Proceedings of the
2007 IEEE Intelligent Vehicles Symposium
Istanbul, Turkey, June 13-15, 2007



# Communication solution for Vehicles Navigation on the Airport territory

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*Abstract* - **Communications solution represents one of the key parts of the Intelligent Transport system (ITS). Methodology of the communication system identification and configuration was studied within projects CaMNA[1] and SRAUTVU[2]. Goal of CaMNA project is to improve airport over-ground traffic efficiency and security for all moving aircrafts as well as service vehicles. Requirements on the communications environment are quantified indirectly by telematic sub-system performance indicators, which are usually applied in the ITS area. Right selection and configuration of the appropriate communication solution are achievable, if "transformation matrix" between vectors of communications and telematic performance indicators is correctly identified. Basic principles of method are introduced. Application of the proposed methodology is demonstrated on the CaMNA communications system identification and its parameters settings. CaMNA vehicle unit is designed for special navigation services operated in specific lively airport area conditions. Positional data are obtained from all service vehicles equipped with GNSS (Global Navigation Satellite System) as well as from non-GNSS A-SMGCS (Advanced Surface Movement Guidance and Control System). These data are centrally processed and together with dispatcher's decisions are delivered to every active service vehicle. Results of the communication solution parameters tests processed within CaMNA pilot installation and relevant recommendations are presented as the last part of this paper.**

## I. INTRODUCTION

MAIN goal of the project CaMNA[1] (Car Movement maNagement on the Airport) is to improve efficiency and security of the airport over-ground traffic, i.e. movement of all service vehicles on the airport territory as well as all individual aircrafts. It is projected that this telematic application based on GNSS (Global Navigation Satellite System) will be integrated with already operated management systems A-SMGCS (Advanced Surface Movement Guidance and Control System) based on the non-GNSS based localization systems. CaMNA sub-system is designed in client – server structure – see Figure 1. Powerful client is inevitable to be installed in every vehicle used at airport area. Client, i.e. OBU (On Board Unit) is designed as modular system equipped with PC based powerful unit. Right now are available modules like GNSS unit, wireless communications units, display and audio unit. Both SW and HW modular architecture gives to CaMNA system remarkable potential to extend functionality of the system by means of a newly integrated modules.

Information about vehicle position is periodically sent to the central server together with vehicle driver/operator requirements. Server collects and processes data received from all service vehicles. Obtained information is combined with data gained from A-SMGCS, processed and delivered to the airport management display unit, as well as to each vehicle equipped with active OBU. Each OBU receives also managerial data generated by either airport control system or by dispatcher. Positional information shares the OBU screen with administrative data.

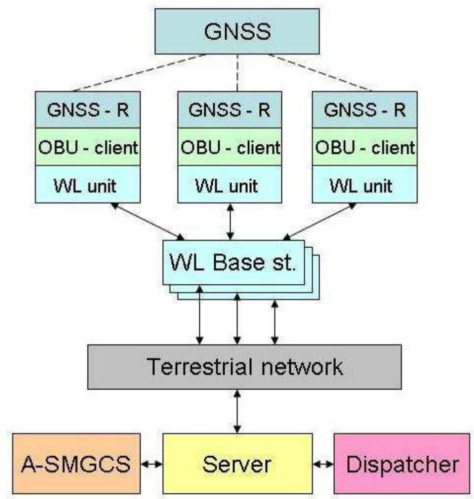


Fig 1. Car Movement Management on the Airport (CaMNA) functional units structure

Described client-server application could resemble the widely spread publicly available car navigation systems. However, this application displays all moveable objects in the area on both dispatcher as well as users units and extensive set of bidirectional interactivity tools is available, as well. There are also outstandingly higher requirements on telematic (CaMNA) system performance indicators. This fact is caused by specific conditions this application is operated on the airport area (see table 1).

## II. TELEMATIC PERFORMANCE INDICATORS

ITS architecture processes are defined as a chain of sub-system components connected by information links. If processes are mapped as physical subsystems or modules the following results of process analysis can be achieved:

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[1]CAMNA – "Car Movement maNagement on the Airport" is part of grant 802/210/112 "Joining of the Czech Republic into Galileo project" supported by Ministry of Transport of the Czech Republic.

