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THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

Collaborative Navigation

'Challenges before Spatial Data Infrastructure'


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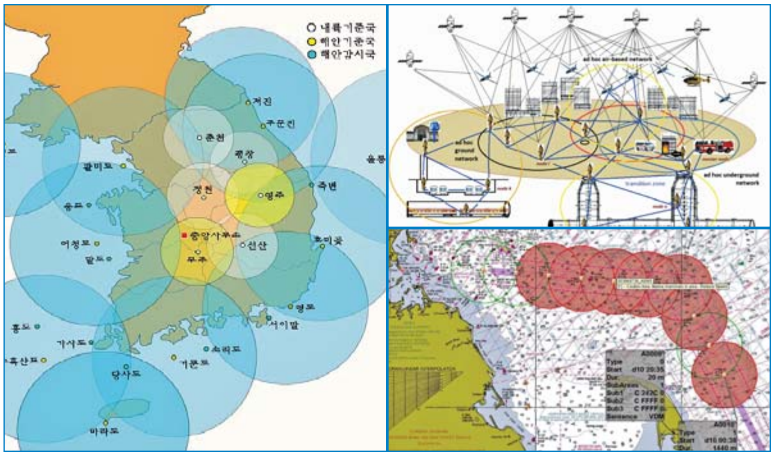

In this issue

Coordinates Volume 10, Issue 07, July 2014

Articles

Columns

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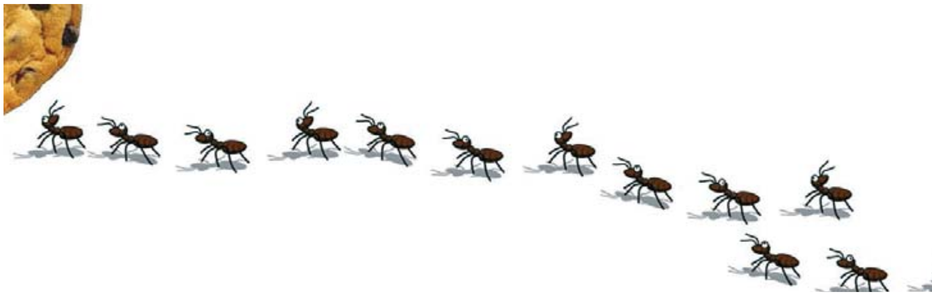

INSPIRE Inspires

Sincere initiatives to success stories

Various national endeavors to regional ambitions

Sustained efforts to impatience for success

Data, metadata, architecture to complex technicalities

Growing complexities to varied user demands

Investments to return on investments

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In an ambience of positivity and hope, at Aalborg, Demark.

The INSPIRE directive came into force on 15 May 2007

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Will ultimately be judged by the uses

And the users.

Bal Krishna, Editor
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Collaborative Navigation and Guidance in Underground Networks Using RFID

Use of RFID for localization and serving as guidance system is very promising in emergency situations, when going underground is mandatory since roads above are impassable

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Collaborative navigation enables multi-sensory robust navigation, including seamless transition between different types of environments (see e.g. [1, 3]). In this concept several users and platforms (including pedestrians, vehicles and UAV's) are equipped with different type of sensors and they navigate together in different layers above ground [2]. So far the scientific community currently is involved in research activities leaving the underground out of consideration. Both authors expand collaborative navigation on to the underground. They have developed emerging strategies for navigation and guidance of emergency crews and first responders in such settings. Useable underground structures include metro and road tunnels, subways, large sewer canals, long-distance heating tunnels, etc. In this article the concept and the use of the underground layer is introduced. RFID is identified to be the major absolute location technology.

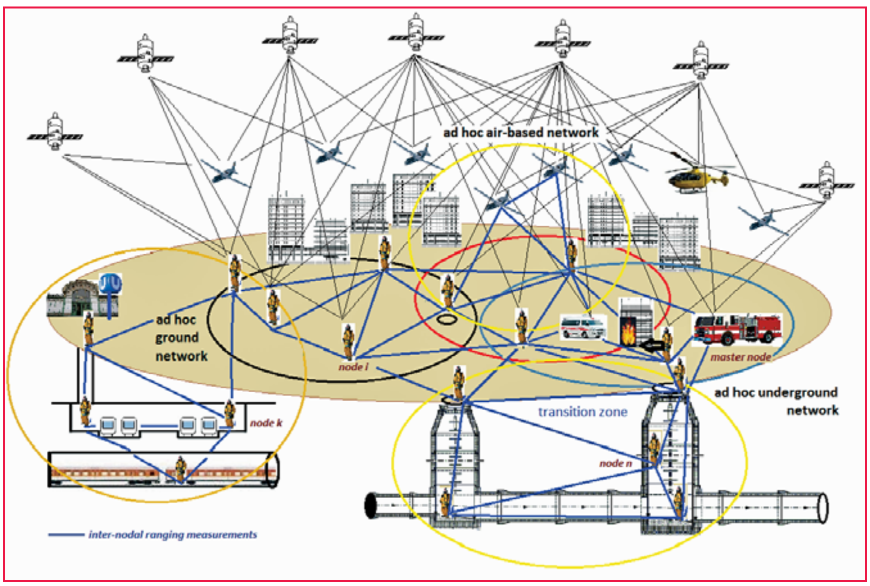

Figure 1: The collaborative navigation concept for emergency crews

Collaborative Navigation Principle

The operation principle of collaborative navigation is that a group of multiple users in the area may be navigating together using useful sensor observations combined together. Apart from GNSS, sensors, such as MEMS-based INS, magnetometer, odometer, digital compass, barometric pressure sensor, or active/passive imaging sensors may be employed, augmented by inter-nodal ranging measurements in order to form a joint position solution [2]. Hence, collaborative positioning can improve the individual navigation outcome in terms of both accuracy and coverage, and may reduce the system's design cost, as equipping all users or sensor platforms with high performance multi-sensor positioning systems is not very cost effective. Figure 1 illustrates the concept of collaborative navigation in a dynamic network environment.

Key components of a collaborative network include the inter-nodal ranging sub-system (each user can be considered as a node of a dynamic network), the optimization of the dynamic network configuration, the time synchronization, the optimum distributed GNSS aperture size for a given number of nodes, the communication sub-system, and the

> Collaborative positioning can improve the individual navigation outcome in terms of both accuracy and coverage, and may reduce the system's design cost, as equipping all users or sensor platforms with high performance multi-sensor positioning systems is not very cost effective

selection of master nodes [1]. Sub-networks of users navigating jointly can be created ad hoc, as indicated by the circles in Figure 1. Some users (nodes) may be also part of different sub-networks as shown for the fire-fighters in this emergency scenario. In a larger network, the selection of a sub-network of nodes is an important issue and information exchange among them must be assured. Conceptually, the sub-networks can consist of nodes of equal hierarchy or may contain a master node that will normally have a better set of sensors and will be collecting measurements from all client nodes to perform the collaborative navigation solution [2]. In an emergency situation the commander of the first responder crew and the fire-fighting vehicle can serve as master nodes. They are equipped with better sensors and should have access to sufficient GNSS signals or other absolute positioning technology.

Applicable Positioning Technologies

The suitable positioning and tracking techniques include absolute as well as relative positioning methods. In the first case, the location of the user is directly obtained in an absolute reference coordinate frame, whereas in the second case, relative measurements in relation to a start location are continuously carried out and then the trajectory of the user is determined using dead reckoning (DR). Hence, it is possible to bridge gaps between different user's locations obtained by absolute positioning technologies. For DR an emergency crew member has to be equipped at least with a digital compass and step sensor based on accelerometers. Then the direction of movement and distance travelled can be obtained where DR yields the trajectory of the user. Due to large error accumulation of low-cost MEMS-based accelerometers which cause large drift rates, a frequent update using Zero Velocity Updates (ZUPT's) is required. In this case, the velocity change rate is set to zero and recalibrates the acceleration output when the foot of the user is touching the ground where it is stationary for a very short period of time. In addition, map matching of the DR trajectory can be performed if a detailed 3D GIS exists. Large smart cities are expected to have such a GIS for their underground structure network. As an alternative, sensor drifts can be reduced by an update with an absolute location technology. As described in the following, RFID is a suitable technology as it may be deployed permanent or temporally in the underground network.

RFID for Emergency Guidance and Rescue

The RFID technique was originally designed as a contactless and low energy consumption device for automatic identification of objects. The application of this technique has been predominantly in logistic industries for transferring object identification to monitoring sensors. The major applications also reflect the extension of the use of RFID from a stand-alone identification system to tracking and positioning. The advantages of using RFID in combined indoor/outdoor personal positioning include the simplicity of the system, low-cost of the device, high portability, ease of maintenance, a long effective range, and the use of RF signals which have the capability of penetrating obstacles. A passive RFID tag has practical reading ranges of about a few mm up to several meters depending on the radio frequency used whereas long-range active tags can have reading ranges up to several hundreds of meters. In general, two specific positioning strategies are possible. The first scenario is that RFID readers are installed at specific locations or waypoints of interest. The person or object to be positioned is then equipped with an RFID tag and can be located in a certain section between two waypoints. The second scenario is a reverse approach. In this case, tags are mounted at certain known locations of interest (i.e., active landmarks) and the mobile user is equipped with a reader. The tag's ID and additional information (e.g. the 3-D coordinates of the tag) can be retrieved in the given read range if the user passes by. Note that the second scenario usually is less expensive than the first as a high number of low-cost tags may be installed at known locations instead of more expensive readers. The location of the user can then be determined using different methods such as cell-based or lateration and fingerprinting. The use of RFID for location determination is described in detail in [4]. In the following, only the most suitable cellular positioning approach which makes use of the second positioning scenario is discussed.

The cell-based positioning method uses the level of Received Signal Strength (RSS) from tags to determine the mobile user's appearance in the RFID tags' coverage areas (i.e., cells). The benefit is its simplicity of use, as active landmarks either provide approximate positions in large areas or accurate positions over an extremely small range (e.g. within a few meters). However, one of the limitations in the algorithm is the relationship between the cell size and positioning accuracy. By setting a threshold for the RSS the size of the cell can be set in range tailored to the specific application. The probabilistic cellular positioning method uses an adjustable ring-shaped

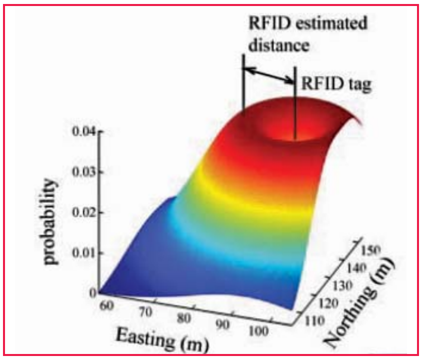

Figure 2: Schematic plot of the probabilistic cell-based positioning algorithm [after 4 and 5]

cell. The probability distribution shown in Figure 2 is like a crater with its center located at the position where the RFID tag is detected. Its peak is a ring with the tag in the center and a radius equal to the estimated distance determined according to the RSS-based ranging model. The probability of the mobile user's position can then be estimated by joint probabilities of the RFID-based and external sensor based probabilities from sensors, such as INS. The advantage of using the probabilistic approach is that it does not identify the mobile user's position as being at the center of the cell. However, it estimates the probability of the distance between the user and the center based on RSS measurements and external sensor observations. Such an improvement provides an adjustable cell in real-time positioning [4, 5].

