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MOBILE TRACK AND TRACE INFRASTRUCTURE (FOR HUMANITARIAN AID AND DISASTER MISSIONS)

Radek Holý[1], Petr Bílek[1], Lukáš Vopařil[2]
[1]Computing and Information Centre, [2]Faculty of Transportation Sciences, Czech Technical University in Prague, Czech Republic

Abstract- This article focuses on the development of system and technology with constant monitoring, to secure supply of goods and materials for humanitarian aid, including natural disasters or military missions, using a global navigation satellite system (GNSS). The aim is to prevent occurrence of a gap between the immediate aid and the recovery phase, which would eventually slow down the normalization process, as often happens, based on the UN (United Nations) statistics on the early recovery funding. At the same time, the focus is on preventing omission of acute risks in the long-term development strategies initiated by the central governments, while the risks often impact the marginalized groups of population. These risks will be minimized upon implementation of the GNSS system, when the complete logistics, i.e. transportation of the shipment from point A to B, will be identified by Radio-frequency identification (RFID) and monitored along the way. This system secures synergy of immediate aid and long-term sustainability, while prevents inefficient use of financial resources and the entire organizational structure.

Keywords- RFID; GNSS; Localization; Humanitarian; Track and tracking

INTRODUCTION

The character of military conflicts and natural disasters marks the late twentieth and early twenty-first century. Places where they were spread all over the world and didn‘t avoid to practically any continent. Although it is always a local problem, they have one thing in common: the need for rapid global aid to those most affected. In such cases, thousands and thousands of civilians are dependent on humanitarian aid, without which their lives are threatened. In the first phase, large quantities of food, water and supplies, rescue teams and their equipment, medicines, medical supplies and medical personnel are moved to the affected areas. From the perspective of security, there are three areas of concern:

MACHINERY AND EQUIPMENT

Immediate help, which solves a critical situation, is replaced by long-term projects after some time. It is necessary to restore infrastructure and health care, start agriculture industry. In the affected areas are transported expensive devices and equipment, mobile hospitals, sewage and water treatment plants, power stations and generators, sanitation, computer and school equipment, agricultural machinery, etc. Transport of the equipment is complicated and expensive logistic operation. Secure the transport to their destination, and control over the routing is a difficult task. Following local movements, whether intentional or not are in these conditions very complicated and often improvised. Not a few cases where the equipment was lost, stolen or moved and no one is able to declare where they are at any given moment. Often the equipment is considered as a gift not a short-term humanitarian aid. This equipment is missing in places where it is needed the most: In other crisis areas.

INVOLVED PERSONS

This equipment is usually accompanied by excellent staff and humanitarian workers. Journalistic teams travels to the affected areas also. Especially in areas military conflicts, they face a significant risk of assault, forced transfer, kidnapping and other. Options for effective monitoring of the movement of these people are now very small. In case of relocation are the subsequent searches and rescue operations very difficult.

CRITICAL PLACES

In the affected areas, many important objects and places that need to be identified very accurately. The coordinate designation may be in such cases inadequate. In the area can be several identical objects or places serving the same purpose. It can leads to confusion, which can be dangerous. In one object, a few locations, rooms that need to differentiate and accurately identified. This category includes, for example, controlled local water resources, food stores, etc. In addition to these objects, there are places that are for civilians potentially dangerous, and it is important to accurately set their coordinates. This includes for example mine fields, swamps, etc.

The immediate assistance covers the first days to weeks after the disaster and includes the elemental assistance aimed at saving lives (rescue teams, paramedics, medical supplies) and initial support for survivors (food, water, emergency shelters and generators). The GNSS system together with RFID play essential role in collecting data on the affected areas and immediate needs, and passes them to the Red Cross and rescue teams.