[2]SRAUTVU – "System Requirements and Architecture of the Universal Telematic Vehicle Unit" is grant 2A-1TP1/138 of Ministry of Industry and Trade of the Czech Republic.

- *functional specification* assigned to each selected subsystem or module,
- *performance specifications* of all processes,
- *interface specification.*

Correctly done system decomposition (see e.g. [1] - [5]) allows to precisely define requirement on each telecommunication service, as well as it lets to quantify risks related to the requested parameters of communications system which are not reached.

Telematic subsystem performance indicators – see e.g. [2] or [4] - are structured as follows:

***Availability*** – after service initiation data is available within defined time interval on certain probability level,
***Reliability*** – defined level of service accessibility in appointed time interval on certain probability level,
***Accuracy*** – maximal measuring error is less than defined limit on certain probability level,
***Continuity*** – defined maximal time period the service is not available in defined time interval on certain probability level,
***Integrity*** - if accuracy exceeds defined limit, central system must be informed within defined time interval, on certain probability level,
***Security*** – risk analysis and classification must be done based on detailed knowledge of system environment and potential risks. Fraud can be caused by external attack on measuring method. Relevant solutions can be seen namely in application of additional security tools and usage of redundant alternative applied methods.

Typical telematic sub-system is defined as a chain – GPS/Galileo GNSS (Global Navigation Satellite System) based ODU (Out Door Unit) frequently with user communication unit (e.g. touch screen) included, wireless communication sub-chain with BSs (Base Stations) network, terrestrial communication network and management system interconnect.

## III. Communications Solution

### A. *Telematic sub-system requirements on communications solution*

Airport is strictly, but precisely and transparently regulated area and CaMNA telematic sub-system performance indicators are displayed in Tab. 1.

Required mobility of the communication solution represents one of the crucial properties namely in context of specific demand on availability and security of the communication solution.

TABLE 1
CAMNA TELEMATICS PERFORMANCE INDICATORS

| Performance indicator | Limit value | Probability level | Time interval |
|---|---|---|---|
| Accuracy | 7.5m | 99% | - |
| Availability | 30s | 99% | after unit init. |
| Reliability | 36s | 99% | 3,600s |
| Continuity | 5s | 99% | 180s |
| Integrity | 5s | 99% | - |

Required data transmission capacity represents another critical system parameter. In TCP/IP communication structure one positional data represent approx. 70 Bytes. If position each of *n* object is identified by GNSS method and *m* additional object are localized by A-SMGCS both with frequency *f* than needed transfer capacity for localization data flow between server and clients is

$$tci = pd.n.f.(n+m).8 \text{ [b/s]}. \quad (1)$$

In case e.g. $n = 100$, $m = 100$ and $f = 1s^{-1}$ than $tci = 11.2Mb/s$. Required transferred capacity for localization data in opposite direction, i.e. from client to server is

$$tcc = pd.n.f.8 \text{ [b/s]}. \quad (2)$$

If broadcast regime instead of the individual communication between server and clients is applied, the data transfer

$$tcb = pd.f.(n+m).8 \text{ [b/s]}. \quad (3)$$

Any other individual supervisory server to clients data flows are above that value. Data flow in broadcast regime from server to clients

$$tcb = tci/n \text{ [b/s]}. \quad (4)$$

plus individual managerial data flow between server and clients.
In case broadcasting regime of data distribution is not for any reason applicable (e.g. for limited security reason), there is possible principal potential reduction of the transmitted data volume, if positional data are specifically transmitted to each moving object with individual variable frequency. Distance between objects represents simple but effective criteria for such data flow control.

Transparent interoperability of generally accepted IP protocol is paid by need of wide range of techniques and tools, which must be carefully installed and managed to obtain requested service quality. Telematic real-time applications frequently strictly require precise specification, control and continuous monitoring of the communications services parameters.

