface Movement Guidance and Control Systems (A-SMGCS), invented in the early nineties, comprises technical support systems for controllers, pilots and vehicle drivers. In the meantime it has reached a worldwide standard that is published by ICAO document 9830 [1] and derived EUROCONTROL material. A-SMGCS and the comparable system ASD-X in the US have a modular concept and are already implemented operationally at European and US-airports. It has been proven that A-SMGCS is enhancing the safety and efficiency of airport operations as well as maintaining the throughput in low visibility situations [2].

With this knowledge the project CARMA (Car Management on Aprons) was initiated, taking the first approach to develop a concept for the detection, the identification and the management of vehicles operating at the apron. In [3] the approach and basic ideas are presented. An overall concept and a very first technical implementation were realized at the end of the project. With the follow on project "Competitive Airport" the basic concept was further developed towards operational requirements and advanced technical system components. Especially the connection to operational airport systems and the use of real live data were implemented.

The cooperation of different institutions has lead to a wide variety of competences ensuring a successful completion of the projects. Partners of both projects where Hamburg Airport (FHG), the German Aerospace Center (DLR), the Technical University Hamburg-Harburg (TUHH), the University of Hamburg (UHH) and the Technical University Braunschweig TU-BS). The German air navigation service provider "Deutsche Flugsicherung GmbH" (DFS) and Airbus were involved in the project CARMA only.

III. CONCEPT

A. Operational concept

1) Actual operation: The actual processes of the operation of the luggage cars at Hamburg Airport were the base for the developed operational concept. For incoming flights the cars are picking up loaded trolleys from the aircraft and deliver them to the respective luggage belt. For the outgoing flights they pick up loaded trolleys at the baggage sorting facility and transfer them to the aircraft stand. The task to be carried out by the vehicle driver is communicated by the dispatcher via voice.

As the operations centre of the ground handling company has no view on the apron, the dispatcher has to remember all vehicle positions and assigned tasks. Today this is be done mentally and with a lot of experience by the dispatcher. With increasing number of resources this is not possible any more and support systems are needed.

2) Operation with a vehicle management system: The vehicle management system should support the dispatcher and the drivers of ground handling vehicles and allow an optimized use of available resources. The following differences to the actual operation are foreseen*:*

- Use of data link for dispatcher/driver communication
- Automatic recording of time stamps during the handling process
- Support of resource selection by providing an optimization module
- Providing a traffic situation to driver and dispatcher
- Reduction of number of information systems (monitors)
- Easy drag and drop operation and reduced workload
- Providing Status information of task execution

With the use of data link communication for standard procedures the time and workload intensive task of voice communication can be reduced. When a task is assigned by the dispatcher an automatic message is generated and sent to the respective vehicle. All information regarding the task will be displayed on the onboard unit informing the driver about time, callsign and stand. The driver has the possibility to accept or decline the task by pushing a button. The decisions as well as all ongoing status messages about the progress of the task are communicated by data link. After finishing the task, the driver has to push a button to inform the dispatcher about completion and availability for the next task. Main status information about a task, like halted or aborted, are already covered by the concept. In any other case revert to voice is envisaged. A color scheme of the HMI-elements was developed to keep the dispatcher informed.

As A-CDM (airport - collaborative decision making) is more and more a factor the inclusion of the turnaround process could be beneficial. The milestone approach of A-CDM could be extended in using time stamps of ground handling processes also. During task execution a number of automatic generated time stamps are recorded and available within the database (e.g. task assigned, luggage pickup, luggage on stand, task finished). This could be analyzed and presented to other stakeholders. Apron control could use this information to estimate earliest ready times and coordinate pushback and taxi.

The idea of the optimization module is to avoid task assignments causing long distances to be driven by the vehicles and coordination of incoming and outgoing luggage transports. [7] has already shown, that optimization can reduce travel distances and serving times and as a result operational costs and environmental influences. Based on the position of the vehicles and the tasks to be carried out, the module has to calculate the best available resource and present this as a recommendation to the dispatcher. As the dispatcher is still in the loop he has the possibility to decide the final assignment accepting the recommendation or changing the allocation. The optimization module has to process the inputs made by the dispatcher and recalculate if necessary.