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TRACK & TRACKING SYSTEM

There are different ways how to locate an object, place or person. In our case mainly for humanitarian aid. For instance, a GNNS uses a receiver that picks up emission signals sent by a plurality of satellites and a trilateration process to determine a position. Yet, one of the disadvantages of GNSS systems is that they cannot provide indoor tracking. Similarly, cellular telephone networks can identify the approximate position of a mobile device by detecting which cell is being used by the device. The accuracy of this technology is still inadequate (around 200 metres) and depends largely on the size of the cell. Moreover, there are several technologies that provide indoor tracking, such as, the technologies based on active (RTLS) radio-frequency identification (RFID). RFID only provides short-distance radio signal transmission to RFID readers. Once picked up by a reader, the signals are relayed to a computer to be processed. RFID tags can be active or passive.

Active tags have their own energy source and send their identification and position, which are necessary data to ensure real-time tracking. Passive tags have no battery and are activated by using the power generated by the magnetic field of the radio-waves of the reading sensor. Thus, they are only activated when they are near a reading sensor, which reduces their scope. Consequently this becomes a constraint on real-time tracking situations.

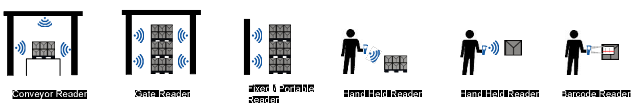

Fig. 1 Basic types of RFID reading

We assume that it would be possible to use a combination of these technologies to create an efficient tracking system. This system satisfies all of the important characteristics, such as real-time tracking as well as indoor and outdoor tracking. In following paragraphs is generally described proposal of new generation tracking system, which include general idea and scheme. System is designed in three versions according to complexity and usability.

Basic GNSS and RFID Tracking system–Idea is based on the integration of static RFID components and GNSS Tracking components available on the market. The main idea of the approach is to use the RFID as an important enabler to improve tracking and tracing in supply chain management in combination with GNSS modules providing on-line location to the tracing system. This infrastructure enables user's full indoor and outdoor tracking of goods and persons for e.g. humanitarian aid missions where the optimal management of assets is one of the key factors of success. Main building blocks are provided on figure 2.

Advance GNSS and RFID Tracking system is an extension of the basic tracking system by the integration of extended tracking device combining GNSS Tracking functionality, RFID tag, and internet connectivity (GPRS, satellite ...). Main building blocks are provided on the figure 3.

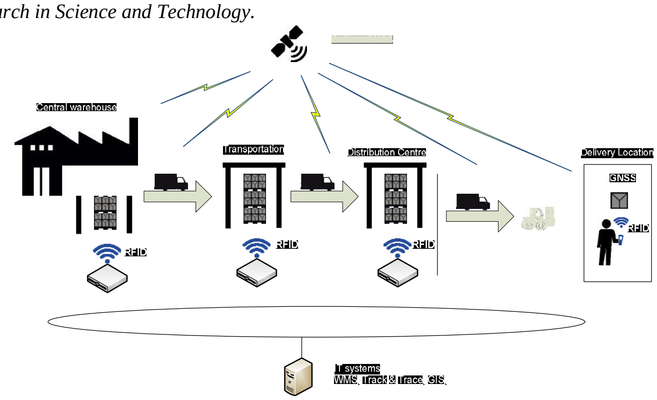

Fig.2 Basic track and trace system using GNSS and RFID

The system should be usable by end-users in defined track and trace use cases extending the basic system scope and it will also be a basic building block for further development. The advanced tracking unit extends usability of the tracking system by additional use cases (e.g. container tracking, valuable asset on-line tracking in the field...) that will be identified, analyzed and implemented.