Physical layer (L1) has been essentially improving its quality parameters. Due to this fact link layer (L2) BER (Bit Error Rate) is today reaching level of $10^{-9}$ in case of carrier grade wireless systems and $10^{-12}$ for fiber networks. L1 has got so minor influence on the communication system BER. However, due to packet/frame information structure L3 and L2 nodes performance is critical for the whole communications systems system parameters.
Following communications performance indicators quantify service quality:

- *Availability,*
  - *Service Activation Time* (SAT) - defined as time needed for activation/modification of the network archived on certain probability level,
  - *Mean Time to Restore* (MTTR) - defined as time service is restored from unexpected inoperable stage on certain probability level,

  - *Mean Time Between Failure* (MTBF) - defined as time between two unexpected inoperable stages on certain probability level and
  - *VC availability* - percentage of correctly provided service in appointed time interval on certain probability level.
- *Delay* is an accumulative parameter. It is defined as time delay the frames are delivered within a defined time period on a certain probability level. This parameter is effected by *(i) interfaces rates, (ii) frame size, and (iii) load / congestion of all in line active nodes (switches).*
- *Packet/Frames Loss* - percentage of undelivered packets/frames within defined time period on certain probability level.
- *Security* - Risk Analysis (RA) and classification must be done based on detailed knowledge of the system environment and potential risks. Risk of information integrity can be caused by attack on any part of the information transfer chain. Relevant solutions can be seen namely in additional security tools – like on L2 authentication, coding and on application layer - authentication, coding and tunneling.

### B. Communications design methodology

Performance indicators described for communications applications must be transformed into telematic performance indicators structure, and vice versa. Such transformation allows system synthesis. Final *additive impact* of the vector of communications performance indicators $\overrightarrow{tci}$ on the vector of telematic performance indicators $\overrightarrow{\Delta tmi}$ can be expressed by Eq. 5, however, only under condition that probability levels of all indicators are set on the same level and performance all indicators are expressed exclusively by time value. We can experes that

$$\overrightarrow{\Delta tmi} = TM \cdot \overrightarrow{tci}, \tag{5}$$

where *TM* is transformation matrix. Identification of the *TM* represents iterative process and it can be handled in four iterative steps. Identification process starts with matrix in as general as possible structure - $TM_0$. Transformation matrix $TM_0$ takes in account all potential relations between communications and the telematic indicators. Matrix construction is dependent on the detailed communication solution and its integration into telematic system. Probability of each phenomena appearance in context of other processes is not deeply evaluated in period the $TM_0$ identification.

In case of CaMNA final communications solution vector $\overrightarrow{\Delta tmi}$ consists of

- *Accuracy* $\Delta p_i$,
- *Availability* $\Delta t_{ds,i}$,
- *Reliability* $\Delta t_{tma,i}$,
- *Continuity* $\Delta t_i$,
- *Integrity* $\Delta t_{tsna,i}$.

and vector $\overrightarrow{tci}$ of

- *time to upload* $d_{u,i}$,
- *time to download* $d_{d,i}$,
- *handover within the same media* $rc_{hs,m,i}$,
- *handover within different (CALM) media* $rc_{hd,m,i}$,
- *feedback parameters settings period* $rc_{r,m,i}$,
- *MTTR of the terrestrial network service* $rc_{r,f,i}$,
- *MTTR of the access mobile service* $rc_{rp,m,i}$,
- *time period fix service is not available (self-healing not available or not successful)* $t_{na,f,i}$,
- *time period mobile service is not available (self-healing process not successful)* $t_{na,m,i}$,
- *time to accept OBU into relevant cell* $t_{oi,i}$.