A synthetic traffic situation display helps drivers and dispatcher to asses the current situation at the airport. Information about position and movement of aircraft and vehicles are available and can be used to plan and coordinate resources. Especially onboard the vehicle the information can be used as a safety net in low visibility conditions, alerting the driver in case of runway incursions or entering restricted areas.

An integrated display solution, combining information from different sources will help the dispatcher to assess information and interact with the system more easily. While in the current working environment information are presented by widely commonly used systems, a specially designed interface for the dispatch of luggage cars will be used. Partially redundant information on several monitors (input from different systems) will be eliminated. Only the most important information, necessary to fulfill the assignment task will be displayed on the main working elements. Additional information is available on interaction with the system when needed (e.g. mouse over, mouse click).

A simple way of operating is the key of a new system to be accepted by the operators. A drag and drop functionality allows easy assignment, reassignments and changes. A minimum of user interactions will reduce the workload and the time needed for executing a task assignment.

B. Technical concept

1) Current situation: Currently a basic software system, developed by the IT-company at the airport, is provided to the dispatcher presenting a table of the scheduled flights with the most important information and a list with the actual vehicles operating. During analyses and discussions with operators it was stated, that the system is a good base, but some shortcomings have been identified already, e.g.

- To many interactions in assigning and controlling tasks
- To many systems to gather information from
- Missing presentation of the status of a task

A basic mobile system is in place also. To the date only busses are equipped with the onboard unit, which is only capable of delivering different time stamps without any position information.

2) Overall system concept: The overall system concept is based on the architecture of A-SMGCS. Three central elements are needed:

- The onboard system for the mobile objects to be incorporated
- The ground system for processing and control
- A communication infrastructure to connect onboard and ground system

The following Figure 1. shows the adaption and translation of the A-SMGCS concept elements to the vehicle management system.

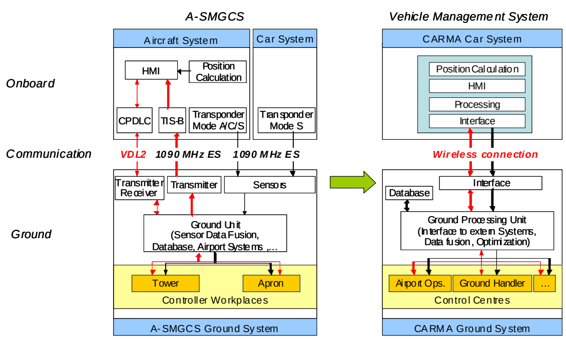

Figure 1. Overall system concept

The following paragraphs describe the main requirements for the three elements.

3) Onboard system: The onboard or vehicle unit is responsible for position calculation and acts as the interface to the driver for task management.

In general the position of the vehicles can be determined actively onboard (GPS, Galileo, signal strength) or passive with existing airport sensor infrastructure (Radar, MLAT, induction loops, RFID). Based on different criteria like available infrastructure, system capabilities and costs the decision was made, to use a of the shelf GPS solution. Two main problems were identified:

- General Availability of GPS
- Indoor Position calculation

Keeping in mind additional future satellite navigation systems (Gallileo), the availability was considered as a minor problem. As ground handling vehicles often operate within buildings (catering, luggage…) the problem of missing indoor satellite coverage has to be addressed in detail. Two different solutions were identified.

- Use of pseudolites (“pseudo-satellite”)
- Use of existing vehicle components

Even pseudilites appear to be a good solution in the first place the use is likely related to significant cost, setup of a complex infrastructure and effort to integrate them. This could not be realized within the projects and needs to be addressed separately if wished by the airport.

The second solution could be realized by using a special equipped test vehicle and a developed position calculation software module. Actual vehicles already offer sensors for determining wheel speeds and steering angles that can be used to calculate position differences over time. With the knowledge of a starting position these information can be used to stabilize the GPS signal and provide position data without satellite connection for a certain time.