In the developed emerging concept parts of the underground network can be fitted with passive or active RFID tags, for instance, at landmarks or important crossings of the underground infrastructure network, for recognizing and leading the correct way. Also temporally deployed tags at certain waypoints can help to guide emergency crews. For instance, the first responder can place tags at active landmarks which he has passed on the way to the site. Thus, these tags can lead the way for an efficient rescue out of the effected emergency area. In such a way RFID serves as an underground guidance system. An emergency crew member may also wear a head-mounted display as it is used in Augmented Reality (AR) applications, showing him the current location as well as the marked areas with RFID tags in the underground GIS. In addition, the current location of the crew members can be transferred to the operations centre where their position is displayed in respective to the underground network system. Then commands can be given to the individual emergency crew member.

> The advantages of using RFID in combined indoor/outdoor personal positioning include the simplicity of the system, low-cost of the device, high portability, ease of maintenance, a long effective range, and the use of RF signals which have the capability of penetrating obstacles

Hence, it can be said that the use of RFID for localization and serving as guidance system is very promising in emergency situations, when going underground is mandatory since roads above are impassable. Due to the integration of RFID positioning with other technologies a collaborative navigation solution for all involved users is achieved. For the further development of the RFID concepts for emergency situations international collaboration is proposed and motivated by the authors of this article. They believe that underground structures will play an important role in emergency situations for guidance and rescue. New ideas and suggestions are welcome and should be addressed to guenther.retscher@tuwien.ac.at.

Acknowledgements

The paper entitled 'The fourth layer in collaborative navigation – going underground' published in the proceedings of the XXV FIG Congress in Kuala Lumpur, Malaysia, in June 16-21, 2014, presented for the first time the concept of using underground structures in emergency situations.

References

[1] Grejner-Brzezinska, D.A., Toth, C., Li, L., Park, J., Wang, X., Sun, H., Gupta, I.J., Huggins, K., Zheng, Y. F., 'Positioning in GPS-challenged Environments: Dynamic Sensor Network with Distributed GPS Aperture and Internodal Ranging Signals', ION GNSS Conference, Savannah, Georgia, USA, September 22-25, 2009, pp. 111-123.

[2] Grejner-Brzezinska, D.A., Toth, C., 'GPS-challengend Environments – Can Collaborative Navigation Help?', 8th International Symposium on Mobile Mapping Technology, May 1-3, 2013, Tainan, Taiwan, 7 pgs.

[3] Kealy, A., Retscher, G., Alam, N., Hasnur-Rabiain, A., Toth, C., Grejner-Brzezinska, D.A., Moore, T., Hill, C., Gikas, V., Hide, C., Danezis, C., Bonenberg, L., Roberts, G.W., 'Collaborative Navigation with Ground Vehicles and Personal Navigators', IEEE Xplore, 2012 International Conference on Indoor Positioning and Indoor Navigation (IPIN), Sydney, Australia, November 13-15, 2012, 8 pgs.

[4] Retscher, G., Zhu, M., Zhang, K., 'RFID Positioning', Chapter 4 in: Chen, R. (Ed.): Ubiquitous Positioning and Mobile Location-Based Services in Smart Phones. IGI Global, Hershey PA, USA, ISBN: 978-1-4666-1827-5, 2012, pp. 69-95.

[5] Zhu, M., 'Positioning Algorithms for RFID-based Multi-sensor Indoor/Outdoor Positioning Techniques', PhD thesis, RMIT University, Melbourne, Australia, 2011, 183 pgs.

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Challenges before Spatial Data Infrastructure

Experts discuss the challenges before SDI and the road ahead

Governance is the most demanding challenge to overcome

Ulla Kronborg Mazzoli
Head of Function Policy and Governance, National INSPIRE Contact Point, Danish Ministry of the Environment, Danish Geodata Agency, Denmark

"There is nothing like a challenge to bring out the best in man," Sean Connery once said, addressing neither SDI or geospatial information. However, his quote holds a key to how we can choose to address the many and continued challenges in working with SDI on national, regional and global levels.

Even though we can agree that the challenges are many, we may not fully agree on their character -- not to mention on the means we should use to meet and overcome them.

We each face different challenges, depending on the angle we take on SDI and the role we fulfil as data providers, users or application developers. My view is therefore one of many, and is coloured by my position as a European public sector employee.

In Denmark, we have developed and maintained our national SDI over the course of more than 15 years. Our main goal was - and remains - to position the SDI as a backbone for eGovernment. This will ensure that the public sector can harvest the many benefits inherent in spatial information through their everyday work routines. With a national, open and free data policy in force since January 2013 (http://eng.gst.dk/), we now also extend these possibilities to the private sector.

The EU directive INSPIRE (INfrastructure for SPatial InfoRmation in Europe) aims to establish the basis for easier and more efficient sharing of data across EU's many borders. The aim is interoperability and the means is standardization via common and legally binding regulations addressing metadata, datasets and network services. During the still ongoing implementation of the directive, awareness of the importance of SDI has increased, also beyond the geospatial domain. Thus awareness has grown regarding obstacles and challenges in reaching the goal of easy access and beneficial use of spatial information.

From a national perspective, governance appears to be far the most demanding challenge to overcome. And what do I mean then with governance?

As SDI consists of many entangled and interrelated elements, and is developing in the direction of many new and varied user demands, its complexity is growing as well. In order to make sure the SDI "machine" is running efficiently and can continuously meet user demands, it is necessary to steer, make agreements, organise, prioritize and strategize. In short, to govern.

We tend to understand governance as something that´s conducted in steering committees, on coordination boards and at the political level. That is still true and necessary, but we also need to think about and apply governance at all levels - from technique to decision making - when developing and maintaining our SDI. We also need to connect these levels and look at governance as a whole.

The main reason for working with SDI in the first place is that it should be used – we can all agree on that. Whether a public agency, a citizen, a student, a private enterprise or another stakeholder entirely, each user has unique needs and demands that the SDI has to meet. This puts pressure on our ability to prioritize and requires structured reuse of data and shared services. Only in this way can we keep SDI development as cost-efficient as possible.

The growing complexity, the shared services and the user driven data modelling all call for governance. As in the butterfly effect, even small changes to a data model can cause great inconvenience to a single user who depends on a specific service to deliver a specific dataset. In the worst case, it can make it impossible to use, and can lead to economic loss by continually adapting the end user systems to small changes.

Likewise, one service that is not operational can mean that a whole chain of interconnected services does not function, leaving the user with an error message and no data.

So how do we get this complexity running smoothly so the user can get information as easily as switching on the light, without having to concern herself with the underlying infrastructure?

My bid is that we need to address governance with the same amount of importance and energy as we are using on the technical elements of the SDI.

It is time to head for end user satisfaction by implementing location as service component

Mauro Salvemini
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President of AM-FM GIS Italia
Evangelist of INSPIRE and SDI architect

There are no doubts that INSPIRE, as legal and technical initiative carried out by the European Commission fully politically supported by the European Union, has interested and is still fascinating the international community of geo information. From South America to Far East, as I personally had the opportunity to verify in technical and professional missions, the interoperability dogma is widely accepted and the praxis of concentrating on metadata and web services as well.

INSPIRE 2014 Conference demonstrated that individuals, organisations and also nations, referring to thousands of pages of regulation, specification and guidance documents, could relate to their own benefits. It has also to be recognised that presently the shared datasets are still very basic while the organizations' behaviour of not sharing data is still often to be seen in many countries. European nations differ among themselves on final user satisfaction while the involvement of the local public authorities in realising the National SDIs deeply varies within the Union nations. The paradigm of data flow from central to local and vice-versa is conjugated differently depending on the administration organizational and functioning model . INSPIRE application, use and achievements, besides the reporting to the Commission, are to avoid any infringement procedure which may be applied to the nation not meeting the requirements of the directive. The success of interoperability and of SDI depends on the cultural environment where it is going to be applied. It has to be considered that INSPIRE is not only a technical directive but it is having some substantial ideological, political and economic fundamental components. Interoperability is the tool while the principles are the foundations.

> Since data are originated locally and are shared accordingly to sub-national administration's rule, it can be said that SDIs are very much dependent on local culture and local originated data

INSPIRE addresses national data sets and deals with themes specifically oriented to environment and the representation scale is located in the middle and small cartographic range. On the other hand, presently, the most used geographic information for satisfying end user needs is the micro geographic information. The answer of basic question "where" has the solution, for common users and citizens, in the large scale range about from 1:2000 to 1: 500, the typical walking distance. The semantic and visual aspect of the answer to "where" has also the most relevant value because the common end user is not interested in digits representing coordinates but in recognising the "place" described in an easy to understand model. To this regard INSPIRE sets the foundations but the already defined data specifications have to be developed to match the needs of semantic management of data sets and spatial knowledge.

It is matter of the fact that, for the time being, public central administrations, specially in Europe, delegate their functions more and more to local authorities. Data sets are originated locally for detailed purposes and at sufficiently large scale, they flow through the national SDI only if they are compliant to data specifications and services' standard. The interoperability from local to central has to be in place for insuring the SDI running. Since data are originated locally and are shared accordingly to sub-national administration's rule, it can be said that SDIs are very much dependent on local culture and local originated data.

Public administrations' functioning modes, places fruition and use, toponyms and their languages or dialects are components of the culture. It is my opinion that in order to guarantee a strict adherence between GI and final users - citizens satisfaction, it is necessary to move from the position paradigm (the cartographic coordinates) to the location paradigm which solves the "where" issue and gives the location knowledge to the end user. SDIs are data and services oriented but it is time now to head for end user satisfaction by implementing location as service component. This is the challenge to be faced by public administrations implementing GI in public services provided to citizens.

