High-precision positioning of asphalt fleet machines

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BIOGRAPHIES

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Juergen Seybold received his Dipl.-Ing. degree in 1980 from Stuttgart Technical Professional Academy. Among others, he was working in leading positions for companies like Alcatel / Airsys Navigation Systems, Thales ATM, and Alcatel SEL Defence \& Aerospace Division for several years. Since 2006 he is Managing Partner and Chief Operating Officer (COO) of TeleConsult Austria GmbH.

Agata Ligier received the Doctor of Mathematics in 1994 from University of Lodz, Poland. From 1999 until 2003 she worked at the University of Karlsruhe, Germany and was involved in Computer Integrated Road Construction (under FP4) and Open System for Road Information Support (under FP5). Since 2006 she has worked for MOBA AG and is involved in development of GNSS based systems for road construction machines.

Santiago Urquijo received the M.Sc. and Ph.D. degrees in Electrical Engineering from the University of Navarra, Spain, in 1994 and 2005, respectively. From 1994 to 1997, he worked on the electrical department of the C.E.I.T. where he developed several digital ASICs. In 1997 he was in the analog department of the Fraunhofer Institute for Integrated Circuits (FhG-IIS) as a visiting researcher, returning to San Sebastian as Assistant Professor. Since 1998, He is member of the navigation group at Fraunhofer IIS in Nürnberg. His main activity domain is currently in the field of mixed IC, signal processing, data converters, and system architecture. He assumes responsibility for the receiver system architecture and implementation of GNSS-systems.

Hans-Juergen Euler studied at the Technical University of Darmstadt. He has been awarded his PhD degree for fast integer ambiguity resolution for dual frequency GPS. After working for Terrasat (now Trimble) and Leica Geosystems he founded inPosition gmbh in 2006. InPosition does algorithm and concept development in the area of precise GNSS positioning .

ABSTRACT

The European Union has more than 5 million kilometers of paved roads, and 90% of the total road network has an asphalt surface. Continuous monitoring and control of parameters during road construction are significant for the quality and durability of the road. Any sub-optimal operation within the asphalt construction chain will lead to a reduction in road quality, what results inevitably to a decreased life-time. An increasing lifespan, on the contrary, will result in a reduction of cost of road maintenance. Key factors are to optimally manage truck fleets, operate the paver, and steer the compactors. Thereby GNSS technology has been chosen to play a major role.

This paper introduces the ASPHALT project, describes the newly multi-frequency GNSS receiver under development, the high precision multi-frequency antenna, the RF frontend, and in particular the baseband; the RTK solution to achieve the high precision position solution, and the EDAS implementation to provide continuous EGNOS correction data stream for position output. First results of RTK solutions will be presented as well as the performance of the multi-frequency GNSS receiver tracking loops. The objective is to meet the requirements of the asphalt road construction in order to increase the quality of roads.

INTRODUCTION

The penetration of GNSS technology in asphalt road construction is low in contrast to the ever increasing mass market. Although satellite navigation is broadly used in surveying and partly used in earth moving on a construction site, the management of asphalt truck fleets, the operation of the paver, and the steering of the compactors are done without help from space. Today's asphalt road construction relies to a great extend on the experience of the construction worker.

Any sub-optimal operation within the asphalt construction chain will lead to a reduction in road quality, what results inevitably to a decreased life-time. An increasing lifespan, on the contrary, will result in a reduction of cost of road maintenance. Accounting for the 5.000.000 km of paved roads within the European Union, and considering that over 90% of the total road network has an asphalt surface which must be regularly repaired or rebuild, a tremendous cost saving factor arises when a life-time increase can be achieved.

The decisive mission is to explore the asphalt process chain and with the intensive use of positioning data, evaluate and control the possibilities of improving each subprocess. Constant monitoring and control of parameters during road construction is significant for the quality and durability of the road.

The asphalt aggregate has to be delivered from the asphalt plant to the paver just-in-time in order to guarantee that the temperature of the aggregate does not drop below a critical limit during the pavement process. Too many asphalt trucks in front of the paver will cause too low temperatures, whereas a disruption of the supply chain will make the paver stopping, what causes a bump in the road. For these fleet management tasks augmented single point position solution is fully sufficient. For the docking of the truck to the paver and for the control loops steering the thickness and evenness measurements during the pavement process high-precision real-time position solution is needed with high update rate. The compaction process, finally, requires simple pass counting systems, which, however, have to be accurate enough to detect overlapping areas of several passes. Therefore the positioning system in general, and the GNSS technology in particular, has to provide accuracies in the millimeter, decimeter and meter range. Furthermore, continuity, reliability, and availability are of concern.