To use these additional sensor data, an interface to the vehicle BUS-system (CAN – Controller Area Network) has to be implemented. The position calculation algorithm combines raw GPS-data and vehicle sensor data for a more robust position calculation.

Besides the position determination the vehicle should provide a graphical interface to the driver allowing situation awareness and interaction with the dispatcher. A map of the airport with information about topographic elements like runways, taxiways, aprons, roads or buildings and the actual traffic situation (aircraft and other vehicles) should be displayed. In addition information windows, menus and buttons are necessary for system interaction and accomplishing the task.

Finally the onboard system has to provide communication components for sending and receiving tasks, status messages and traffic position information. The technical solution has to be compatible with the communication infrastructure used in the overall system design (see Communication).

4) Communication: Communication between ground and onboard units has to be realized by a wireless communication technology.

While A-SMGCS has to use aviation standards that are also certified, the communication for the vehicle management could be done by any means of wireless communication. As there is no direct safety critical operation, some of the technical requirements can be relaxed. Wireless technologies like Bluetooth, Wireless USB, IrDA, Zigbee, WiMAX, WLAN, GPRS und UMTS where analysed and advantages and disadvantages were worked out [4]. While some technologies are not adequate in terms of technical specifications like range or data transfer rates, some others are associated with running costs. Finally WLAN was selected as communication layer, also because of the already existing infrastructure at Hamburg Airport which is covering a wide range of the vehicle operation area.

5) Ground system: The ground system includes all components, not belonging to the vehicles and the communication infrastructure itself. The following necessary parts have been identified

- Interface for the dispatcher

- Ground processing unit (including optimizer, data Adapter to operational airport systems, data fusion)
- Communication module
- Database

To achieve a maximum modularity every component (even every part of the ground processing unit) should be a self-contained element capable of communicating with each other via a network interface and standardized protocols.

The interface to the dispatcher should have a presentation of the actual traffic situation and a possibility to manage the disposition of the luggage cars. A basic A-SMGCS working position display will be used and adapted to the needs of the vehicle management system. A second system, for the management part is developed separately. Both systems are coupled via the network.

The ground processing unit is responsible for processing all external data, data from vehicles, interactions of operators and the optimization module. Position data of aircraft are available from the A-SMGCS at Hamburg airport. Vehicle position data are provided by the vehicle and received via the communication infrastructure. Both data need to be combined to achieve an overall traffic situation (fusion process). Flightplandata are received from the operational airport database and stored in the project database. The optimizer is the central element of processing information from vehicles and the dispatcher working position. The module is responsible for mapping of tasks and resources, task message generation and the interaction to the operator HMI. Interpreting status messages of vehicles and the task assignments or changes by the dispatcher it provides recommendations correlation open tasks and available resources.

Independent from the communication infrastructure a communication module is responsible for all data transmitted from the vehicles to other components and vice versa. All functionalities for connecting, addressing, routing and data transfer have to be implemented. Different protocols like TCP and UDP will be used for different types of messages.

A separate database is needed to store and modify data as interference with the operational system must be avoided. The database can also be used as a communication method to inform components about updates and changes.

IV. Prototype-Realisation

Based on the technical feasibility studies and implementations of the project CARMA, an advanced prototype was installed at Hamburg Airport. This was conducted within the "Competitive Airport" project. The following Figure 2. illustrates the overall system and the connection and data exchange between the components.