The present situation is having a positive trend to develop in this sense offering to SDIs the way to fulfil the mandate of making data and services interoperable for user needs satisfaction. The so called Location Framework has been already pursued by some member states in Europe and it may be considered as the unifying system for providing GI integrated services to citizens.

Just considering the ancient maps not using exact cartographic and projection systems, they were not giving positioning data to users but location useful information for travellers, sailors and explorers. They were used for centuries in multi-cultural and multi-language environment: which are beautiful examples of interoperability, of distributed services and of standards. Are we aiming to that?

There are problems of data relevance provision to ensure the harmonization of different kinds of data

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At a time of rapid development of information technologies state institutions and agencies in Ukraine are experiencing a transition from paper archives and stack of paper reports with a variety of statistical and attribute data to automated systems with which you can get fast access to any information.

Since the beginning of 2013 in cooperation with the World Bank in Ukraine was introduced **National Cadastral System (NCS).**

NCS is a multilevel hitech system that includes integrated databases, informational and geoinformational technologies, digital electronicmaps, airphoto- and space pictures in which work, serve and maintaine few thousand professionals all over Ukraine.

Also in 2013, the online public cadastral map was opened, which contains all land parcels and basic information about them: cadastral number, form of ownership, purposive appointment, square and graphic display on ortho-photoplan. Public cadastral map became one of the most popular web resources of the country - in 2013 it was visited over 3.5 mln. times.

To fill in the state land cadastre with indigital form data took four months to converte from paper to electronic form of 300 000 sheets of cartographic materials and 24 milions sheets of State Land Acts.

The time spent by cadastral registers for the registration of land parcel and issue of extracts - impresses. Before the NCS started to operate, the registration could take several weeks, or even months, and «facilitating» of faster registration often served to corruption actions, but now such factor is excepted.

Thanks to the implementation of new software, the average time for the complete registration process through Ukraine (starting from filling out the application, up to printing of the land register and extract) was 21 minutes. Previously, approximately the same time took a citizen to only write the application for registration.

National cadastral system was highly praised by the international inspection experts from the World Bank and the FAO (UN). The Project on Cadastre Development between the government of Ukraine and the World Bank hailed success and caused a great deal of attention that allows Ukraine the opportunity for starting negotiations on national geo-spatial data infrastructure development in Ukraine on the basis of the State Land Cadastre (NSDI).

The State Agency for Land Resources of Ukraine (hereinafter - SALR) and the State Enterprise “State Land Cadastre Centre” (hereinafter - SLCC) has analyzed the situation in Ukraine on the work of various ministries, agencies and organizations dealing with geospatial data.

We found that geospatial data are developed and maintained by individual agencies and departments, and have administrative-territorial and industry sector focus. Lack of unified standards and requirements for shape, size and type of data complicates their storage, conversion into electronic form and search, and the use of various software products while collecting new data makes it impossible to complete their processing and analysis.

Analysis of work of different authorities also indicates that information is created and stored in parallel in different systems, which results in additional expenditure of time, financial and human resources. In addition, a variety of duplicated data complicates their updates.

These problems do not allow providing end-users with reliable information. Similar problems are typical for Ukraine and for the most countries of the world, including European. The solution approach of these problems was the creation of spatial data infrastructure.

In order to test our ideas, in 2013 was decided to carry out works on the pilot project to develop and implement NSDI in Ukraine. Thus, experts from SALR and SLCC have conducted a pilot project to establish such a system (prototype) on the territory of one administrative unit (1,000 sq. km.).

The prototype of system established under the pilot project include 22 thematic datasets available online and over 200 of information layers filled on an already existed electronic map of Ukraine: land plots, water and forest resources, mineral resources, ground and underground utilities and networks, buildings and addresses, infrastructure objects, statistic and demographic indicators, taxes data, etc.

While working on a pilot NSDI project our specialists followed the recommendations of INSPIRE Directive as well as the experience of other countries. Requirements of the Directive have been taken as a basis for structuring data storage, from the standpoint of the unification approaches to work with data.

Creation of NSDI in Ukraine has all preconditions. In particular, developed a draft law "On the National Geospatial Data Infrastructure". Under authority of SALR operates state-owned enterprises that are able to provide administration of NSDI. The system of executive establishment and organizations of land resources management have experienced, energetic, proactive staff, moreover, are existed tested technologies and experience of creation of such systems. The confirmation of this is the working system of the State Land Cadastre, cadastre of land and objects of natural reserve fund, and a series of holding of successful pilot projects in some regions of Ukraine for working with geospatial data.

However, there are some problems that are systemic and exist not only in Ukraine. These are problems of data relevance provision to ensure the harmonization of different kinds of data and creation of a platform for such systems.

The development of NSDI throughout the whole territory of the country will enable to have a complete electronic picture of Ukraine in one place, that will affect the adoption of effective management decisions; reduction of the budget costs on all levels; transparency and investments; the possibility of modeling of emergency situations and ways of eliminating them; as well as provision of all types of analysis to support the economic development of the country.

The biggest challenge is the problem of effectiveness

Marc Leobet
French representative to INSPIRE Regulation Committee, Spatial Data Office, Directorate of Research and Innovation, Department of the Commissioner-General for Sustainable Development, Ministry of Ecology, Sustainable Development and Energy, France

We got experience and we are the world leaders in SDI implementations. We met a problem of effectiveness. We need an European funding to solve the issues we are the first to encounter at this level. Besides, fine governance and good openness to users will allow to overpass the technical obstacles we encounter here or there.

We are implementing the 10 years old dreams of experts, designing the European Spatial Data Infrastructure as an open and decentralised framework. We got collectively, in European Union, the biggest experience in the world about SDI. We have learnt so many things about coordination, governance over technical points, real uses of metadata, maturity of standards...

Some of issues with data sharing and reuse we have known in my old and large country – at European scale! - are on the way to be corrected: it is easier to get metadata and datasets, even if it is not always through OGC's services but sometimes through the contact address in metadata. Today, in France, most of the producers know that the rule is to share, and the limitation to public access the exception.

Of course, some points have to be strengthened. One is quite important in my mind, that is getting out of the GI's box to enlarge the communities of developers and, finally, of users. During the 2014 INSPIRE's Conference, Thomas Wojaczek, the responsable for INSPIRE activities in con terra society, answers to a question that his "dream would be a translator between INSPIRE and the others communities". This will be a major issue in the close future to get a good return on investment in SDIs.

And some other points are painful. Most of them are connected to the architecture: control access and authentification, registers, production of the INSPIRE schemas in GML, the ability to be used by humans. In my opinion, it is not really a fault made in 2000-2006. We needed to light the future to be able to run the race. But now some of the high objectives we have accepted, specifically in terms of delay, are hard to achieve because of the lack of maturity of some tools.

So, facing to public authorities, we have to go back to the dream – and to the absolute necessity – of an easy-to-use world of datasets and services with limited efforts. The biggest challenge is the problem of effectiveness.

Just an example : we are certainly among the firsts to have developed so highly complex mandatory schemas for interoperable data specifications. We consider that this complexity is the cost of interoprability, and it could only be the beginning. But they are too complex for GIS-type QGis and their users. We need either improve GIS, or install an intermediate reprocessing (but it would surely be costly). The challenge will be to improve tools, and maybe get open source softwares under European funding to give to Europe the opportunity to achieve its own SDI.

For the INSPIRE Conference, I described what could be the future of our SDI: needing datasets for a public consultation about wind mills implementation, one would type "public environmental enquiry : wind mills" on a device and get back a pack of datasets (or SD services), even if the project is near two others countries with foreign languages. He would check the metadata and begin to add it to the project's data. What else?

That would mean semantic interoperability in different languages (in our point of view, that's the most valuable result of the INSPIRE data specifications and have to be continued), registers and management of codelists, and real interoperability. More important, that would lead to hide the complexity of the infrastructure under a cover of applications that we have to build or let build over.

In conclusion, the success of INSPIRE, as an European infrastructure, is not yet an evidence. There is a possibility that the complexity, the lack of technical maturity and the distance between experts and users lead to a formal compliance with the rules without achieving interoperability. But we begin to see the first results of the investments made, and it sounds good. So I am confident that a fine governance and a good openness to users will allow to overpass the technical obstacles we encounter here or there.

Agencies participating in NSDI are yet to evolve suitable Geo-ICT Strategies

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NSDI is at a threshold of major transformation with the emphasis of its activities gradually shifting from pure 'Data Domain' of an enabling infrastructure to the 'Product Domain' of a performing infrastructure. With the proposed launch of the National GIS and State SDI Initiatives during the 12th Plan, NSDI is gearing itself towards providing an effective governance of GIS processable data assets and making those accessible as standard services for the development of applications and products.

The coordinating infrastructure of NSDI became operational following its approval by the Union cabinet in June 2006. Its underlying Geo-ICT infrastructure consisting of the architectures, processes, and skills spread over various agencies has started to function over the past few years. Some of them have been enabled to make metadata and standardised interoperable map services accessible for reference and concurrent visualisation through the single window access mechanism of the India Geo Portal. Interoperable web map services from selected agencies could now be accessed on a standard GIS package for development of applications and products. There is a need for provision of a catalogue of accessible data services based on ISO 19119 standards for automatic access and manipulation. Other agencies are expected to join this data service network with the operationalisation of their data nodes.

Support of a network of R & D institutions under the Natural Resources Data Management System (NRDMS) Programme of Department of Science & Technology has primarily enabled NSDI and the pilot scale State SDIs over the past years. Promotion of free and open source packages has been an important strategy of NSDI in building the data network.

There are however major challenges to be overcome before NSDI is put to effective utilisation:

Agencies participating in NSDI are yet to evolve suitable Geo-ICT Strategies in order to contribute effectively to geospatial data sharing and utilisation. Scope of such strategies, the systemic competencies, and the governance procedures need to be further evolved.

Although the traditional business infrastructure like the organisational hierarchy of personnel, the existing business processes, and the required traditional skills are in place for provision and sharing of geo-spatial data in hard copies and CDs to the end users, those continue to be provided mostly in legacy formats (built upon cartographic data models) and not suitable for quick processing/ manipulation. Re-engineering of data sets based on open standards is thus an essential pre-requisite and has to be quickly carried out by the agencies for their successful utilisation.

Data governance needs further improvement with deployment of required technical artefacts like registers. Registry should function as a common reference point for feature definitions, feature descriptions, machine-readable data models/ schemas, and feature (classification) codes etc. These are essential for correct analysis and interpretation of applications/ services and products.

Lack of market orientation for Geo-ICTproducts and services, insufficient inter-sectoral data flow, and institutional inertia have been some of the other bottlenecks those need to be overcome in the coming phase of the NSDI implementation.