On the one side a scalable, cost and precision optimized system for the real-time control of the position will be developed and tightly coupled with the machine control system. On the other side a novel machine monitoring and control systems will be worked out based on availability of the position. The signal concept of GPS and Galileo, as to be used for the application, allows quasi-triple frequency tracking. The envisaged GNSS receiver architecture is based on a 3 frequency approach combining the E1/L1 Galileo/GPS/EGNOS with the E5a/L5 Galileo/GPS and E5b Galileo signals. This availability of more than the traditional dual-frequencies for real time kinematic (RTK) allows faster and more robust RTK solution. The combination of Galileo and GPS strengthens the system with more available satellites.

The main building blocks of the receiver architecture are therefore: a multi-band RTK antenna receiving L1 and E5 frequency bands; an RF frontend able to process L1, E5a, and E5b frequency bands as specified in the latest issues of the GPS and Galileo interface control documents; and a processing module for the signal conditioning and processing, the tracking loops and a FFT block for fast signal acquisition are implemented.

Beside the implementation of RTK solution, the receiver shall process SBAS data of signal in space or of a data access service via internet, like EDAS, to support a faster RTK initialization and to provide code-pseudorange position where meter / sub-meter position accuracy is sufficient, e.g., compactor pass counting system. The envisioned system, therefore, offers high precision applications in road construction and fleet management and logistics in the construction just-in-time process chain.

As an example of the areas of operation, the paver control system and a compactor pass counting system including on-site compactor fleet management system will be designed and demonstrated, as well as a concept for asphalt truck fleet management will be proposed.

The research work circumscribed is done within the GSA funded project "Advanced galileo navigation System for asPHALt fleeT machines" (ASPHALT) [1] with the final objective to build roads of better quality and durability. The distinct commitment is to bring the system to the market within few years, even though Galileo will not be fully operational by that time.

The ASPHALT project started in February 2010 and lasts 24 months. The project team composes of MOBA Mobile Automation AG (Germany), Fraunhofer Institute for Integrated Circuits IIS (Germany), TeleConsult Austria GmbH (Austria), inPosition gmbh (Switzerland), DKE Aerospace (Luxembourg), and Dynapac AB (Sweden).

ASPHALT ROAD CONSTRUCTION

Asphalt, in this context, is considered as a combination of mineral aggregates and a particular asphalt binder, called bitumen. The aggregates act as the structural skeleton of the pavement. The asphalt binder acts as the glue of the mixture. The mixture consists of about 5 percent binder and 95 percent aggregates. Bitumen is a thermoplastic material and due to its viscous nature the binder must be heated so that it can be mixed with the aggregates. Once the asphalt mixture cools below 80°C, the asphalt binder thickens rapidly.

The asphalt material has several advantageous, two of them are the 100% recyclability of the material, the second one, which is of particular interest for road maintenance, is that it can be renovated by removing a thin layer of asphalt without destroying the whole structure. 80-90% of the road construction work in Europe is maintenance operation. Therefore a thin layer is removed by a milling machine. Then the new layer is floored using paver machines. The asphalt material is transported by trucks from the mixing plant to the paver. The pavers are loaded with the material and then lay it to the road. Finally rollers ensure the right compaction of the asphalt material. Fig. 1 shows schematically the process of asphalt paving.