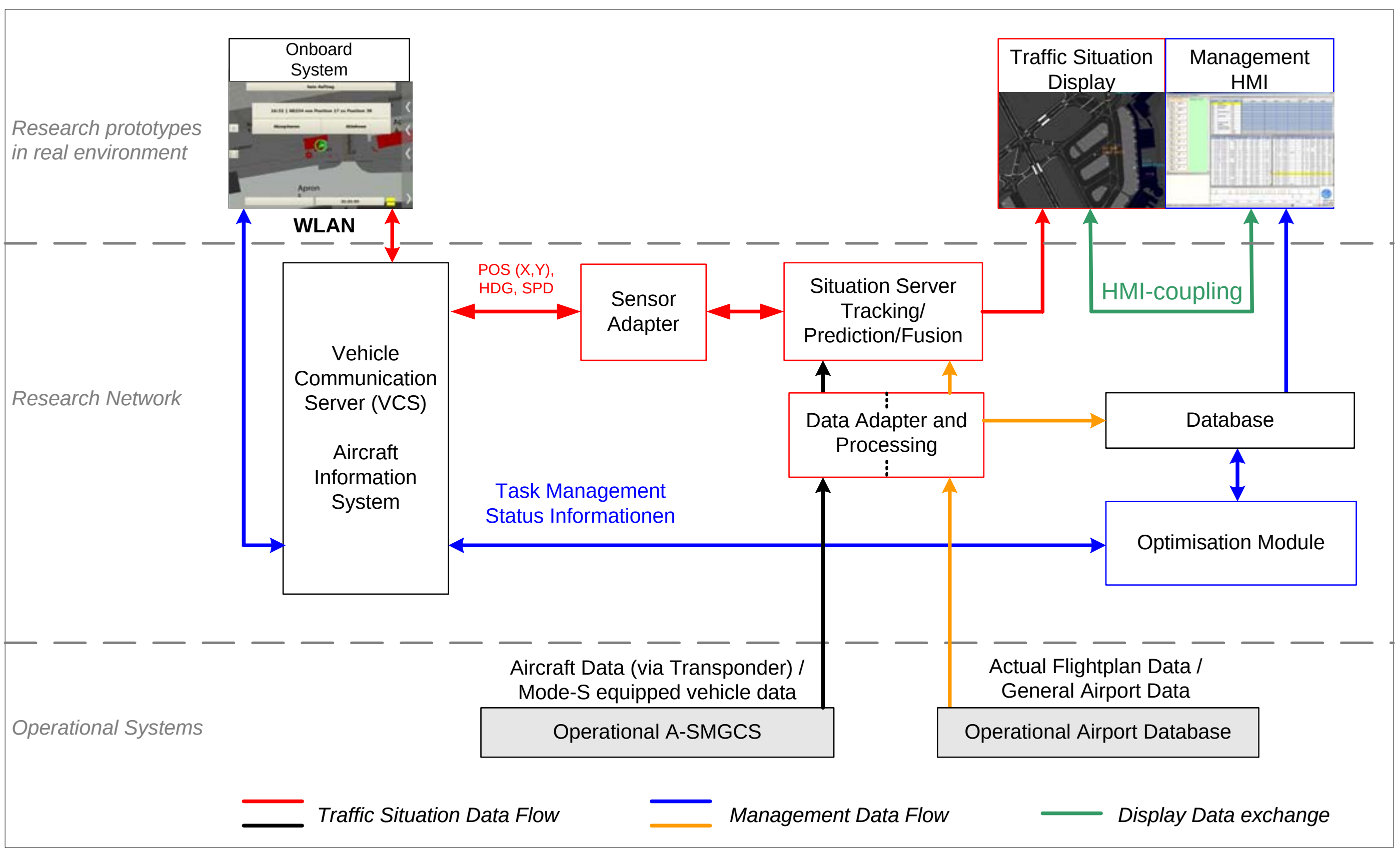

Figure 2. Overall architecture of the prototype vehicle management system

A. *Vehicle Onboard Unit*

The onboard unit, developed by the Technical University of Braunschweig, is responsible for the calculation of the own ship position, the communication with the communication server and represents the interface to the vehicle driver. Figure 4. shows the installed onboard unit. With a special designed carrier the netbook, the touch screen and all other components are mounted to the windshield of the luggage car. That includes the adapter for the vehicle power supply as well as a backup battery. With the removable suction cup an easy mounting and demounting for testing could be achieved. A waterproofed roof box holding all antenna equipment was connected to the assembly.

Figure 3. luggage car with integrated onboard unit

With the help of the ground handling company Groundstars this installation was placed into 15 luggage cars. All necessary software modules were developed to run on a normal windows operating system using Qt for the graphical representation.