Inadequate alignment between the existing data and the ubiquitous web, lack of information-based decision-making culture, insufficient and slow uptake of standards by the participating institutions, inherent difficulties in building the required skill set amongst the GIS personnel of different institutions, slow pace of implementation/ framing of required policies, non-availability of and inaccessibility to spatial data of desired resolution and currency, incompatible data, heterogeneities in semantic, thematic and syntactic aspects of data sets, low communication bandwidth, cost of commercial GIS packages and non-affordability of their cost, lack of user-friendliness of processing tools; and inadequate capacity amongst the end-users are some of the factors responsible for inadequate integration of NSDI data services with the business workflows of end user organisations.

In the immediate future, the challenges in capture and use of geo-spatial data sets of right resolution and currency are proposed to be met by larger scale surveys and map preparation using active sensors (LIDAR), deployment of virtual reference systems, use of sensors for thematic data collection, and the data processing tools for conversion of data to right-kind of information for decision support.

Some of these challenges are proposed to be addressed while setting up the National Geographical Information System (NGIS) and the State level Spatial Data Infrastructures. Overall improvement in the economic and social environments of the geo-spatial data is expected to facilitate successful building and utilisation of the NSDI network.

The views expressed here are in personal capacity.

The Galileo Commercial Service: Current Status and Prospects

According to the Galileo Mission Requirements, the Commercial Service (CS) will provide an 'added value' with respect to the Galileo Open Service and other GNSS signals. This paper presents some background of the Galileo CS, its current status and its prospects for the next years.


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Introduction and context

A Brief History of the Galileo Commercial Service

In the late 1990s, while the European Union was defining what services Galileo would offer, two access-controlled services were defined: CAS1 (Control Access Service 1) and CAS2. CAS1 later became the Commercial Service (CS), and CAS2 the Public-Regulated Service (PRS). Both CS and PRS were designed to allow access control by the encryption of the signal at spreading code level, mainly for commercial reasons in case of the CS, and for security reasons in case of the PRS.

The CS was a cornerstone of the Galileo public-private partnership strategy. Back in the early 2000s, Galileo was foreseen to be developed by a public-private partnership, and its costs were going to be shared by the public and private sectors. A consortium of private companies would put their know-how and resources into the development, deployment and operation of Galileo. In exchange, they would collect revenues from the sizeable value-added services that the Galileo program was supposed to bring to society and economy.

However, the public-private partnership negotiations proved that the costs and risks of developing Galileo, even if mitigated by the public sector participation, were not compensated by the potential revenues derived from its exploitation. Finally, by 2007 the Concession approach was replaced by an approach in which Galileo deployment would be fully funded by the European Union.

When the funding approach was shifted to a full public funding, the CS definition and development was postponed in favour of the other Galileo services: the Open Service (OS), the Public Regulated Service, the Search-And Rescue, and the Safety-Of-Life service, the latter currently undergoing a redefinition.

Nevertheless, the Galileo CS appeared in the EU 2008 GNSS Regulation (European Union, 2008) where it was stated that Galileo should "*offer a commercial service (CS) for the development of applications for professional or commercial use due to improved performance and data with greater added value than those obtained through the open service*".

Since the reorientation of Galileo exploitation in 2007, a number of activities have been performed toward the further definition of the CS:

- Round tables in 2009 were held to define the services to be offered by the CS.
- An internal (EC/GSA/ESA) Working Group was operative in 2010-2011 to further develop the service.
- A business case for high accuracy and authentication was prepared by the European GNSS Agency GSA, showing the business viability of both services.
- End-to-end provision concepts were developed by the European Commission, by which the CS would be fully provided and exploited by the public sector (as the other services).
- A Commission Working Group was created in 2012 to involve EU Member States in CS discussions.

These activities led to the proposal of high accuracy and authentication as the services to be offered by the CS. However, several unknowns remained about the service definition, service provision architecture, public/private role in the exploitation scheme, market size and eventual profits. The 2013 CS parallel studies later described in this paper were launched to answer most of these unknowns.

EU GNSS Regulation and High Level Objectives

The current EU GNSS Regulation (European Union, 2013) and associated Galileo program documentation state the following about the CS:

- The CS shall enable "…*the development of applications for professional or commercial use by means of improved performance and data with greater added value than those obtained through the open service*"
- The CS is based on "*commercial ranging and data, whose access shall be controllable in order to allow fees to be levied.*"
- "*The Commercial Service signals shall be the Open Service signals, plus two encrypted signals in the E6-band.*"
- "*...the CS shall offer a payable added-value service, which can be exploited through a revenue-sharing mechanism with the private sector.*"

As shown in the rest of the paper, the current CS definition and demonstration work is based on the elaboration of the abovementioned items, in a way that best satisfies the high level objectives defined by the Programmes for the CS, which have been defined as follows:

- Maximize public benefits offered by satellite navigation for citizens.
- Create economic value for the EU in general.
- Provide the best navigation services possible with the current and future assets to the broadest GNSS community.
- Promote innovation by allowing Galileo to offer novel services, ideas and solutions not currently existing or being provided.
- Create a potential revenue source for the public sector to support the maintenance of EU satellite navigation services in the future.

The European Commission (EC) is currently working jointly with the European GNSS Agency (GSA) and with the European Space Agency (ESA), with the support of Member States, through the EU Member States CS Working Group, on the roadmap leading to the provision of an operational Commercial Service, and its associated exploitation model, in the following years.

This paper presents a summary of the current status of the CS and its prospects. The following sections present the Galileo CS signals, the currently foreseen services, including potential architectures and provision schemes, and some plans about its commercial exploitation.

Galileo commercial service signals

The capabilities of the Galileo Commercial Services depend directly on what capabilities the CS signals can bring. This section describes the Galileo signals foreseen to provide the CS.

The Galileo CS is mainly based on 2 signals: E6B and E6C. They are modulated on a carrier frequency of 1278.75 MHz, within the E6 band, as shown in Figure 1. In addition to E6B and E6C, the Galileo mission also allows the CS to be supported by spare bandwidth of other signals.

Although the E6 band is allocated for Radionavigation Satellite Services (RNSS) on a co-primary basis, it is currently used for other purposes, including radars and amateur radio and TV communications. The Commission's Galileo frequency management team have therefore launched actions to implement measures that will allow the successful reception of the CS signals in all regions.

Figure 2 shows the Galileo signal modulations, including E6B and E6C.

As it can be observed in the figure, the E6B and E6C components are both modulated in the in-phase component of the E6 signal, by a Code Division Multiple Access (CDMA) Binary Phase Shift Keying BPSK(5) modulation. Unlike many of the modernised GNSS signals, which follow BOC approaches, the E6B/C follow a classic BPSK modulation and

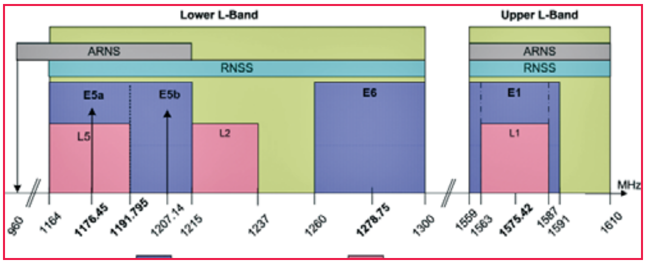


Figure 1: Galileo & GPS Navigation Bands

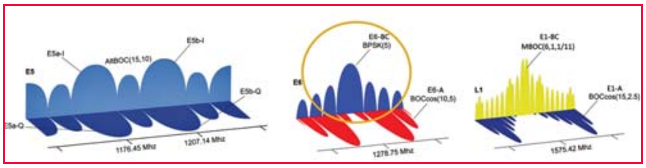


Figure 2: Galileo Signal Modulations

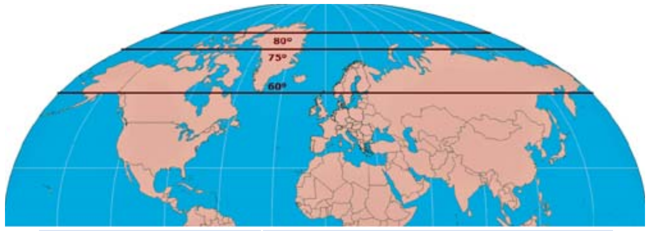
Table 1: E6B/C signal properties

	E6B	E6C
Component	Data	Pilot
Carrier Frequency	1278.75 MHz	1278.75 MHz
Spreading Modulation	BPSK(5)	BPSK(5)
Chip Rate	5.115 Mcps	5.115 Mcps
Primary Code Length	5115 chips	5115 chips
Secondary Code Length/Duration	N/A	100 chips/ 100ms
Symbol/Data rate	1000 sps / 500 bps	N/A

Sync	Symbols	Total [symbols]
16	984	1000

Page type	Word: Commercial Data / key Management	CRC	Tail	Total [bits]
14	448	24	6	492

Figure 3: E6B Data



latitude[°]	Best possible GEO elevation [°]
55	27.3
60	21.9
65	16.6
70	11.5
75	6.4
80	1.3
81.3	0.0

Figure 4: latitude vs. GEO satellite elevation

reach its maximum power spectral density at the carrier frequency. Table 1 further details the CS signal components.

Spreading codes are 1ms long, and a 100-chip secondary code with a duration of 100 milliseconds is added to the pilot component.

The E6B data signal provides 1000 symbols per second. 16 symbols are used for page synchronisation, while the remaining 984 are used for convolutionally encoding 492 bits of data. Convolutional encoding follows the same Forward Error Correction algorithm as other Galileo signals. This format is described in the Galileo OS SIS ICD (European Union, 2010). This scheme is also followed by other radionavigation signals, as e.g. SBAS or GPS's L5 or L2C (GPS Directorate, 2012).

Out of the 492 bps, 448 can be used to transmit Commercial Service data, as shown in Figure 3.

Foreseen services

Without precluding the provision of other services in the future, the main services foreseen to be part of the CS are high accuracy and authentication.

High Accuracy

High accuracy is understood as the ability of the system to provide a positioning accuracy in the order of a few centimetres. State of the art techniques for high accuracy are based on the use of carrier-phase measurements and include Precise Point Positioning (PPP), through which high accuracy satellite clock and orbit data are provided to a user, and Real Time Kinematics (RTK), through which a reference station or network of stations provides precise measurement corrections to the user. The main high accuracy approach under study for provision by the CS is based on PPP.