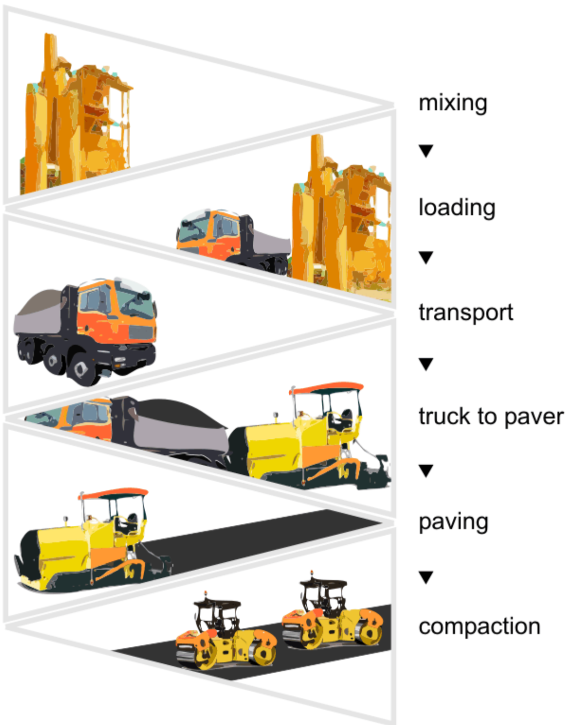

Fig. 1: Asphalt laying process chain

There are about 4.000 asphalt mixing plants in the U.S. distributed over the whole country. The asphalt mix is prepared with a temperature of 160-200°C. Overly cooling of the mix has to be avoided during the transportation from the mixing plant to the paver. Thus any waiting periods in front of the paver, or any long travel distances will result in too low temperatures. Therefore, the truck tipper is typically covered with an isolating cover, some trucks are even equipped with separate heaters. The asphalt mix is loaded from the truck to the paver, while the paver is in operation. The truck has to be placed in front of the paver carefully to avoid any bump which will result in a bump in the road, and a reduced road quality. The paver starts to push the truck while the truck is unloaded and the paver continues with the asphalt paving. Constant paving processes with respect to speed, temperature and material quality also improve the quality of the road. The steering of the paver is either done using string-line technology, where a string is spanned along the road side. More sophisticated techniques rely on a 3D model of the road and cost intensive total stations for real-time tracking and positioning. The uniformity of the asphalt texture and layer is continuously checked and using appropriate adjustment points corrected. The last process of asphalt laying is compaction. The first compaction is already done by the paver but final compaction is performed by one or several rollers. Thereby the level of compaction again determines the quality of the road, its strength, durability, and impermeability. The compaction must not be performed when the temperature of the material drops below 80°C otherwise the structure of the layer is destroyed. Furthermore compaction shall be between 93% and 97% to guarantee optimal characteristics.

Thus, important processes during paving are:

- mass flow control from asphalt plant to the paver,
- asphalt temperature measurement while paving,
- paver steering,
- thickness measurement and control,
- evenness measurement and control, and
- asphalt compaction.

Four important applications have been identified where a system can support the use of resources and machines during the laying operation. Such systems contribute to a more uniformly compacted asphalt layer, a higher quality of the road, and an optimized application flow.

Asphalt truck fleet management – mass flow

The main objective of a supportive system for the asphalt truck fleet management application is to reduce the waiting time for the trucks in front of the mixing plant but also in front of the paver. Just-in-time delivery with a minimum of buffer time, reduces the number of trucks required. This is a direct benefit for the construction company which saves resources, but also for the community. Furthermore the temperature of the asphalt mix will not drop below a critical temperature, what therefore is in favor of the quality and durability of the road.

Asphalt truck fleet management – docking

The docking between the truck and the paver is still a critical process. Any bump during docking will result in a reduced quality of the road. Supporting systems shall reduce the time needed for docking and support soft docking operations. These are benefits for the construction company as well as for the community.

Paver leveling control system

The thickness and the evenness are of particular interest and importance. The construction company does not want to build in too much asphalt material. The awarding authority on the other hand defines a minimum thickness of the new asphalt layer. If this limit is underrun the construction company has to rebuild the new asphalt layer. A leveling control system helps both: the construction company does not waste resources and material; the community has a means to check the thickness of the layer. The evenness of the asphalt layer depends also on a continuous build-in process. Therefore the paving machine must be constantly loaded with the hot mix to avoid any stop. The introduction of new technologies shall ensure uniform thickness and evenness of the road, and an accurate height control at the back edge of the paver. Further the paver shall be equipped with a steering system to facilitate the road construction – another benefit for the construction company.

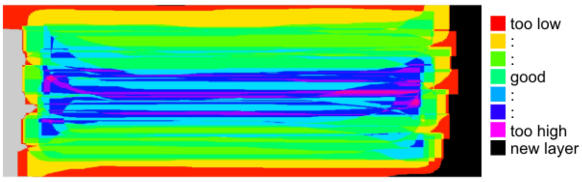

Fig. 2: Visual pass counting system based on position information

Compactor system

Depending on the size of the worksite there are one to five compactors working behind the paver. The compactors can stay up to 500m behind the paver.