1) Position determination and Communication: The concept for the position determination is based on a general GPS solution taking into account the need for indoor navigation and continuous position information during phases without GPS. This requires additional vehicle sensors, which are available in new vehicles but may be missing in older ones or highly specialised ground handling vehicles. During the projects there was no possibility to check the luggage cars for available sensor data. To verify the technical realisation of the concept and to get some first test results a special equipped test vehicle was used.

An advanced GPS module (antenna, receiver, software) was used for the determination of the position. In addition to the calculated position by the module itself, the receiver was able to provide raw satellite data. Therewith it was possible to use the developed position calculation method which combines GPS-data and vehicles system data.

The position information was being sent every second by an external WLAN antenna to the vehicle communication server, using the reserved virtual WLAN segment. A proprietary position format was used, which was developed during the projects.

2) Driver Interface: A ten inch touch display was used for the presentation of the traffic situation, the task information and the interaction with the system. The display was mounted in the middle of the cabin easy to read and reach for the driver.

The system has a full start-up procedure with no interactions required to be operational. All connections are setup automatically. The following Figure 4. illustrates the main screen, with the airport layout, interactive elements and the actual traffic situation.

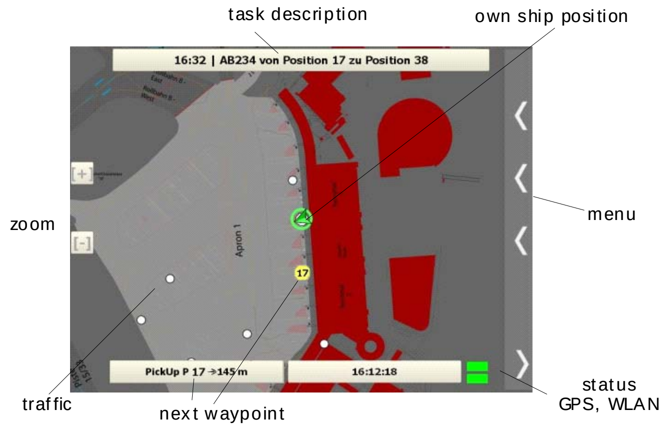

Figure 4. Onboard HMI

B. *HMI for Dispatcher*

The ground unit for the dispatcher of the luggage cars, developed by DLR, was placed directly besides the operational working position and connected to the research network. The management HMI consists of two screens, representing the two concept elements traffic situation and management interface. The following Figure 5. illustrates the setup at the control room of the ground handling company.

Figure 5. Management HMI

1) Traffic situation: The Traffic situation display was developed by DLR as an in-house solution for A-SMGCS related research. Using C++ and Qt the software can be installed on Linux and Windows operating systems. The interface to other components is implemented using UDP for the connection to the management display and the standardized ASTERIX format for the data sent by the situation server.

The display is divided into two sections. The approach window, displaying aircraft on final, acts as an information area about the actual arrival-sequence. This gives the dispatcher a good guess about the order of aircraft arriving the apron and the on-block times that are to be expected.

The apron window is the main working area showing the apron with a higher zoom for better situation awareness. Displayed are all aircraft and vehicles that are adequate equipped and merged by the situation server. Each object has a specific symbol and a label for identification. The display offers typical functionalities like scroll, zoom and move of the map but also some specific elements to the work of the dispatcher. The selection of objects is linked to the management display for relevant information. This link is implemented bidirectional, which enables a coupling of position and information of an object distributed on two monitors. Either the selection of a resource/flight on the traffic situation or the management display brings up the associated information on the other screen. It is only possible to have one flight and one vehicle selected at the same time.

2) Management: The management display has been developed as a replacement for the actual system considering the data link aspects of the new operational concept. The display is divided into four window elements:

- Flights/Task
- Resources
- Flightplans (divided into Arrival/Departure)
- Details

A fifth section was implemented, presenting an overview of the traffic demand within the next hours, but was stated as not necessary by the operators.

While flightplan and details sections are more informal, flights/tasks and resources are the interactive parts to operate the system.