Several internal studies have shown that a 448 bps bandwidth per satellite allows the transmission of PPP satellite and orbital data at an adequate update rate to provide accuracy in the centimetre level. The update rate is especially relevant for the satellite clock corrections, which should be corrected and transmitted to the user with a latency of few seconds.

One advantage of transmitting PPP corrections in the L band is that PPP receivers are already equipped with L-band antennas and RF front-ends, which may simplify the reception of the data. Another advantage of the use of Galileo satellites is that the coverage at high latitudes is significantly improved with respect to that of geostationary satellites, whose reception may be difficult above latitudes around 60º, as shown in figure 4 (note that *best possible GEO elevation* refers to the case where the satellite and receiver are at the same longitude). At high latitudes, Galileo (and other GNSS) satellites can be received in good visibility conditions.

Authentication

Authentication is understood in this context as signal authentication, i.e. the ability of the system to guarantee to the users that they are utilising signals from the Galileo satellites and not from any other source. In this context, spreading code encryption (SCE) can be included as one of the authentication options, as can navigation data-based authentication through asymmetrical or symmetrical architectures. Authentication can also be extended from the signal domain to the user position domain through the appropriate technologies, to ensure that the user position calculated with Galileo and potentially other navigation satellites and sources, is authentic.

In addition to the above mentioned features, the Galileo E6B and E6C signals have the possibility to be encrypted at spreading code level. Therefore, the Galileo CS signals offer the first-ever GNSS spreading code encryption capability for purely civil purposes, allowing to increase the civil security of professional applications.

In addition to the spreading code encryption capability, part of the 448 bps bandwidth can be used for data authentication, and the CS may be complemented with E1-B I/NAV message bits (see Galileo OS SIS ICD (European Union, 2010) for more details), either as the navigation data to be authenticated, or by the use of spare bits for a data authentication service. At the moment, both standalone and communication-assisted modes are being investigated. Communication-assisted modes can lighten the burden of the receiver hardware by allowing the remote processing of the received encrypted samples.

Authentication Service Provision Schemes

As mentioned above, the objectives of the EU GNSS Programmes with the

CS should go beyond just obtaining revenues. A means to achieve this is by the provision of two levels of authentication, a data-based authentication service in the E1 I/NAV open signals for mass market users, and a data-based plus spreading-code based authentication service through the CS signals. The Programmes are studying the performance of a Navigation Message Authentication (NMA) service that could be offered by Galileo (Fernández-Hernández, I. 2014). Within this provision scheme, a lighter NMA service could be provided on the E1 signals with the following features:

- Lower receiver/key management complexity
- Adequate for lower security / mass market applications: e-commerce, road, handheld location-based services, etc.
- Potential Provision scheme: Free & based on NMA.

In addition, a professional authentication service based on E6 or E1+E6 with these features could be provided:

- Higher receiver/key management complexity and robustness
- Adequate for high security commercial applications: surveying, tracking & tracing, maritime, etc. and potentially some institutional applications
- Potential provision scheme: Controlled & Based on NMA + Spreading Code Encryption (SCE).

Both services could be operated and exploited in parallel. As a means to improve bandwidth for high accuracy services, the professional service could be totally or partially based on the E1 NMA service for data authentication purposes.

One way to optimally provide the two authentication services plus high accuracy, which seems to satisfy the end user and service provider needs, would be:

- To leave the E6B component unencrypted at spreading code level, so high accuracy providers could transmit high accuracy data but not be involved in the spreading code key management.
- To have E6C component (pilot) encrypted, so E6C ranging measurements based on encrypted spreading codes can be used for authentication.
- To transmit data authentication information in E1B (open NMA service), E6B or both.

EC/GSA, with the support from ESA, are currently studying these aspects to define the best exploitation scheme of the CS to achieve the previously mentioned objectives.

The CS parallel studies (2013)

In order to cover more exhaustively all the possible Commercial Service options, the Commission launched in December 2012 two 1-year parallel CS definition studies. The purpose of the studies was to define the technical options and exploitation model most suitable for the Commercial Service with the current and future Galileo assets.

The study CESAR ("Galileo CommErcial Service, A Reality") was led by GNSS consultancy firm FDC (France Development Conseil), and included the participation of major GNSS high accuracy service providers and infrastructure developers as Trimble, Fugro, Thales Alenia Space France and Keynectics. The study GALCS ("Galileo Commercial Service definition") was led by GMV, and included the participation of CGI and Helios Consulting. Both studies have successfully concluded by mid-December 2013. The developments of the studies have been actively monitored by the EC's Joint Research Centre (G6 unit), which has also participated in the analysis of Galileo authentication, GSA, ESA and EC DG ENTR and have confirmed high accuracy and authentication as the two principal services to be pursued by the Galileo Commercial Service.

The studies analysed the needs and constraints of 50+ market segments having a potential interest in a GNSS high accuracy or authentication commercial service, with positive results. The main results are summarised in the following items:

- Galileo should provide high accuracy and authentication services on a separate basis but simultaneously through the CS signals, in a way that can be used separately or combined. This implies that access control to the two services must be managed separately.
- There is an interest from external service providers to provide high accuracy services from the Galileo constellation through the CS signal. The service provision scheme, algorithms and technology are mature enough, since they are already used through existing services based on GPS signals and through GEO satellite communication links.
- There is an interest from external service providers to provide authentication services from the Galileo constellation through the CS signal. Although the requirements for the system infrastructure are mature, the service provision scheme and exploitation technology require some further definition.
- The provision of both high accuracy and authentication will require external service providers to connect to the Galileo system. This connection is currently foreseen through the GNSS Service Centre. The high accuracy service can highly profit from a real-time connection to the system, and the authentication service requires a key management interface with an external service provider that will liaise with the end users. Security accreditation issues derived from this architecture are under study at the moment.
- Accuracy is sensitive to the bandwidth used in the CS. The use of around 75-90% of the CS data transmission bandwidth (448 bps per satellite) for the high accuracy service is likely to be required. Accuracy is also sensitive to data transmission latency, as the satellite clocks need to be estimated and transmitted frequently. A reliable low-latency data channel in the order of few seconds to broadcast data through Galileo would be required. This means that only the satellites that are connected to the ground at a certain time can transmit high accuracy data.

- High accuracy providers prefer not to be part of the key management processes for the CS spreading code encryption and therefore their interest on the CS requires the control of the user access at data level.
- The encryption capability of the CS signal spreading codes can be used to increase authentication robustness.
- There are no GNSS authentication services as such in the market yet, so it is not possible to take into account market and user experiences as much as for the high accuracy case.
- Authentication could be accommodated in the remaining CS E6B signal data transmission bandwidth (10-25%). If the authentication data is modulated on a non-encrypted spreading code signal or component (e.g. E1 I/NAV or E6B, if the signals can be encrypted separately), this would allow the segmentation of users into two authentication levels, one based on data authentication only, and a more robust one based on data and encrypted codes. This two service level approach was not considered as a negative point towards a potential commercial exploitation of authentication.
- If a GNSS authentication service is mandated for certain specific security-critical applications, this service should not be based on a payable authentication commercial service.

The CS demonstrator (2014-2016)

Based on the results of the CS studies, the European Commission launched the CS Demonstrator project in early 2014. The project has been named *Authentic and Accurate Location Experimentation with the Commercial Service*, or AALECS. The contract has been awarded to a consortium led by GMV and involving CGI, QASCOM, IFEN, Veripos and KU Leuven. The project will last around two and a half years.

The AALECS project will build a platform to connect to the Galileo system and transmit CS data through the Galileo satellites. This platform is foreseen to be operational by 2015 and will demonstrate the CS real performance.

It should be noted that, in order to guarantee equal treatment in later stages of the CS exploitation roadmap, particularly in the case of high accuracy services, the CS Demonstrator is oriented to the development of a testing platform and authentication solutions. It is not funding any activity related to the development or adaptation of high accuracy solutions for the CS, and as soon as the platform is qualified, it will be open for testing by external entities.

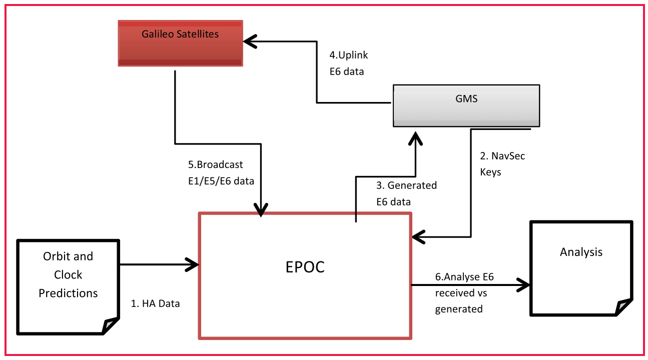


Figure 5: Early Proof Of Concept

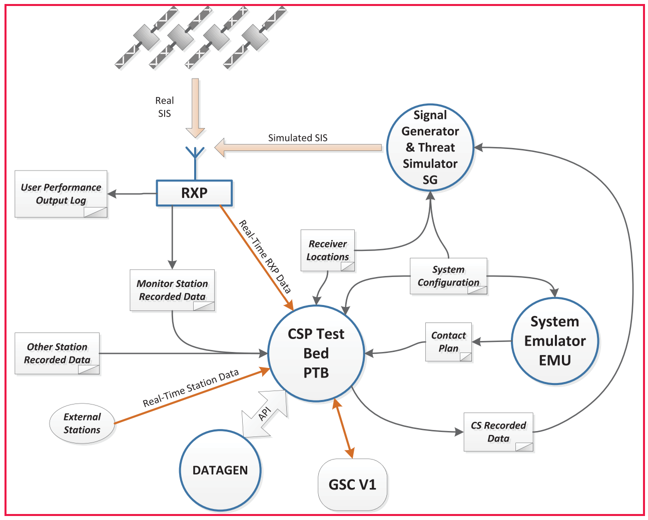


Figure 6: CS Demonstrator Architecture Overview. GSC stands for Galileo Service Centre

CS Early Proof-Of-Concept

Before that, the AALECS project will perform some early testing with the Galileo system to prove the CS concept viability during 2014. This early testing will be performed by an activity named CS 'Early Proof-Of-Concept', or EPOC, and its results will be officially reported at the Galileo Early Services Declaration.

The objective of the EPOC is to demonstrate the main functionalities of the Commercial Service at the Galileo Early Services milestone, which is currently foreseen for the end of 2014, or the beginning of 2015. This fact has led to a design philosophy in which simplicity has been the main driver.