The important parameter for compaction is the temperature, which shall never drop below 80°C. The compactors continuously drive back and forward in order to achieve the optimal compaction. Thereby the compactors shall pass the same parts of the road several times. The number of times depends on the temperature, on the roller weights and vibration amplitudes. The lateral overlap has to be kept constant. In longitude it has to be accounted for the continuous movement of the paver. Inadequate compaction increases the risk of permanent deformation (rutting), fatigue (cracking), bitumen oxidation, or stripping. Since with increasing number of passes it becomes more difficult to distinguish, where and how often the roller has passed a certain path, a system to support the compacter is envisioned (cf. Fig. 2). Research has shown that compactor operators tend to pass the middle of the track more often than the roadsides. The goal of the application of new technologies is to support the compactor driver in achieving the uniform compaction, where the main factors are: uniformly distributed passes done by several machines; passes done within the temperature range specific for mix; and lane change on the cold asphalt.

Such a system is advantageous for the construction company, since the number of compactor passes is limited to a minimum. Such a system is also advantageous for the community since the quality of the road can again be pushed to an optimum.

GENERAL SYSTEM DECOMPOSITION

Within the GSA funded project “ASPHALT” three types of machines within the asphalt paving process are addressed (Fig. 3): the trucks, the pavers, and the rollers. The paver requires high position accuracy in the range of 1-5 cm horizontally and 2-10 cm vertically. For the pass counting system horizontal (relative) position accuracy of 40 cm and a vertical position accuracy of 80 cm is required. For fleet management a position accuracy of 5 m is appropriate. Furthermore continuity and availability of 98% and 99%, respectively, pose stringent requirements onto the system.

The proposed system uses as the major element for position determination, either absolute or relative, satellite navigation. To achieve the required high position accuracy real time kinematic (RTK) processing is applied. This will allow for soft-docking operations, but also for leveling support during the paving process. The position, velocity, and time (PVT) processing integrates the signals from the GNSS systems with correction data from EGNOS, either from satellite or via a terrestrial link. Additionally autonomous sensor information will bridge GNSS signal outage and increase the performance for relative positioning. This will provide the required accuracy for the fleet management of the trucks but will also support the compactor application. The introduction of these elements into the road construction has the objective to provide the means for continuous monitoring and control of parameters to increase the quality and durability of the road.

The main positioning hardware is the GNSS receiver which processes Galileo/GPS/EGNOS signals of three different frequencies. The position is computed either in a PVT engine using single point measurements but incorporating augmentation information from EGNOS or EDAS. For high precision applications an RTK engine processes the measurements to gain position information with centimeter accuracy.

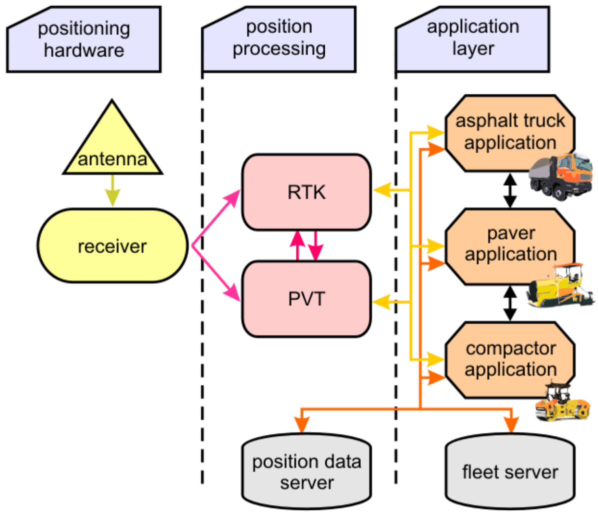

Fig. 3: ASPHALT system decomposition

GNSS RECEIVER ARCHITECTURE

The application requirements call to integrate a multi-frequency satellite navigation receiver. Thereby a combined GPS and Galileo receiver, which is also able to process satellite based augmentation signals has been designed. The receiver will process signals on the E1/L1 frequency band as well as on the E5/L5 frequency band, thereby jointly using the E5a and E5b signals of Galileo. Various antenna designs have been analyzed which provide an optimal performance for the denoted frequency bands. In particular the phase stability is of concern when considering the RTK processing. The radio-frequency (RF) frontend has been designed to process and filter a 14 MHz signal bandwidth in order to handle C/A and TMBOC, and the CBOC signals respectively of GPS and

Galileo. A 24 MHz bandwidth in the E5a/L5 and E5b allows to process the BPSK(10) signals of GPS and Galileo. Thereby the two main lobes of the AltBOC Galileo signal are mirrored to one joint signal.