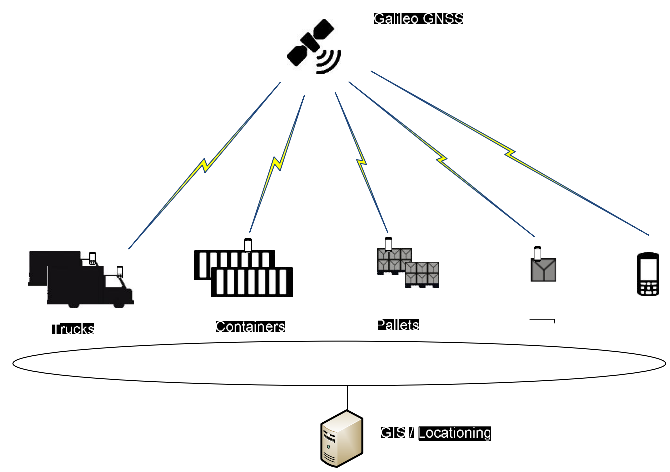

Fig.3Advanced track and trace system using the enhanced GNSS Tracking device

Next Generation Tag - In the last phase of the proposal, the system should consist with the Next Generation Tag (NGTag). Research and implementation of next generation (NG) tracking device integrating the advanced tracking device (GNSS, RFID, GPRS, WiFi, BT ...) with additional sensors and internal memory unit that allows continual tracking not only of the location but also conditions of the tracked asset (e.g. temperature, shock, inclination, humidity...). This enables extensive monitoring of end-to-end journey of valuable assets that require special treatment (electric devices, food...). As the NG tracking device is an innovative use cases extending the overall system scope. Main building blocks are provided on figure 4.

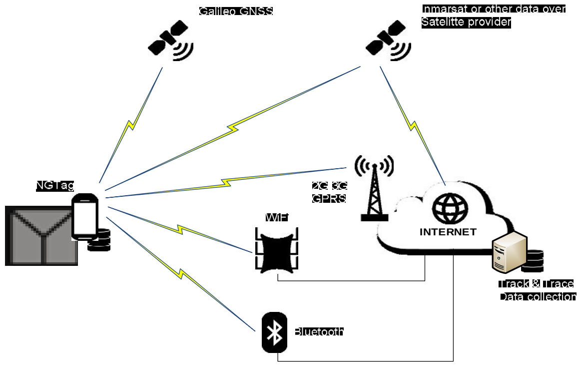

Fig.4 Next generation tag in the track and trace ecosystem

The software solution consists of following components:

- Tracking system (TS)
  - Processing and storage of tracking events and master data
  - Public API for 3rd party WMS and GIS integration
- Warehouse management system (WMS)
  - Lightweight implementation of WMS as an out-of-the-box part of the solution
  - GUI available for desktop and mobile devices
  - Support of basic use cases for arrival and dispatch procedures, control and monitoring, follow-up, transport
- Geographical Information System (GIS)
  - Lightweight implementation of GIS using open-source resources as an out-of-the-box part of the solution
  - GUI available for desktop and mobile devices
  - Supports storage, visualization functions, management of tracking and other geographical data, statistical analysis and advanced queries

Main building blocks are provided on figure 5.