The main requirement for the EPOC is to be able to test the capability of the Galileo System to correctly transmit CS data in the E6 band, including the demonstration of user applications at terminal level. In this framework, the main identified abilities of the EPOC are as follows:

- Testing the capability of the satellites to transmit data in the E6-B band.
- Testing the encryption and decryption process of the CS signal in E6-B and E6-C components.
- Testing the robustness and performance of position and timing authentication with the E6 real signals
- Testing the reception conditions of E6 signals in realistic target user environments

In order to perform this demonstration the EPOC shall be able to close the loop of E6 data from its generation to its reception (the loop steps have been numbered). Figure 5 depicts the communications links established between the EPOC and third parties and keeps the EPOC system as a black box.

By late June, the transmission by the available IOV Galileo satellites of data external to the Galileo system has been successfully demonstrated. The external data, that is, data generated outside of the Galileo perimeter and later injected into the system, were broadcast through the Galileo E6B signals for a period of some hours. Current tests under execution including authenticated satellite position information show promising performances.

The CS Demonstration Platform

In parallel to the proof-of-concept phase in 2014, a CS demonstrator platform is currently being developed. It will allow the transmission of CS data in real time from the Galileo satellites. Its architecture is shown in the figure 6.

The CS Demonstrator will consist of the following components:

- The CS System Emulator (EMU): is a software platform deployed on a commercial PC that will emulate the Galileo system including its bandwidth and latency capabilities and perform service volume simulations. Its key output is a Contact Plan describing which satellites will be connected to the ground segment and therefore able to send CS data. This plan will be used by other elements as a fundamental configuration parameter for test scenarios.
- CS Receiver Platform (RXP): is a multi-GNSS multi-frequency receiver with E6 capability and an attached hardware platform able to process Galileo E6 signal and other GNSS signals to log data and to communicate in real time with the CS Provider Test Bed. The RXP will be used as a Commercial Service Provider (CSP) monitor to feed the CS data generation algorithms, and also as a user terminal to test user performances.
- CS Provider Test Bed (PTB): is a real time platform able to process recorded data files from receivers. Through an Application Programming Interface (API), the PTB will allow up to five CS

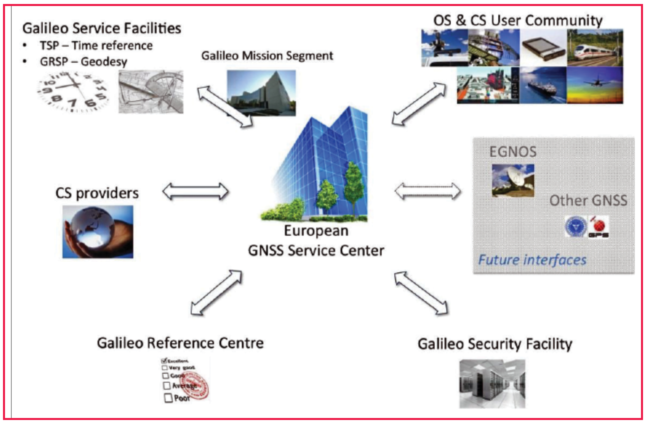


Figure 7: Overall context of the GSC

- data generation elements (DATAGENs) to be tested concurrently, either connected to the real Galileo system or to test equipment to allow the service to be explored thoroughly and with simulated stress scenarios. The PTB is the core of the CS Demonstrator.
- CS Signal Generator and Threat Simulator (SG): is a platform generating Galileo signals and allowing the testing of a receiver under different user conditions and threats. For example, it will simulate the representative threats at the Signal-In-Space level, such as meaconing, replay and spoofing attacks. This is a necessary function to test the performances of the authentication service.

Once the CS Demonstrator platform is built by mid-2015, and the GSC and the Galileo system are ready, the Real-time Signal-In-Space phase will start (Phase 2): in this phase, the CS Demonstrator platform will connect to the Galileo system through the GNSS Service Centre (GSC), which will enable the transmission of real-time E6 SIS data with a latency of some seconds. Once this chain is integrated and validated, the CS Demonstrator will start Phase 3. In this phase, it will support the connection of external service providers to test the transmission of their own data in the real Galileo CS signal.

The GNSS Service Centre and the CS Demonstrator

The GNSS Service Centre Nucleus (GSC-n) is the precursor of the fully-fledged GSC. Since November 2012, the GSC-n is providing basic services to the user community via a web portal (http://www.gsc-europa.eu/) and a dedicated user helpdesk. The web portal is conceived as the one-stop-shop for the Galileo users providing easy access to Helpdesk support, information on system status, user notifications and general programme information.

The fully-fledged GSC is identified as the element of the Galileo infrastructure providing a centralised ground interface between the broad Galileo Open Service (OS), Commercial Service (CS) user communities and the Galileo system infrastructure and operator for the provision of specific services beyond the Galileo Signal In Space (SIS) transmitted by the operational satellites.

This centre is conceived as a centre of expertise, knowledge sharing, custom performance assessment, information dissemination and support to the provision of value-added services enabled by the Galileo OS and CS core services. To implement these missions, the GSC has interface with the key elements of the Galileo ground segment, as well as with external entities. Figure 7 depicts the overall context of the GSC.

Phase 2 of the CS Demonstrator considers the connection of the platform to the Galileo system through the GNSS Service Centre (GSC V1) located in Torrejon de Ardoz, Madrid (Figure 5). This integration will be done on the basis of a CSP-GSC interface that is under definition in parallel with the rest of the CS activities. The main flow in this interface will be the CS data that is generated by the CSP and provided to the GSC for broadcast through the Galileo SIS. Other flows are under definition in this interface:

- Broadcast status information from the GSC to the CSP
- Transfer of CS key material from the GSC to the CSPs
- Provision of Galileo system status information to the CSPs and results of specific data queries
- Provision of off-line data to the CSPs to assist with their service provision
- Provision of near real-time data to the CSPs to assist with their service provision.

The integration activities of the CS Demonstrator with the GSC consider scenarios without Galileo SIS. This will facilitate the CS Demonstrator integration with the GSC even if no access to the Galileo SIS is possible at some stages. If necessary, the CS Demonstrator platform could be moved to the GSC for on-site integration.

As a result of this integration, the CS Demonstrator platform will be ready for the transmission of CS data through the Galileo signal within Phase 2 activities, and ultimately, during Phase 3 activities, it will support the connection of CSPs to test the transmission of their own data through the Galileo CS signal. This will be a valuable input for the final definition of the Galileo CS.

A key aspect of the CS provision architecture through the GSC will be security accreditation. The GSC project is regularly coordinating with the Galileo security team to develop an architectural solution that is secure while allowing the delivery of the CS.

Commercial exploitation

Potential users have indicated their willingness to pay for services offered by the Galileo CS. Market studies from the GSA Market Development Department predicted a potential 15 million worldwide user base for the CS with revenues in the order of 120 M€ per year, from both authentication and high accuracy services. These figures are sensitive on assumptions regarding the initial CS exploitation date and exploitation model that are under consolidation at the moment. The GSA has prepared in parallel a "CS Business Plan" with an analysis of the CS target markets and exploitation options.

In parallel to the market studies, GSA organises periodic industry consultations involving, among others, the main high accuracy commercial providers, to discuss technical and exploitation models proposed by the private sector and identify candidates for a potential service provision. The work by GSA confirms high accuracy and authentication as the most promising options for the CS according to the downstream market and industry.

GSA consultations and market studies have highlighted the fact that the window of opportunity for the CS may not remain open until the next generation of Galileo arrives. The services therefore should be available already for the Galileo 1st generation.

Authentication is a new market whereas there is already a global high accuracy market established. Therefore, when it comes to defining a commercialisation scheme, especially for High accuracy, it is important to understand how the arrival of a public infrastructure can affect the market and its competition. Galileo is aiming at increasing the global market on high accuracy rather than disrupting it.

The commercialisation scheme will be conceived once the services are fully defined. However, there are some key principles concerning cooperation between public and private sectors that the commercialisation scheme will need to follow:

- The commercialisation will be done in collaboration with the private sector (Commercial Service providers broadcasting high accuracy data via E6)
- The procedure for implementing the commercialisation scheme will be undertaken as openly as possible for all market actors
- The future scheme will aim at not disrupting the market – industry will be fully briefed and involved during regular industry consultations.

Summary and conclusions

The Galileo Commercial Service (CS) was a cornerstone of the Galileo public-private partnership exploitation strategy. Since the reorientation of Galileo exploitation in 2007, when the Concession approach was replaced by the full funding of Galileo by the European Union, the CS strategy has broadened to pursue the maximisation of public benefits, value creation, innovation promotion and navigation performance increase, in addition to the generation of revenues.

The Galileo CS is mainly based on 2 signals: E6B and E6C, modulated on a carrier frequency of 1278.75 MHz. The CS signals permit the transmission of 448 bps per satellite, and spreading code encryption. The current services foreseen to be offered by the CS are high accuracy and authentication.

High accuracy can be transmitted in the 448 bps of the E6B component. The current bandwidth and foreseen latency permit the transmission of precise point positioning (PPP) corrections from the Galileo satellites with an accuracy of a few centimetres. The final performances will depend on the Galileo downlink capabilities and system latency. One of the potential advantages of a high accuracy Galileo CS is the coverage and transmission robustness at high latitudes.

Authentication data can be accommodated in the spare bandwidth of the E6B and E1B signals, and can be also based on the spreading code encryption feature. The provision of an open data-based authentication service for end users and mass market applications, and a controlled spreading code-based authentication service for professional and institutional users is currently under study.

The Commission launched in December 2012 two 1-year parallel CS definition studies. The studies have confirmed the feasibility and potential of high accuracy and authentication. The next step is to build a CS Demonstrator platform, to test services with the real Galileo signal-in-space. This platform will be built as part of the AALECS ('Authentic and Accurate Location Experimentation with the Commercial Service') project, recently started. The first building block of this project is the Early Proof-Of-Concept, which between June and September 2014 will allow the testing of E6-based navigation authentication. In its operational setup, the CS Demonstrator will transmit data through the GNSS Service Centre, located in Torrejón, Spain. A key driver of the CS provision through the GSC will be security accreditation of an architecture allowing the transmission of CS data with an adequate latency.

The commercial exploitation of the Galileo CS is currently under definition, and will be further defined once the technical feasibility and timeline of the foreseen services is confirmed. In order to promote dialogue, transparency and equal treatment, GSA has established periodical consultations with users and industrial stakeholders, that allow to commercialise Galileo services in a way that avoids value destruction while maximises public benefits and the usage of Galileo assets. In any case, the Galileo CS represents a great opportunity for the European GNSS Programmes and has the potential to significantly improve the security and accuracy of worldwide civil location services.