The digital output of the frontend is finally processed on processor modules including FPGAs. Particular care is put on the signal conditioning and processing within the acquisition and tracking loops. The position processing of the PVT and RTK engine are separated between the receiver internal FPGA and an external processor. The multi-frequency tracking will enable fast and reliable RTK position solutions. The combined use of GPS and Galileo thereby increases the robustness and the number of satellite even in signal unfavorable environments. The receiver prototype additionally interfaces to autonomous sensors and to communication modules in order to request differential GNSS data and the phase measurements of a reference station. The differential information comes either from a local reference station or from the EGNOS data access service (EDAS) which provides EGNOS information. This can be enhanced using local atmospheric data. The communication, furthermore, is needed for position exchange between the different machines and applications.

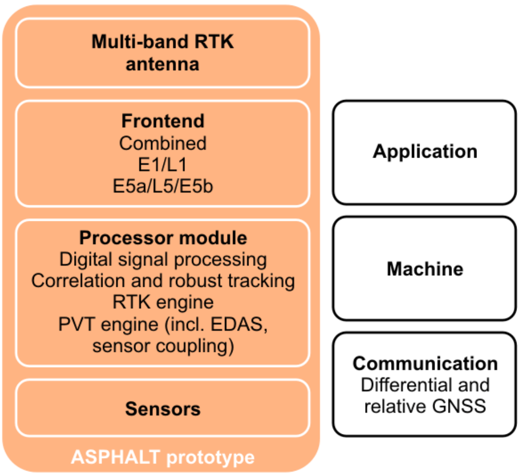

Fig. 4: Schematic diagram of the ASPHALT system

Antenna

In order to achieve a coordinate measurement precision in (sub)centimeter-range, the antenna should show a passive antenna gain of more than 3 dBic with a good polarization purity (RHCP) and a high front to back ratio for a good multi-path rejection. It is also required to have an omnidirectional radiation pattern and a 10 dB-beamwidth of more than 150° (important for receiving signals from satellites at low elevation angles) and a well known and stable phase centre.

The proposed antenna consisted of a radiator in the middle of the PCB and parasitic elements arranged around it. Measurement results in the anechoic chamber achieved a base peak gain and 10 dB beamwidth of 3.9 dBic / 177° (E5 Band) and 3.6 dBic / 170° (L1 Band).

RF-Frontend

The RF signal provided by the antenna is after a low noise amplifier (LNA) divided in three paths (GPS/GALILEO L1, GPS/GALILEO E5, GPS L2). The RF channel filtering is performed using low group delay ceramic filters. Employing a direct conversion topology with I and Q signals, the low frequency signals are digitized by dual high speed ADCs. All necessary clock signals are generated from a unique TCXO oscillator. The RF antenna is powered by the board.

All signals are sampled simultaneously by the ADCs. The digital output signals are connected to a FPGA which performs the signal conditioning and sets continuously the optimal gain of the variable gain amplifiers.

Note that the L2 frequency is not used within the ASPHALT project.

Digital Signal Processing

The receiver digital architecture is formed by the signal conditioning, the acquisition module, the correlators and two processors including floating point unit. The correlators are configurable and include 5 complex output taps, remove the Doppler and performs the code correlation. The tracking software updates the code and carrier NCO and decodes the navigation message.

The receiver needs to synchronize the incoming signal PRN code, with a self- generated PRN code replica. The main objectives of the acquisition module is to be robust and fast. In order to do this process as fast as possible, an FFT correlator has been implemented.

The prototype receiver board (160x100 millimeter; Fig. 5) includes the RF-Frontend and two spartan6 FPGAs which perform the signal processing and PVT.

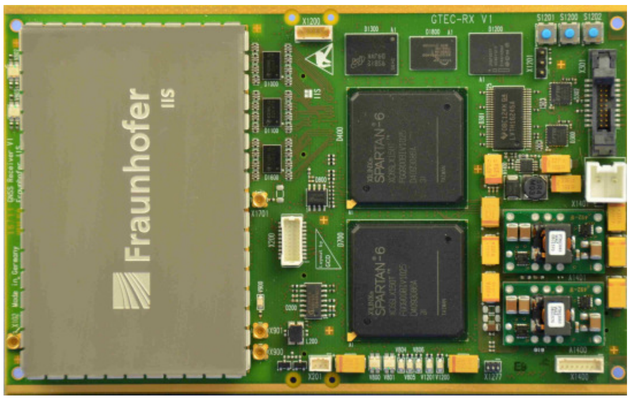

Fig. 5: GNSS receiver board

Position Processing

The baseband processor provides pseudorange, phase, and Doppler measurements and estimation about the signal to noise power, along with navigation data and some other attributes. All this information is time attributed which allows computing position solution. In return the position processing provides information about visible satellites and their approximate Doppler frequency. The baseband uses this information to configure the acquisition loops.