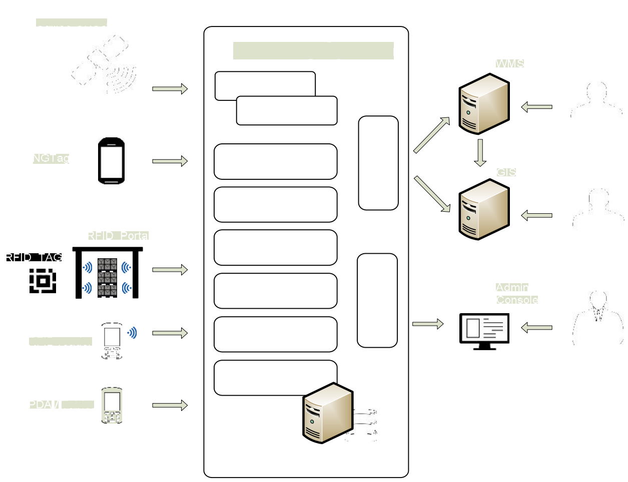

Fig.5Components of software solution

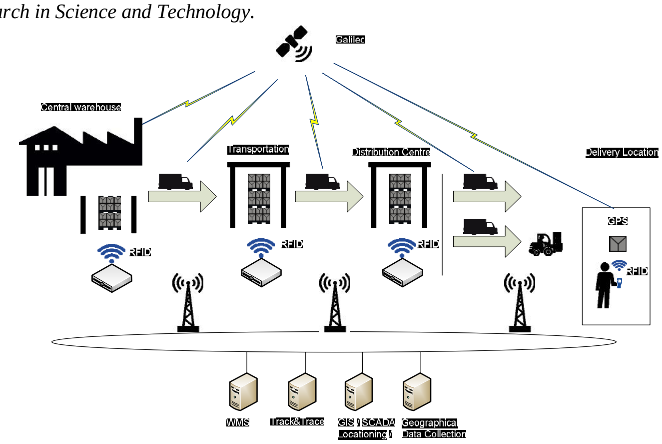

Fig. 6 Complete track and trace system using GNSS and RFID

PROCESS OF DEVELOPMENT

This section describes general procedures how to develop mentioned system.

Analysis, specification and design

Specification documents will make use of textual descriptions, use case diagrams and other illustrations to analyze and describe:

- Overview of the extended system architecture (HW and SW)
- Definition of user interfaces
- Business services and functional flows in detail
- Data model as entity relation model and table structure
- References to the descriptions of interfaces to be integrated including the definition of the technical integration.
- Final definition of the HW and SW components used as base of the system
- System requirements and middleware infrastructure definition

HW INTEGRATION

Bringing together the HW component subsystems into one system and ensuring that the subsystems function together as a system.

The HW components relevant for this phase are:

- RFID tags of different categories including advanced hybrid tags and NG tags
- GNSS receivers with mobile network connection
- RFID readers and gates
- Desktop and mobile devices for management and controlling access
- Network infrastructure

SW IMPLEMENTATION

The SW solution extension should be developed as defined by the specification documentation. The implementation work should be done by an experienced development team guided by a responsible project manager.

The implementation covers the following components:

- Tracking system (TS)
  - Extension of the processing and storage of tracking events and master data
  - Extension of the public API for 3rd party WMS and GIS integration
  - Extension of the system by data structures, business logic and presentation layers to provide full use of the next generation device for tracking and tracing
- Warehouse management system (WMS)
  - Extension of the lightweight implementation of WMS as an out-of-the-box part of the solution
  - Extended support of basic use cases for arrival and dispatch procedures, control and monitoring, follow-up, transport
  - GUI available for desktop and tablet devices
- Geographical Information System (GIS)
  - Extension of the lightweight implementation of GIS using open-source resources as an out-of-the-box part of the solution
  - Supports storage, visualization functions and management of tracking and other geographical data
  - Additionally supports statistical analysis and advanced queries over extended data structures provided by NG devices
  - GUI available for desktop and tablet devices

INTEGRATION TESTING

Linking together all HW systems and software applications physically and functionally to act as a coordinated whole. Quality assurance is driven as continuous process and concomitant to all other activities. Typical tasks of the quality assurance during lifetime are:

- Verification of the completeness, accuracy and feasibility of specifications documented
- Compilation and harmonization of test cases on the basis of accepted specifications
- Project internal quality audits and developer test supervision
- Module- and integration tests of the software and hardware components including an extensive regression test with systematic positive, negative and borderline tests
- Integration of 3rd party and committee resources into the integration tests of the solution

The test phase should be prepared during the implementation phase. In parallel to the implementation activities, an experienced quality management should prepare and work out a testing specification describing:

- the testing infrastructure
- the testing organization
- the testing procedure
- the test cases to be performed

This testing specification serves as reference document for the testing phase following the implementation phase.

PILOT AND ACCEPTANCE TESTING

As a part of this task, a pilot environment should be defined and setup that will allow full acceptance testing of the system. This environment includes:

- Relevant HW components
- Network infrastructure
- Installed software
- Physical model of the domain environment that allows execution of all use cases

The target of this phase should determine if the requirements of a specification are fully met. Acceptance suite of tests should be demonstrated on the completed system. Each individual test case exercises a particular operating condition of the user's environment or feature of the system, and will result in a pass or fail outcome. The test environment is usually designed to be identical, or as close as possible, to the anticipated environment of the final system usage (e.g. humanitarian mission conditions), including extremes of such. Solution should be considered as accepted if there are no blocking findings identified.