Comparable to the flightstrips of an electronic flight strip system the flights/tasks window contains task strips representing the flights to be served within the next time. At the moment a time frame of two hours is implemented, but can be adapted to the needs of the operator. The two columns show open tasks and tasks currently in progress. Each task strip displays the most important information only. The following Figure 6. illustrates the flights/task window with a couple of task strips and the respective information. While open tasks are presented on the left column, tasks currently in progress are shown right. The developed color scheme is cognizable as some elements are red and need instant attention by the dispatcher.

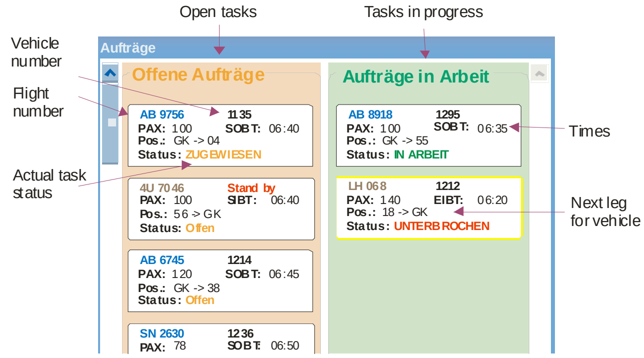

Figure 6. flights/tasks window for dispatcher

The open task window is filling up constantly with new tasks relevant for the selected two hour timeframe. Different colors are used to have good situation awareness about required actions, the actual status and possible problems. The optimization module calculates a recommendation of the optimal vehicle for each task and the solution is presented to the dispatcher in the vehicle number field. To assign a task to a vehicle, the dispatcher drags the task strip with the mouse and drops it on the timeline of the designated vehicle at the resource window (Figure 7.).

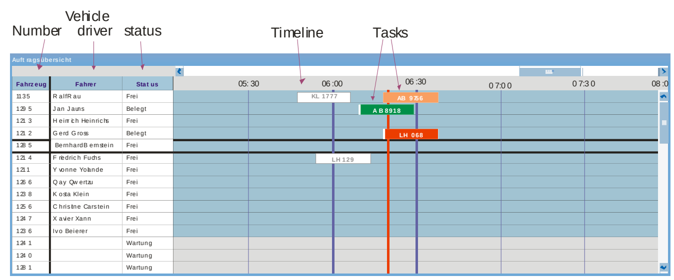

Figure 7. resources window for dispatcher

The task is automatically positioned according to the departure and arrival times (EOBT-25min for departures, EIBT-2 min for arrivals) but can be adjusted be the dispatcher manually. Until acceptation by the driver, assigned tasks can be switched to other resources by moving the task block to the respective resource line. Once a task is accepted, this can only be done by deleting the task (goes back into open task because it was not finished) and assigning the task again to the new resource.

All changes on the HMI related to the management of the tasks (updated information, interactions) are communicated via update tables of the system database to other components.

C. *Airport Research Facility Hamburg*

The *Airport Research Facility Hamburg* is a unique platform for developing, testing and evaluating future support systems. DFS, Hamburg Airport and DLR have agreed on cooperation on installing and operating a field test platform for research and development in the field of air traffic management and airport operation. With an extension to the operational A-SMGCS Level 2 at Hamburg Airport the system is capable of sending real traffic data to the research network by an extended ASTERIX interface. Besides the merged traffic situation from the sensor data fusion, the system also provides raw data from every single sensor and information from various functions of the system (e.g. alerting).

The research facility was used to integrate all components without a direct interface to the operators. This includes the data adapter to the operational A-SMGCS and the airport database, the communication server, the optimization module, the situation server and the system database.

For the communication between the vehicles and the research network a reserved segment of the WLAN existing at the airport was setup by the IT service provider at the airport (Airsys) and routed directly to a second network card of the communication server described later in the chapter.

1) Optimizer: The optimizer is the central element for processing the actual status of allocations, the preparation of vehicle recommendations and the data exchange with the vehicles. The optimizer was developed in Java by the University of Hamburg as a self-contained application, embedded in the research network.