Acknowledgements

The authors would like to acknowledge the CESAR, GALCS and AALECS teams for their contributions to the CS definition and demonstration, and O. Chassagne and H. Tork from the European Commission for their involvement on the Galileo Commercial Service in the last years.

References

European Union (2008), Regulation (EC) No 683/2008 Of The European Parliament And Of The Council of 9 July 2008 on the further implementation of the European satellite navigation programmes (EGNOS and Galileo). Official Journal of the European Union, L 196.

European Union (2010). European GNSS (Galileo) Open Service Signal In Space Interface Control Document. OD SIS ICD, Issue 1.1, September 2010.

European Union (2013), Regulation (EU) No 1285/2013 Of The European Parliament And Of The Council of 11 December 2013 on the implementation and exploitation of European satellite navigation systems. Official Journal of the European Union, L 347.

Fernández-Hernández, I. (2014), GNSS Authentication: Design Parameters and Service Concepts, Proceedings of the European Navigation Conference 2014, Rotterdam, Netherlands, n.150.

GPS Directorate (2012). Navstar GPS Space Segment/User Segment L5 Interfaces. 2012. IS-GPS-705C. 05-SEP-12.

Design and Validation of Korean WA-DGNSS Reference Station Software

In this paper, the results of design, implementation and validation of the Wide Area Reference Station software are described

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In Korea, technologies on WA-DGNSS (Wide area differential GNSS) has been being jointly developed by a consortium of universities and research organization in order to construct the system in the near future (Ho Yun et al., 2011 and Ho Yun et al., 2011). WA-DGNSS provides the correction data and integrity information via geostationary satellite to various users, i.e. aerospace, maritime, LBS etc (Fig. 1).

WA-DGNSS comprises Wide Area Reference Station, Master Station and User segment. Wide area reference station (WRS) receives data from the GNSS satellite, performs quality monitoring of decoded navigation data, and sends the correction data to the wide area master station (WMS) via terrestrial communication network. Wide area master station (WMS) processes the data collected from the WRS, and uplinks the calculated correction data as well as the integrity information to the geostationary satellite (GEO). GEO satellite downlinks the correction data to the users such as aerospace, marines, land applications etc for accurate and reliable positioning.

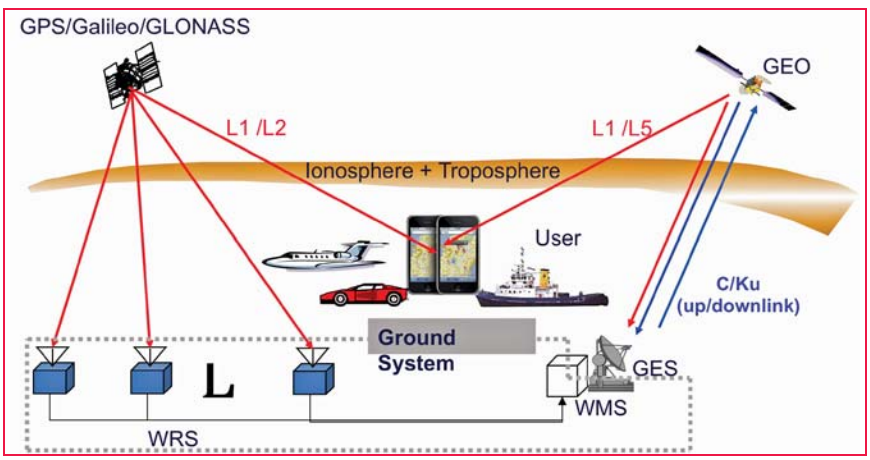

Figure 1: Korean WA-DGNSS Architecture

Figure 2: NDGPS Network in Korea

In Korea, the nationwide DGPS network (Fig. 2) completed by the MOF (Ministry of Ocean and Fisheries) in Nov. 2002, has been providing the dual coverage service since then. Some of the NDGPS reference stations are being considered for the utilization as the WRS of WA-DGNSS system. The internet based NTRIP (Network Transport of RTCM via Internet Protocol) service has also been provided to facilitate the DGPS service since Nov. 2002. Furthermore, the so called smart phone DGPS comprising electronic chart, NTRIP server and Bluetooth is expected to be provided in realtime by using the TDMB (Terrestrial Digital Multimedia Broadcasting) network from 2015.

This paper describes the results of design, implementation and validation of WA-DGNSS reference station software that is being carried out by applying the Object Oriented Programming methodology to provide flexibility in software: ease of model changes (ionospheric delay model), system addition (Galileo, GLONASS in addition to GPS) etc.

WRS software design

WRS software is designed to support the following functions of the Wide Area Reference Station (Changdon Kee et al., 2011) of the WA-DGNSS system:

- Collect Raw GPS Data
- Determine Satellite Orbits
- Determine Satellite Corrections
- Determine Satellite Integrity
- Calculate Ionospheric Delay
- Calculate Tropospheric Delay
- Calculate Pseudorange
- Estimate Pseudorange Residuals
- Monitor Data Quality
- Determine WRS Integrity
- Perform Data Verification
- Transmit Raw and Pre-processed Data to WMS
- Log data

The object oriented methodology is applied for the design of the WRS software that includes Use case diagram, Architecture diagram, Activity diagram and Class diagram. Data transmission from WRS to WMS is also designed to support TCP/IP communication between WRS and WMS.

Through the preliminary design phase (Uzair Ahmad et al. 2011 and Wan Sik Choi et al. 2012), UML based use case diagram is designed by identifying 18 use cases to fulfill the WRS functions. Based on the use cases designed, WRS software architecture is designed with 19 components in order to perform the designed use cases. The Activity diagrams (Fig. 3) and Class diagrams (Fig. 4) are generated as the results of the WRS software detailed design phase activities (W.S. Choi et al. 2013).

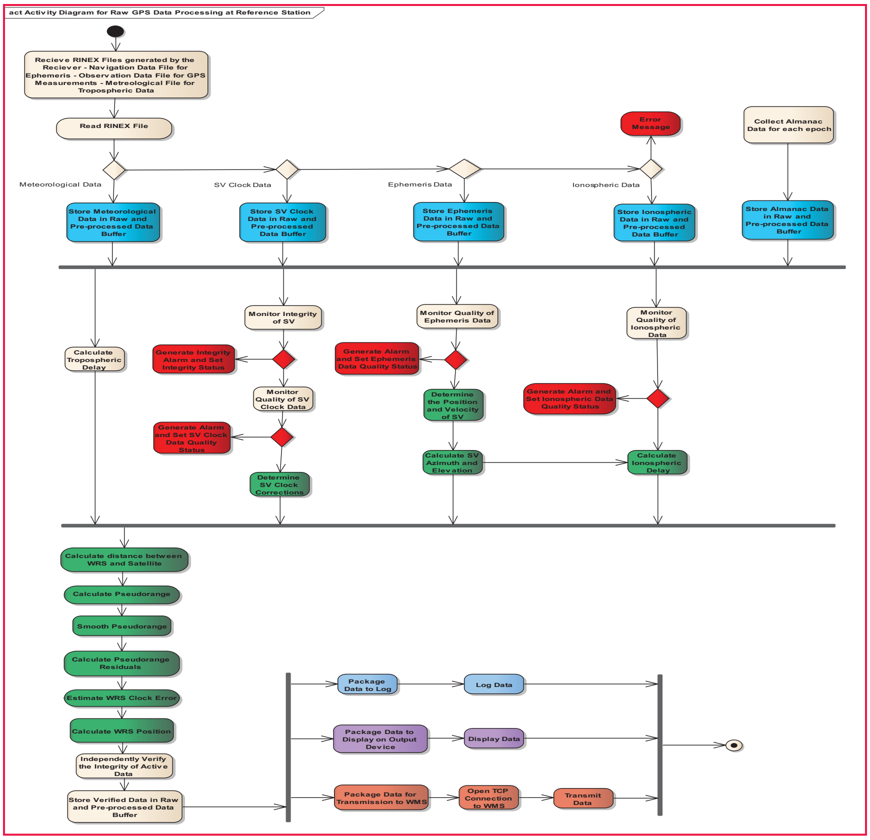

Figure 3: Activity diagram for GPS data collection, processing, store and data transmission to WMS

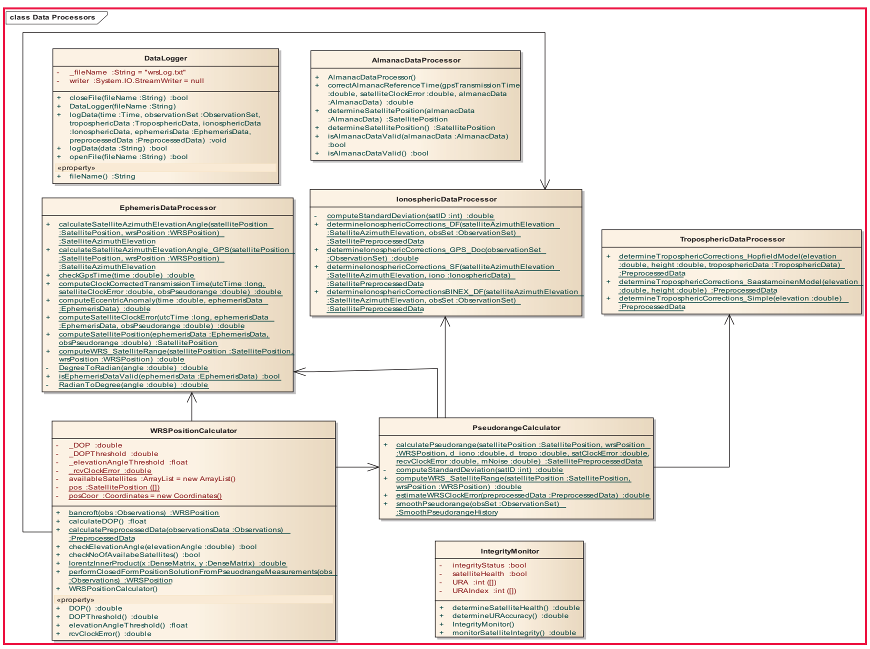

Figure 4: Class Diagram of WRS software Data Processor

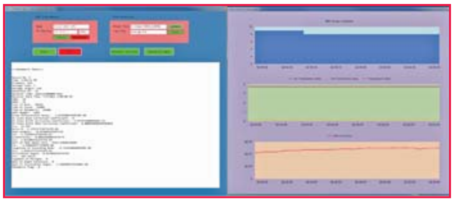

Figure 5: WRS Main Screen and Preprocessed data

Figure 6: Validation of BINEX data parsing

Activity diagram is designed to represent the workflows of stepwise activities and actions of WRS software. Elements of activity diagram include Start Node, Finish Node, Activity, Action, Control Flow, Decision Node and Fork/Join Nodes.