The increasing number of GNSS signals increases the redundancy and opens the door to implement new mitigation and correction strategies, e.g., ionospheric corrections or multipath-mitigation algorithms. Sophisticated weighting strategies integrate the measurements of the different frequencies, different satellites, and different system to one optimal solution.

The position processing furthermore uses differential and assistance data provided to the receiver via one of the interfaces. Within the ASPHALT project the prototype accesses data from the position data server (PDS). The PDS links to the EDAS service to retrieve differential information and ephemeris and clock information. The EGNOS corrections are further improved by local atmospheric corrections and the differential and assistance data are then provided to the receiver in RTCM data format.

Implementation of the RTK Engine

The RTK engine may use any combination of signals (pseudoranges and phase ranges) as provided by current GNSS equipment. This certainly includes the three signals of the ASPHALT receiver, but also GPS L2 and the Galileo E6 signals. The principal capabilities of the algorithms have been already demonstrated based on a predecessor RTK engine as used in another EU FP6 project ARTUS. Details may be found for instance in [6] and [7].

As noted before the RTK Engine is hosted on a separate so-called RTK processor board for the ASPHALT project. This processor board has a processing core Marvell XScale PXA-320 and runs on 806 MHz with WinCE5 as operation system.

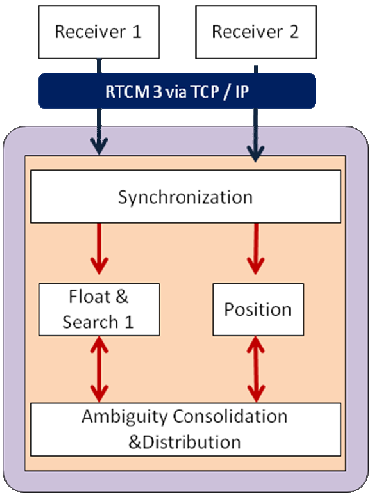

Fig. 6: Principal RTK processor scheme

The RTK algorithms implemented on the RTK board are from inPosition's development specifically tuned and substantially revised for the lower performance of WINCE5-based platforms without floating point processors. The principal processing scheme is shown in Fig. 6. The communication interface for the ASPHALT receiver has been chosen to be compatible with the industry standard RTCM, which allows full compatibility with other professional off-the-shelf GNSS receivers.

Due to the timeframe of the project several integration steps have to be performed in parallel. The compatibility of the RTK kernel with the RTCM standard allows for using other industrial receivers as measurement engines providing the required high-precision observation information. The integration of the communication SW module supplied by MOBA and RTK kernel supplied by inPosition on the processor board has been successfully completed beginning of September. The completion of the integration has been verified by a field test at MOBA headquarter.

MOBA has an established rail-bounded robot for their various real-time kinematic machine guidance developments. For the testing this rail robot has been equipped the ASPHALT RTK processor and a still separate DataGrid dual frequency GPS receiver. The engineering test setup is shown in Fig. 7. The box at the top of the robot with the screen and yellow buttons hosts the processor board running the communication SW module and the RTK kernel. Currently this is a standard GUI component (Operand D) manufactured by MOBA. The ASPHALT receiver board will be integrated by replacing the display as next step.

Fig. 7: MOBA rail-bound test robot

The reference station information is received by a standard radio communication unit in the back indicated by the whip-antenna.

The mono-rail for the test robot is a hockey-stick shape running roughly North-South with the handle pointing towards the West. The robot runs autonomously at a constant speed forward and backward. The ends of the rail are detected by ultrasonic sensors. The initial integration test has been concluded by a test run of several laps on this course. The main purpose was the testing of the communication and integration of the equipment as step towards out test readiness milestone of the project. The RTK algorithms performed also as expected. The algorithms have been automatically soft-reset during the course of the test-run on a regular basis. Each independent initialization of integer ambiguities has been successful.