Based on the actual flight plan the module determines the flights, which need service within the next two hours. A task is generated and the calculation of a recommended resource is carried out. Taking into account the availability of all resources and the distances to be covered by the vehicles one resource is selected. The vehicle number is stored in the database, communicated via update tables to the management module of the HMI and presented to the dispatcher as part of the task strip. In case of lack of available resources a message is displayed and the recommendation postponed. Continuously checking the update tables and the messages received from the vehicles the optimizer analyses the actual situation and recalculates if necessary. The optimization is based on a shortest distance algorithm using a static matrix of distances between discrete points (e.g. stands, baggage sorting facility).

2) Data adapter: To use real live data, adapter to the operational systems are necessary. The already existing interface of the Airport Research Facility to the A-SMGCS was used to handle aircraft position data. The ASTERIX-messages were received from the output of the sensor data fusion of the A-SMGCS and sent to the situation server.

A second adapter was implemented with a connection to the operational airport database. Proofing correct data retrieval on a test system, the connection with the real operating database was established. To reduce the amount of transmitted data a catalogue was set up and the respective queries were implemented. To avoid interference with the airport operation, all information is stored in the project database for modifications by the vehicle management system. To access data two different types of services are implemented. The file service transfers a complete set of data only used in the initializing phase of the system. Besides the topographical information (e.g. active stands) a complete daily flight schedule is transferred once a day. Thereafter the update service will be used to transfer changes in operations to the vehicle management system database.

3) Situation server: The situation server is the main module to set up the overall traffic situation. Combining the position of aircraft with the position of the equipped vehicles led to an overall traffic situation which was sent to the dispatcher HMI (ASTERIX to the traffic display) and to the vehicles via the vehicle communication server (proprietary position report). As position updates are available 1/sec for aircraft and vehicles the situation server operates at the same rate providing a continuously traffic situation every second.

While sending the traffic situation to the dispatcher HMI directly using the ASTERIX-format, vehicles get the traffic situation via the communication server.

4) Communication server: The vehicle communication server (VCS), developed in Java by the Technical University Hamburg Harburg, is responsible for the communication between the ground components and the vehicles. The data exchange of the traffic situation as well as task information is coordinated by this module. In general the VCS does not interpret the packages but is responsible for the routing to the correct vehicle.

The VCS receives position and identification periodically via UDP from every vehicle and sends them to the situation server. The overall traffic situation will then be broadcasted by UDP to all vehicles simultaneously. Because of the non safety critical character of this function a loss of single packages is acceptable.

For task messages a TCP connection has been implemented to overcome the shortcoming of loss of information. Even this is not safety critical it has a direct influence on the operation as there is a possibility that tasks are not transmitted and therefore aircraft are not served. After a vehicle onboard unit has been activated the system stores the network address. Each task package (sent by the optimizer) has an id to specify the receiver of the package. VCS matches the id with the hardware network address and sends the package to the respective vehicle. The connection to the vehicle will be established when a message needs to be send and released when a successful transmission feedback was received. In case the vehicle is not reachable VCS will retry sending the message.

V. FIELD TRIALS

The main goal of the field trials was the technical verification of the overall system and the chosen technologies.

To verify the quality and coverage of the wireless network long term measurements where conducted by the TUHH. For a period of two months receivers and recording equipment where installed on follow me cars and as static components, storing a substantial amount of data. As a result of the post processing, a detailed map of different areas was produced showing the quality of the WLAN and the percentage of lost data packages. In general the coverage and quality is adequate and independent from weather influences also. Only a few parts of the manoeuvring area should be improved. The GPS-signal was available at any time on the manoeuvring area but not inside the building of the luggage sorting facility [5].

To verify the position calculation module combining raw GPS data and vehicle sensor information several test runs were carried out by the TU-BS. Using the special equipped test vehicle various track segments were analyzed using the single GPS-position and the developed robust calculation method and additional sensors. The following Figure 8. presents two examples of the comparison between the two solutions. While the yellow path represents the single GPS solution, the red track shows the result of the position calculation module.

Figure 8. Comparison of single GPS and integrated position solution [6]

It can be clearly identified, that the integrated solution is more stable in terms of precision and can compensate outliers resulting from reduced satellite coverage. Presenting these position changes to a dispatcher could cause confusion about the real position of the object.