General impact of listed set of communications performance indicators on above defined set of telematic performance indicators is described by Eq. 6 – 10:

$$\Delta p_i = v_i * \begin{pmatrix} d_{u,i} + rc_{hs,m,i} + rc_{hd,m,i} + rc_{rp,m,i} + \\ + rc_{r,f,i} + rc_{r,m,i} + d_{d,i} + t_{na,m,i} + t_{na,f,i} \end{pmatrix}, \tag{6}$$

$$\begin{aligned} \Delta t_{ds,i} = {} & t_{oi,i} + d_{d,i} + rc_{hs,m,i} + rc_{hd,m,i} + rc_{rp,m,i} + \\ & + rc_{r,f,i} + rc_{r,m,i} + d_{u,i} + t_{na,f,i} + t_{na,m,i}, \end{aligned} \tag{7}$$

$$\begin{aligned} \Delta t_{tma,i} = {} & t_{na,f,i} + t_{na,m,i} + ns_{hsm,i} * rc_{hs,m,i} + \\ & + ns_{hdm,i} * rc_{hd,m,i} + ns_{rpm,i} * rc_{rp,m,i} + \\ & + ns_{sf,i} * rc_{r,f,i} + ns_{rm,i} * rc_{r,m,i}, \end{aligned} \tag{8}$$

$$\begin{aligned} \Delta t_i = {} & rc_{hs,m,i} + rc_{hd,m,i} + rc_{rp,m,i} + \\ & + rc_{r,f,i} + rc_{r,m,i} + t_{na,m,i}, \end{aligned} \tag{9}$$

$$\begin{aligned} \Delta t_{tsna,i} = {} & rc_{hs,m,i} + rc_{hd,m,i} + rc_{rp,m,i} + \\ & + rc_{r,f,i} + rc_{r,m,i} + d_{d,i} + t_{na,f,i} + t_{na,m,i} \end{aligned} \tag{10}$$

and transformation matrix structure *TM* of Eq. 5 in its initial stage before processing, i.e. $TM_0$, is described by Eq. 11:

$$TM_0 = \begin{bmatrix} k_{p,u,i} \cdot v_i, & k_{p,d,i} \cdot v_i, & k_{p,hs,m,i} \cdot v_i, & k_{p,hd,m,i} \cdot v_i, & k_{p,rp,m,i} \cdot v_i, & k_{p,r,f,i} \cdot v_i, & k_{p,r,m,i} \cdot v_i, & k_{p,na,f,i} \cdot v_i & k_{p,na,m,i} \cdot v_i & 0 \\ k_{d,u,i}, & k_{d,d,i}, & k_{d,hs,m,i}, & k_{d,hd,m,i}, & k_{d,rp,m,i}, & k_{d,r,f,i}, & k_{d,r,m,i}, & k_{d,na,f,i}, & k_{d,na,m,i}, & k_{d,oi,i} \\ k_{s,u,i}, & k_{s,d,i}, & k_{s,hs,m,i} \cdot ns_{hs,m,i}, & k_{s,hd,m,i} \cdot ns_{hd,m,i}, & k_{s,rp,m,i} \cdot ns_{rp,m,i}, & k_{s,r,f,i}, & k_{s,r,m,i}, & k_{s,na,f,i}, & k_{s,na,m,i}, & 0 \\ 0 & 0 & k_{k,hs,m,i}, & k_{k,hd,m,i}, & k_{k,rp,m,i}, & k_{k,r,f,i}, & k_{k,r,m,i}, & k_{k,na,f,i}, & k_{k,na,m,i}, & 0 \\ k_{i,u,i}, & k_{i,d,i}, & k_{i,hs,m,i}, & k_{i,hd,m,i}, & k_{i,rp,m,i}, & k_{i,r,f,i}, & k_{i,r,m,i}, & k_{i,na,f,i}, & k_{i,na,m,i}, & 0 \end{bmatrix}, \tag{11}$$

where $v_i$ is vehicle velocity $ns_{hs/hd/rp,m,i}$ represents number of appropriate phenomenon appearance (on agreed probability level) in time interval $\langle 0,T\rangle$. Value of each parameter $k_{xx,yy,m/f/-,i}$ is identified as either „0“ or „1“ in accordance to iterative process described below.