This task should result in delivery of the accepted system consisting of:

- Installation media of SW modules including installation and operation documentation
- List of compatible HW modules including a description of their integration into the solution environment
- SW solution operated as a service in the central environment available for setup of a real user of the system
- Methodology specification describing processes of effective system usage in real life

EXPECTED IMPACTS

Lastly, we focused on evaluating the potential impacts of such a real-time tracking system in humanitarian mission. We indicated that the usefulness of such a system was mainly to rapidly provide vital information to support decision-making in emergency situations. We mentioned that the ability to immediately know the humanitarian equipment position in an emergency, would contribute to improve the response times. In fact, they underscored that the broader the area to cover and the greater number of people to be tracked, the more usefulthe system would be. Finally, the govermentmentioned their interest in using the data provided by the system to analyse the patterns and thus to optimize the efficiency, and thus, optimize the use of human resources and improve the global safety of the area.

EFFICIENCY INCREASE

It helps to effectively track equipment as they arrive, be able to easily locate objects when identified for maintenance and subsequent return from maintenance for storage or redeployment to the threatened area.

Inventory accuracy will be decreased the huge costs of assets.

Rescuers, volunteers, employees can use time more efficiently – long detail will reduce time in finding equipment and places.
There is full asset visibility:

- arrival, departure, maintenance in/out
- all stock, in a verifiable record

The improvement in inventory accuracy and accountability will be significant with a large reduction in manual input transactions and reduced time for searches. This system can provide an example of remarkable use of GNSS and RFID technology - providing efficiencies of operations to cut off costs.

PREVENTION

Impact is prevention occurrence of a gap between the immediate aid and the recovery phase, which would eventually slow down the normalization process, as happens often, based on the UN statistics on the early recovery funding. At the same time, the focus is on preventing omission of acute risks in the long-term development strategies initiated by the central governments, while the risks often affect the marginalized groups of population. These risks will be minimized upon implementation of the GNSS system, when the complete logistics, i.e. transportation of the shipment from point A to B, will be identified by RFID and monitored along the way. This system secures synergy of immediate aid and long-term sustainability, while prevents inefficient use of financial resources and the entire organizational structure.

GENERAL BENEFITS AND ADVANTAGES:

- Integration GNSS with RFID technologies allows end-to-end indoor and outdoor tracing of general assets.
- To bring GNSS use cases to NGO (non-governmental) sector with high potential of shift to commercial use.
- To deliver production quality solution directly usable by potential users during and after the system lifetime.
- Extending currently available technologies by research of NGTag bringing GNSS and RFID technologies to new use cases.
- Combines research in the public research and educational institution with contribution of significant companies from the commercial sector
- System opened for international as well as local humanitarian, nongovernmental, non-profit organizations such as International Red Cross and Red Crescent, Medicines Sans Frontiers, UNICEF etc.
- Open platform for other global identification standards.
- Possibility of extension of other navigation systems.
- Ready to collaboration with other GNSS Applications and Solutions

CONCLUSION

This system should be used by local or global humanitarian organizations like Red Cross, Medicines Sans Frontiers, First Aid Africa, Caritas, and United Nations Office for the Coordination of Humanitarian Affairs and many others. They can either use provided applications or integrate their information systems to get global tracking and positioning functionality.

Disasters like tsunami in South East Asia 2003 or Japan 2011, earthquake Haiti 2010 showed us total infrastructure destruction. The GNSS and RFID Tracking would be the most efficient way to track and trace the delivery of humanitarian supplies and of valuable assets on their journey from a warehouse to the final destination.

Mobile Track and Trace Infrastructure for humanitarian aid and disaster missions must be viewed as a living organism. Laboratory applications seems to be functional, but just born individual. It is necessary to respond in time, support the relevant information and eliminate the irrelevant.

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