During a two weeks trial period the overall system was tested. A number of 4-6 luggage vehicles (not all 15 equipped vehicles are at service at the same time) and two test vehicles from TU-BS and DLR were available. In shadow mode all elements of the operational and technical concept were analyzed. Dispatcher and vehicle driver operated in normal procedures using voice for communication. In parallel the vehicle driver operated the onboard system while researches used the new HMI for the dispatcher. Due to the fact, that the HMI was placed directly beside the operational work place all assignments could be copied and the system operated accordingly. A task assigned by voice to a specific vehicle was also assigned to the same vehicle using the new interface and the implemented data link. The vehicle driver got the same task and operated the system. Abnormal statuses like abortion or halting of a task were tested with the test vehicles only (no influence on the real operation). As the field trial were realized in shadow mode, with no direct operational impact the system could not be validated in terms of reduced driving distances or optimized resource usage. Therefore the scope of the trial was to show the technical realization in a real environment. To completely validate the system and quantify benefits, a simulation with baseline and enhancements scenarios have to be carried out.

It has to be stated, that the used technologies are suitable but the selected hardware components have some issues that need to be considered. The goal of the projects was a cost-effective system solution using off the shelf hardware. Experiences during the field trial have shown problems in the reliability of some of these components. One major problem was the use of standard mechanical hard disk drives. While driving on the apron vibrations of the very robust luggage cars where transferred to the disk causing failures and system hang up. To overcome this, the use of solid state disks could be an option. The use of the touch displays was alright during the relative short period of the trials. It may be a problem in long term when the touch area gets dirty.

The connection to the airport systems was successful. The prototype has proven that it is possible to use real live data with relatively low effort once a basic infrastructure at the airport is provided. Fortunately A-SMGCS and WLAN were available at Hamburg Airport. This has to bear in mind when it is intended to use such a system at other airports.

As a first feedback the dispatcher were very interested in the traffic situation. This would be a helpful feature and could relieve the work. The same is valid for the use of data link as this could reduce the workload significantly. The HMI for the dispatcher needs improvements, as it will not be accepted until all operational aspects are covered satisfactory. The map functionality of the onboard system was assessed as not necessary by the drivers. Because of the relatively simple airport layout and a lot of experiences a significant benefit could not be seen. Taking into account the use of the system also in external vehicles where drivers are not familiar with the airport this statement could be relaxed.

VI. Conclusion

The developed prototype realisation has shown a technical feasibility of a vehicle management system including the use of real time data in an operational environment. The modular approach allows for easy enhancements of single aspects of the system. Concentrating on the process of luggage transport the operational concept has been proven to be feasible within standard procedures.

Field trials have shown some shortcomings of the system that need to be addressed in detail. Some of the open work is already covered in the ongoing national project “Airport2030” (to be finished in 2013). The dispatcher working position will be refined. Using the Eurocontrol early development and evaluation platform (eDEP) a new system approach is taken and an integrated HMI combining traffic situation and management will be developed. In addition the system will be linked to a prototype airport operations centre to analyze possible benefit in the context of total airport management.

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Steffen Loth was born in Ludwigsfelde near Berlin, Germany, 09.09.1971. After his apprenticeship as a skilled electronic worker he started his academic studies in the field of Transport, Aeronautics (flight guidance and air transport) at the Technical University Berlin, Institute of Aerospace, Berlin, Germany 10/92 12/02. He got his diploma in Aeronautics in 2002.

After his studies he worked as a junior consultant with GFL for two years and was involved in different projects concerning safety, capacity and environment of German and European airports. In 2005 he joined the Institute of Flight Guidance in Braunschweig of the German Aerospace Center (DLR) as a research assistant. He is involved in the research of Advanced Surface Movement Guidance and Control Systems (A-SMGCS) and the optimization of airport operations (including ground handling). He works as a coordinator of various projects at Hamburg Airport and is responsible for the Airport Research facility Hamburg.

Mr. Loth is the representative of DLR within the EUROCAE (European Organization of Civil Aviation Equipment) Working Group 41 (Surface Movement Guidance and Control System).