Each TM element is consequently in several steps evaluated based on the detailed analysis of the particular telematic and communications configuration and its appearance probability in context of the whole system performance. This approach represents subsequent iterative process managed with goal to reach stage where all minor indicators (relations) are eliminated and the major indicators are identified under condition that relevant telematic performance indicators are kept within given tolerance range. Four steps of the process leading to the final stage are:

*[I]* *primary elimination* of communication parameter based on implementation of relevant communication solution or setting (e.g. guaranteed homogenous radio signal coverage in defined area – e.g. airport runway),

*[II]* *primary disregarding* of communications indicator, if its weight can be justified as insignificant,

*[III]* *identification* and exclusion of indicators with significantly *lower* level of their *appearance probability* (e.g. in case of coincidence of processes with unified probability level of their individual occurrence - the dominant one is appointed),

*[IV]* *concluding iterative identification of dominant indicators* as the last step of the iterative process of the *TM* identification is based on the virtual communication solution parameters settings. Potential solution modification can, however, lead identification process back to step *[I]*.

Presented method is designed as generally as it is possible with clear aim to allow this method to be applied in the widest range of telematic application. This method can be also successfully applied for CALM criteria identification. However, correct results of described iterative process are obtained only if detailed knowledge of studied system solution is available as well as all causal associations are identified and they are correctly taken in account.

### *C. Communications solution for ITS*

Most of ITS serve moving objects, so that mostly appropriate wireless access solution is needed. There are typically applied DTMF (Dual-tone multi-Frequency), CSD (Circuit Switched Data), HSCSD (High Speed CSD), SMS (Short Message Service), USSD (Unstructured Supplementary Service Data), UUS (User to User Signaling) served via widely spread GSM (Global System for Mobile Communications networks). GSM mobile providers, however, preferably offer GPRS (General Packet Radio Service) – see [7] and EDGE (Enhanced Data rates for GSM Evolution) data services. In area growing UMTS (Universal Mobile Tele-communications System) data services, are becoming available, as well. GSM and UMTS data services performance indicators are noticeably limited to let apply such wireless access services particularly for specialized “sensitive” ITS applications.

Carrier grade mobile wireless communications solutions Mobile WiMax, i.e. communications system based on IEEE Std. 802.16d and Amendment 802.16e is promising system, which will be able to meet even very demanding wireless access performance indicators requirements see [9] and [10]. However, Mobile WiMax has not been for the meantime available in certified version. In short term view it is hardly expectable that Mobile WiMax becomes publicly available service. WiMax services will be in short/term view available only in dedicated installations. Nevertheless, expected reasonable value/cost ratio, gives to Mobile WiMax in mid-term view potential to be successful in competition with UMTS. This situation can happen not only in rural areas (see e.g. activities of companies like Intel, Nokia, Samsung and Motorola in IEEE 802.16 working group).

General trend to apply IP communications in highly demanding solutions is leading to availability of the effective tools both on L2 or L3 of the TCP/IP model - see [6] and [8]. Even though MPLS is understood as the most complex IP based L3 solution, L3/L2 switching (IEEE 802.3 and 802.1d and 802.1q applied on L2) is archiving remarkable position in ITS, namely due to notably faster network convergence. ITS solution needs usually to combine both mobile access and terrestrial backbone services and theirs simple transparent interoperability on L2 represents another critical issue. L3/L2 switching based on 802.1q/802.3 so achieved good potential to reach relevant parameters for most of ITS applications with remarkable value/price ratio.

### *D. CaMNA communications design*

Applied transformation method identified telematic performance indicator “accuracy” as the dominant indicator. This dominance is caused by real-time character of the CAMNA application installed in the specific conditions of airport area. Requested level of accuracy (see Table 1) must be reached for every object moving with speed up to 100km/hour. In this case within 200ms vehicle moves 5.4 m. There so remains demand on 2m accuracy of the GNSS sensor (see Table 1). This accuracy will be reachable by selection of Galileo services. For present-days tests based on the GPS sensors requested accuracy can be reached only if the differential GPS method is applied. All the other limits defined in Table 1 are met if total reached delay is below critical 200ms.

Delay limit of 200ms represent critical issue for the communications chain and it must be carefully kept namely in the airport critical areas (i.e. Class 1 areas like runways). This parameter considerably determines the communications chain performance indicators with consequences of elimination of most of available wireless communications solutions.