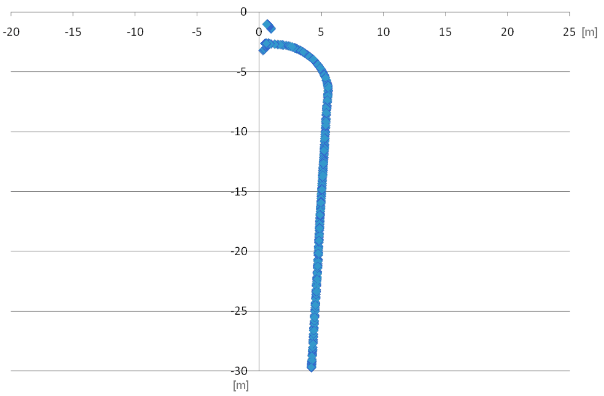

Fig. 8: Hockey stick shape of rail

Fig. 8 shows the complete horizontal plot of the test course. At the North-West end some point of the exact line are positions without integer fixes during the initialization phase of the algorithms. Fig. 9 depicts the curve of the mono-rail with 14 overlaying passes of the robots positioning.

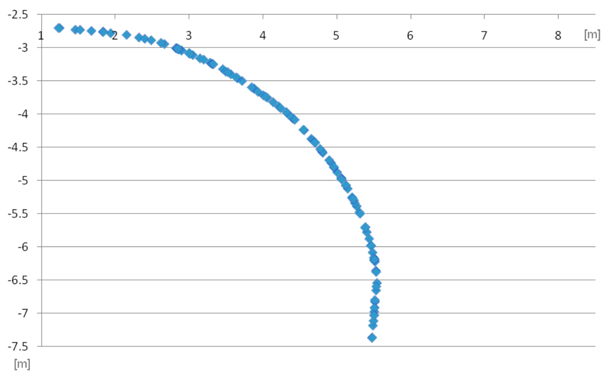

Fig. 9: Curve area (close-up)

BUSINESS AFFAIRS

European investment into highway, street, and bridge construction amounts to EUR 80 billion per year. The US, although having the largest road network with 6,430,000 km, invest EUR 55 billion per year. Not included in these figures are private-sector investments for asphalt surfaces in streets, parking facilities, or commercial and residential facilities, and other transportation-related structures like air-fields or new markets like rail tracks. The system designed during the ASPHALT project provides the means and technological solution for continuous monitoring and control. Benefits will not only arise for the public sector but also for the construction companies.

Primary cost saving factors for the community

The increased quality of the road will increase the life cycle of the road. Assuming an increased quality of 10% will result in an average road repair cycle of about 11 years instead of 10 years.

The road repair costs over a distance of 1km is in the range of 100.000 to 200.000€. One year life cycle extension will save a road repair distance of 45.455km per year for Europe. Taking into account the road repair costs this results into a cost saving of EUR 4.5 billion per year. This primary costs saving is gained, as a result of the increase in road quality by consistent use of positioning data in combination with an increase on paving functionality based on position data.

Secondary cost saving factors for the community

The economic loss caused by traffic congestion has been estimated in 1995 to be 1.9% of the gross domestic product in average over all European countries [2]. Considering a GDP of US $ 2,524.949 billions of Germany in 1995 this results in a loss of US $ 48 billions. Since 1995 the traffic situation has become worse. In 2009, 140.000 traffic congestions have been reported solely on German highways. This corresponds to a length of traffic jam of 350.000 km, and a duration of congestion of 320.000 hours. Statistics maps this number to the population and results into a loss of time of 60 hours per citizen per year. The yearly economic loss is estimated to EUR 122 billions, whereby an additional EUR 11 billions are needed for fuel consumption what results into 25 million tons of additional CO_2 emission.

Traffic congestion on highways are caused by three main reasons: overload of capacity, accidents, and maintenance operations. With respect to the before mentioned statistics interim arrangements due to a construction site on German highways cause 30% of the traffic congestion, resulting into an economic loss of EUR 40 billion, additional fuel consumption of EUR 3.7 billion and CO_2 emission of 8.7 million tons.

There are different means to decrease the number of congestions. Fig. 10 shows some of these and the measures which can be taken in order to meet the goal.

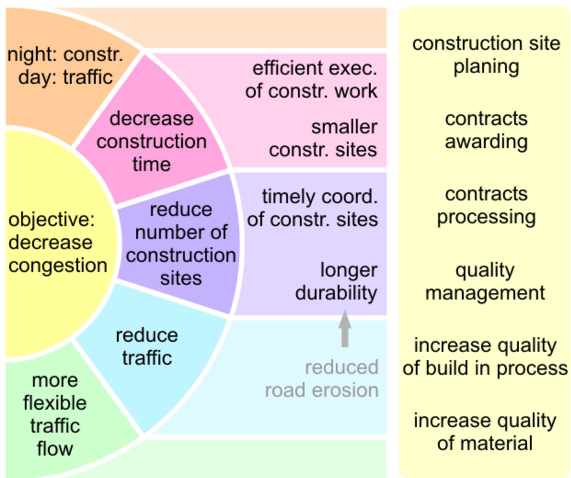

Fig. 10: Means to reduce congestion (extract of [3])