Mobile WiMax (IEEE Std. 802.16e) was identified as the only possible alternative of the wireless access solution for critical areas of the airport. All the other available access systems like DTMF, CSD, HSCSD were identified as inappropriate. Also GPRS and EDGE as well as in area growing UMTS data services served by public GSM operators do not meet system requirements for the critical airport areas (200ms total max. delay).

Even though Mobile WiMax was selected as the core mobile access system for the airport critical areas, whole airport area coverage with this technology is hardly reachable. Some of alternative access solutions for Mobile WiMax difficult areas can be applied (like EDGE/GPRS/UMTS or even WiFi), if system parameters of these technologies meet these areas limited system parameters requirements (Class 2 and lower) . For such case CALM (ISO TC204, WG16.1) access management with implementation of the second generation handover process has been identified as appropriate tool for the final system [11].

L3/L2 switching (IEEE 802.3 and 802.1d,q on L2) in combination with HW redundancy switching system "HYPER ring" (available proprietary solution produced by company Hirschman) was selected due to reachable values of the performance indicator MTTR (incl. convergence procedure below 100ms for 1Gb/s Ethernet ring) as well as due to transparent possibility to effectively interconnect fix and mobile solutions.

Introduces mobile and fix communication chain so offers relevant communications system parameters in context of required by project performance indicators.

## IV. Results of CaMNA pilot project

The main goal of the pilot project communications system tests was to identify parameters of the Wimax wireless access solution integrated into CaMNA system. Because of any certified Mobile WiMax systems based on IEEE Std. 802.16e was not commercially available, the only identified possibility was to process test with implemented communication solution based on IEEE Std. 802.16d. This applied standard, however, offers the only limited achievable dynamic parameters.

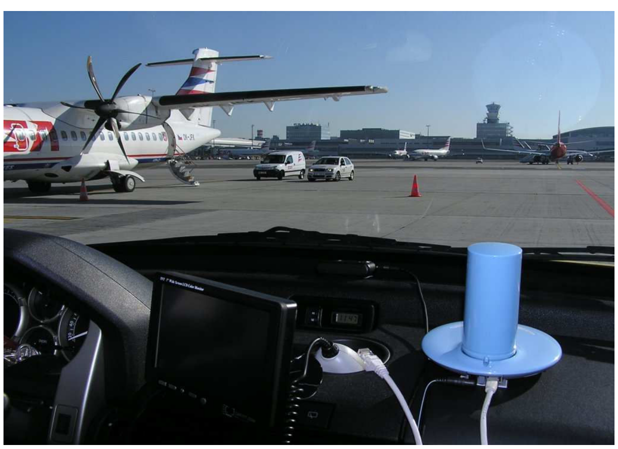

Fig. 2. OBU with display unit and WiMax in-door antenna installed in vehicle - exclusively for pilot test.

The most busy part of the airport area was selected for pilot tests. This area included runways with majority of traffic, as well. Selected area was covered by one WiMax cell. Limits in dynamic processes given namely by applied smart antenna (see Fig. 2) were taken in account in the pilot test design.

Fig. 3. Dispatchers CaMNA display unit (central) installed within active displays of airport management center - for pilot tests, only.

Fig. 2 introduces OBU installation the vehicle cabin for pilot tests purposes. Additional antenna unit in vehicle cabin is installed only for communications system tests and security purposes. Fig. 3 presents CaMNA dispatcher display typical view (central display unit) installed within already functional managerial systems display units. Fig. 4 shows typical screen of in car installed OBU where is displayed also additional information sent either by dispatchers or by central computer control system.

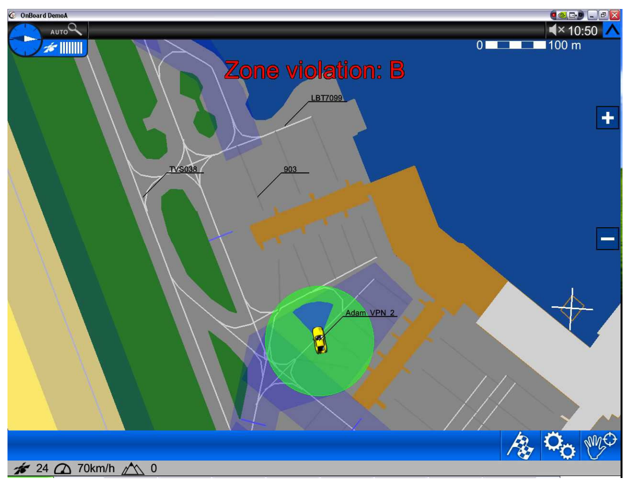


Fig. 4. Typical OBU screen view displayed in moveable object, i.e. all equipped service vehicles (pilot test version)

Due to limits given by applied technology most of tests were processed in the static regime. Obtained communications system static parameters are displayed in Table 2.

Spectra of Round Trip Delay (RTD) in ms identified in static regime are practically identical for both LOS and NLOS configuration - see Fig. 5. Occasional packet re-transmission is most probably caused by interaction between WiMax radio and airport landing radar systems. Resultant probability of those phenomena is, however, deeply below required limit, i.e. 1%.

TABLE 2
PRINCIPLE PARAMETERS OF THE WIMAX ACCESS

| Site | Visibility | LPR | ART [ms] | SNR [db] |
|---|---|---|---|---|
| 1 | LOS | 0,0009 | 45.6 | 33 |
| 2 | LOS | 0 | 47.1 | 32 |
| 3 | NLOS | 0,057 | 44.6 | -26 |
| 4 | NLOS | 0,0647 | 44.8 | -27 |

where LPR is “Lost Packets Ratio”, ART “Average Round Trip” and SNR “Signal to Noise Ratio”.

Test with moving vehicles were operated only in the “open area”, where switching between LOS and NLOS regime frequently accompanied with new setting of the smart antenna is not expectable. Dynamic parameters of applied smart antenna were dominant, so that studied dynamic processes parameters would be overlapped by the antenna ones.

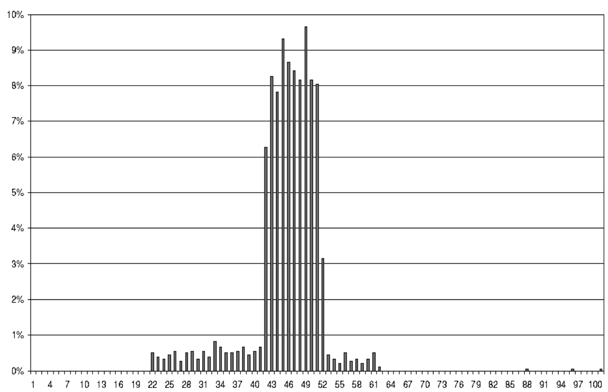

Fig. 5. Packets Round Trip Delay (RTD) spectra of Line of Site (LOS) regime on Site 2 displayed in Table 2.

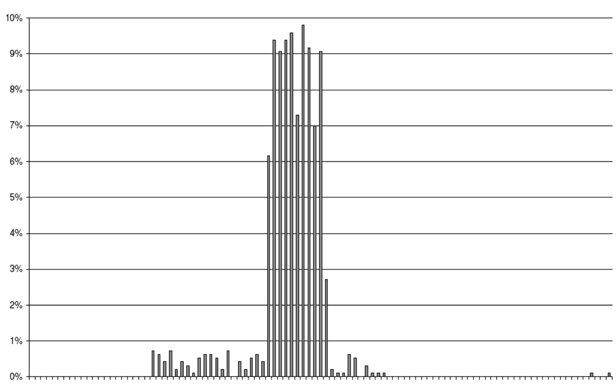

Fig. 6. Packets Round Trip Delay (RTD) spectra of Non Line of Site (NLOS) regime on Site 3 displayed in Table 2.

Dynamic parameters of the WiMax internal processes extended with handover times will be tested immediately certified Mobile Wimax, (system based on Appendinx IEEE 802.16e Std.) is available. Motion tolerance up to required 120km/hour was identified (in “open” area) on required probability level even with IEEE 80.16d based system.