The two main countermeasures for traffic congestions caused by construction sites, are to decrease the time needed for maintenance operation, and to decrease the number of construction site. The first can be achieved by optimized processes. [4] has mentioned the potential reduction of cost if new strategies are introduced to road construction sites (cf. Fig. 11). Thereby the main benefits can be gained by reducing waiting periods of asphalt trucks and pavers, and increase the quality of planning and execution. The second can only be met, when the durability of the road is increased. The durability is directly linked to the quality of the asphalt surface. Both factors, the optimization during the maintenance operation and the quality of the road are major objectives within the research and development project ASPHALT.

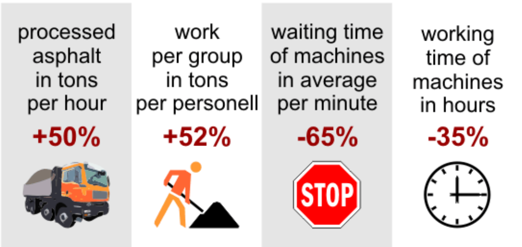

Fig. 11: Benefit of restructuring construction site processes [4]

Summarizing, the increased quality of roads will decrease the number of maintenance areas. Together with a reduced construction time, the number of traffic congestion is reduced, the fuel consumption lowered, the CO_2 emission lowered and in general a major benefit for the community.

Benefits for the construction company

Increasing the life-cycle of the asphalt surface reduces the number of contracts for construction companies. So for what reason should companies be interested to implement such a system proposed by ASPHALT? The continuous monitoring of the road construction will optimize the asphalt material used for construction without falling below the limit of minimum thickness defined by the authority. This reduces the probability of penalty fines for the contractors due to errors and also reduces the probability for reconstruction of parts of the road. The decreased construction time furthermore decreases the probability for penalty fines due to delays on the job.

The ASPHALT solution furthermore optimizes the road construction site organization, reduces time and material buffers, reduces waiting time, minimizes unused potentials and unnecessary transports, and also reduces quantitative and qualitative variances of the asphalt layer. Consequently, the personnel and machinery costs are lowered. Since the contractors plan the penalties within the budget, these can be lowered or saved, and therefore the costs for road construction again reduced.

The ASPHALT solution furthermore allows for continuous digital documentation. This in combination with good job and time management is awarded through bonuses in some countries. The capacity of an asphalt construction site can be increased from 180 tons per hour to 300 tons per hour [5]. This reduces the time for maintenance operation by one third, and appropriate reduces the congestion time. The public side can assist the companies by offering remuneration if the construction site is closed in shorter times.

CONCLUSIONS

The envisioned ASPHALT system offers high precision applications in road construction and fleet management and logistics in the construction just-in-time process chain. This improved process management will enable a better quality and longer durability of road constructions. Thus, the ASPHALT applications are considered of strategic importance and are expected to be early adopters of both EGNOS and Galileo in an important professional high value market where European Union and Member States are spending billions of Euros every year.

ACKNOWLEDGMENTS

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REFERENCES

[1] http://www.asphalt-fp7.eu
[2] European Commission (1995): Towards fair and efficient pricing in transport. COM(95)691
[3] Renner, E., Spiess, H. (2001): StauVerkehr, Voraussetzungen für ein umfassendes Infrastrukturmanagement. FWR-ZHW Studie, December.
[4] Haschek, B. (2009) Autobahn-Baustellen: neue Methoden zur Reduzierung von Staus. auto motor und sport, Juni 2009
[5] Porsche Consulting (2010): Von höherer Effizienz im Tiefbau profitieren Auftraggeber und Auftragnehmer. Innovativ - Lean Management im Baugewerbe, Frankfurt, 18. Mai.
[6] Euler, H.-J., Wirth, J. (2007): Novel Concept in Multiple GNSS Network RTK Processing, ION GNSS 2007, September 25-28, 2007, Fort Worth, TX
[7] Winkel, J., Lück, Th., Bodenbach, M., Göhler, E., Falk, Wolf, R., Granger, R., Readman, P., Simpson, S., Euler, H.-J. (2008): Artus – A Powerful and Flexible GNSS Receiver Platform, Navitec 2008, ESA/ESTEC, December 10-12, 2008, Noordwjik, NL
[8] http://cordis.europa.eu/fp7
[9] http://gsa.europa.eu