Presented results confirmed that critical dominant performance indicator “round trip delay” meets calculated requirements, of course under accepted tests restrictions given by applied available wireless technology. Reached results leave appropriate space (more than 100ms on probability level of 99%) to the terrestrial solution. It is reachable requirement on terrestrial backbone network based on HW switched Ethernet rings, like it is e.g. in case of HYPER ring produced by company Hirschman installed at Prague airport.

Solution covering the whole airport area will, evidently require cellular architecture, i.e. Mobile Wimax (IEEE Std. 802.16e based certified system) combined with alternative access solutions, if it is appropriate and effective. Such combination calls due to economical reason for final solution based on application of the second generation of handover in the cellular structure, i.e. management system based on the CALM family of standards.

## V. CONCLUSION

The main goal of the CaMNA project is to introduce telematic system, which based on positional identification of all vehicles on the airport area (i.e. not only vehicles, but also aircrafts) improves safety and efficiency of existing airport over-ground traffic management. This goal is reached by means of all service vehicles real-time navigation, which must be fully functional under any condition, i.e. even in case of extremely low visibility.

GPRS, EDGE, DTMF, CSD, HSCSD, SMS, USSD, UUS served via widely spread GSM networks are usually applied in ITS systems. Additionally are coming services of in area growing UMTS. GSM and UMTS services performance indicators are, however, noticeably limited to let employ such wireless access services for “sensitive top” ITS applications.

Carrier grade Mobile WiMax solution promises to meet top wireless access performance indicators requirements (e.g. better than 100ms delay in case of airport Class 1 services). Due to fact, that Mobile WiMax has not been nowadays available in certified version, there is no chance in short-term view that Mobile WiMax becomes widely available service. The only dedicated WiMax installation will be available in short term view. Nevertheless, in mid-term view remarkable advantages of this technology (cost, convergence, CoS management) grant good chance to Mobile WiMax services to become important competitor to UMTS and GSM ones, moreover with parameters acceptable for wide range of telematic applications.

Parameters of the communications solution applied in most of ITS project (CaMNA is not exception) are indirectly quantified by the telematic performance indicators. Method which lets telematic sub-system designer to select and configure appropriate communication solution in context of the telematic subsystem performance indicators was presented.

Introduced method based on identification of the transformation matrix *TM* between communications and telematic performance indicators vectors, was applied for CaMNA project communication solution specification. In this specific case telematic performance indicator "accuracy" was identified as the dominant telematic indicator. This fact is caused mainly by the real-time character of the application. Required accuracy must be reached for every moving object under any specific condition (incl. e.g. network element failure), so that communication delay limit represents the critical communications performance indicator. Communications delay limit of 200ms was calculated, under condition that 2m accuracy of the GNSS sensor is reached. This sensor accuracy will be achievable by selected Galileo services and for present-days tests based on the GPS sensors requested accuracy is available with differential GPS configuration. Calculated performance indicators limits are reached if the overall delay of the communications chain is kept below critical 200ms on probability level of 99%.

This limit represents the critical issue for the communications solution and it significantly determines selection and setup of the communications chain. Crucial delay limit must be carefully respected namely in the airport critical areas - Class 1, i.e. namely runways areas. In these areas e.g. handover process probability would be maximally reduced by signal coverage topology.

Applied method curiously disqualified communications services like MPLS backbone terrestrial networking or GPRS/EDGE wireless access as potential core technologies due to fact, that these communications systems cannot guarantee critical areas airport performance indicators limits. Combination of the Mobile WiMax (IEEE Std. 802.16e) access and terrestrial L3/L2 switching solution combined with HW redundancy switching system was selected. "HYPER ring" system has been already applied for other airport area control system purposes. Prime WiMax access solution would be combined with alternative access technologies, where it is quantified as a relevant approach (Class 2 and 3, i.e. less demanding areas like parking or depot areas etc.). Switching between access services must be carefully controlled by management system with CALM standards adopted.

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