Major processing actions include calculations of ionospheric delay, tropospheric delay, SV (Space Vehicle) clock correction, pseudorange, pseudorange residuals etc.

Class diagrams are generated to represent the static structure of the WRS software, and each class is characterized by attribute, operation and relationship with other classes. WRS software class diagrams consist of three parts: WMSTCP Server class, WMSWRS Class Library, WRS Software class. WMSTCP Server class handles communication with client, and extracts data such as ephemeris data, ionospheric data, preprocessed data etc. WMSWRS Class Library handles time such as GPS time, and processes observation data set, ephemeris data packet etc. WRS software is the main class that comprises BINEX parser for realtime data processing, Data Handler data processing such as Raw Preprocessed Data Buffer, Data Processor for data processing such as Ionospheric Data Processor, Ephemeris Data Processor etc, User Interface for GUI processing, WRS_WMS Interface for data processing of data transmission to WMS. Fig 5 shows the Data Processor class diagram which is one of the class diagrams of the WRS software.

Implementation and validation

WRS software is implemented by using the OOP language C# in order to facilitate easy maintenance and extension (Wan Sik Choi et al. 2013). WRS software can be operated in post processing mode as well as in pseudo-realtime mode. BINEX (BINEX) parsing algorithm is implemented to support the pseudo realtime mode of the WRS software.

WRS software implementation includes components for initialization of WMS server, class libraries, Data Parser, Data handler, Data processor, user interface and WMS interface. Part of the WRS software implementation is shown in Fig. 5: WRS Main Screen for initialization, and preprocessed data screen of ionospheric delay etc.

Validation of the WRS software is carried out in two levels: data parsing level, modeling level. Validation of models such as ionospheric delay, pseudorange residuals etc is currently being carried. Validation of data such as BINEX data parsing has been completed as in follows. First, TEQC toolkit (TEQC) is employed to convert the BINEX data format to RINEX (RINEX) format. Then data generated from the BINEX parser module of the WRS software is compared with those from TEQC toolkit. Fig. 6 shows that the value of Square Semi Major Axis is same for both cases, i.e. values from TEQC and BINEX respectively.

Conclusions and future works

In this paper, results of design, implementation and validation of the WRS software are described. WRS software design is carried out by applying the OOP methodology in order to provide the flexibilities in software. Consequently, the software is implemented using the OOP language C#. Validation results in data level show that the data are processed correctly. Model level validation is currently being carried out. After completing the validation for both levels of data and model, extension of the WRS software will be considered for commercial level applications.

Acknowledgements

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References

BINEX – Binary Exchange format for GPS/GNSS, UNAVCO

Changdon Kee, Ho Yun, Wan Sik Choi,"Transmission Data Specification for GNSS (GPS) Wide area Reference Station", TTAK.KO-06.0266, Dec. 2011

Ho Yun, Changdon Kee, Doyoon Kim, "Availability Performance Analysis of Korean Wide Area Differential GNSS Test Bed", The Korea Navigation Institute, Vol 15, No 4, Aug. 2011

Ho Yun, Changdon Kee, and Doyoon Kim, "Korean Wide Area Differential Global Positioning System Development Status and Preliminary Test Results", International Journal of Aeronautical and Space Science, Vol. 12, No. 3, 2011, pp. 225-233

RINEX: The Receiver Independent Exchange Format Version 2.10, University of Berne, Dec. 10, 2007

TEQC — The Toolkit for GPS/GLONASS/Galileo/SBAS/Beidou/QZSS Data, UNAVCO

Wan Sik Choi, Shah Sayed Chhattan, Joong Eup Kye, Ho Yun, Changdon Kee, "Data Processing Design of Korean WA-DGNSS Reference Station", enc2012, 25-27 April 2012, Gdansk, Poland

W.S. Choi, S.S. Chhattan, J. E. Kye, W.Y. Han, H. Yun, C. Kee, "Flexible Software Design of Korean WA-DGNSS Reference Station", Int J on Marine Navigation and Safety of Sea Transportation, Vol 7, No 1, Mar. 2013, pp. 75-78

Wan Sik Choi, Shah Sayed Chhattan, Woo Yong Han, Ho Yun, Changdon Kee," Development of WA-DGNSS Reference Station Software", Korea Institute of Navigation and Port Research Conference, Oct. 2013, pp. 390-392

Uzair Ahmad, Choi Wan Sik, Changdon Kee, "Processing of WA-DGNSS Correction Messages: A Functional Perspective", The 18th GNSS Workshop, Phoenix Island, Jeju, Nov. 2011

TRIUMPH-LS

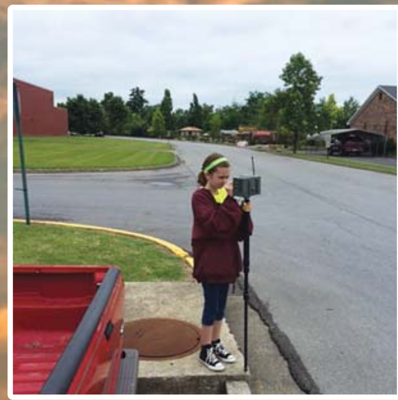

TRIUMPH-LS
Start
Warnings
Help
Lock
Interference
Screen
PrtScn
A/V
Battery
Stop
Collect
Stake
Coord. Sys
Localize
Points
Files
CoGo
Setup
Spectrum
Support
Tuesday, 10 September 2013
14:15:12
Set Up
Collect
Stake
On/Off
Mute
Light
User defined
U1
U2
U3
U4

JAVAD

Wake up to the new world!
Introducing the TRIUMPH-LS

Javad,
Just a note of appreciation. Thank you for implementing so many of my requests. We’re doing real work with this receiver: boundary, topographic and staking. The staking routines are very productive. Every release of the software gets better and better. The hardware is solid, showing great promise in a range of environments. I was skeptical of the all-in-one box approach, but you are winning me over every time I take it out. You’re breaking new ground and this system is unlike anything I’ve ever used.

Shawn Billings
Billings Surveying and Mapping Company



So easy my 12 year old can do it.

Matthew D. Sibole, PLS

- The adjustable and telescoping pole is lightweight and easy to collapse. This will make it easy to **walk through woods** and put into a car to drive around.
- The built in compass makes it **very easy to stake out** points. The stakeout screen points you in the right direction and gives you the distance to the point.
- Long battery life (**24 hours**)
- It seems to fix reliably in locations where **other receivers would stand a slim chance** of fixing.

Matt Johnson, PE

Here are some photos of my boys helping me survey out in the desert yesterday.

Jack M. Smith

I worked with the TRIUMPH-LS and Triumph-2 today for a few hours. I was impressed with the ability to get a good repeatable fix in pretty thick tree cover.
I also was able to localize on an assumed coordinate system without too much trouble. I don’t do this very often but was able to localize three times today (2 times just to write down try and memorize the process).

Matthew Siobel, PLS

Drop Test

See video at **www.javad.com**

GIS for predicting environmental pollution

This study predicts and maps the geographic distribution of copper Cu in the soils of northern Lebanon and soil organic carbon SOC across Denmark

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Lebanese University, Faculty of Letters and Human Sciences, Department of Geography, GIS Research Laboratory, Fanar, Lebanon

Detailed spatial information about environmental pollution/climate change is indispensable for land resources management, environmental decision-making and sustainable development. Distribution patterns of soil copper (Cu) content have a large potential to affect plant growth (chlorosis) (Lewis et al., 2001; Kumar Sharma et al., 2008), and are detrimental to animal and human health (acne, allergies, hair loss, anaemia, anorexia, arthritis, autism, migraine headaches, chronic infections, insomnia, neuralgia, sciatica, hypertension, schizophrenia, etc.) (Dauwe et al., 2006; Zheng et al., 2007; Huang et al., 2008). The geographic distribution of soil organic carbon (SOC) affects global climate, and the international efforts for using soils and vegetation as carbon sinks are rapidly increasing (IPCC, 2000). Changes in soil copper content/soil organic carbon distribution are attributed to both natural processes and human activities, the latter being widely recognized in recent years.

Land use changes, including deforestation, biomass burning, use of manure and inorganic fertilizers, waste disposal, enhanced urbanization, industrial contamination, vehicular emissions, etc. are continuously adding to the pool of Cu contaminant in the soils, and are regarded as the main factors causing loss of soil organic carbon (SOC) and the emission of CO_2 into the atmosphere. These changes can be significant in several areas, where very dense population is highly concentrated, and/or where intensive artificial drainage activities are carried out. This is particularly true in the case of Lebanon/Denmark; in Lebanon, an important increase of urban and industrial areas during the past 30 years has been noticed; and in Denmark, an important reduction of the total wetland area during the past 200 years as a result of much drainage activity (digging of drainage ditches and introduction of tile drainage) has been observed. As part of international efforts to fight the widespread occurrence of pollution in the coastal areas, it seems necessary to establish inventories of heavy metals for Lebanon. The international efforts are also gathered nowadays to stabilize atmospheric greenhouse gas concentrations, and Denmark (like several other countries) is committed to establish inventories of organic/mineral soil distribution in the frame of the Kyoto protocol.

Estimates of diverse heavy metals (including Cu accumulation) and soil properties (including SOC distribution) have been made in several countries using various modelling tools. Recently, different statistical methods have been used by several scientists to predict heavy metals (including Cu) and SOC, such as linear and non-linear regression (function fitting), logistic regression, artificial neural networks (ANNs), and genetic algorithms (e.g., Moore et al., 1993; Dobos et al., 2000; Gessler et al., 2000; Lin et al., 2002; Scull et al., 2003; Manzoor et al., 2006; Hengl, 2009). These methods are heterogeneous in terms of environmental input parameters, ease of use, sensitivity to parsimony, ease of interpretability, handling of mixed data, handling of non-linear relationships, etc. For instance, decision-tree based models are easy to interpret and discuss when a mix of continuous (e.g., elevation) and nominal (e.g., parent material) environmental parameters are used as predictors (McKenzie and Ryan, 1999; Breiman, 2001). They are scalable to large areas (Breiman, 2001), invariant to monotone re-expressions (transformations)

> Applying the preferred decision-tree models (with the high predictive capacity and lowest number of nodes) is relatively simple and practical

of predictor parameters (Scull et al., 2003), and can optimize non-additive and non-linear relationships between inputs (e.g., environmental independent parameters) and outputs (dependent variables) (Breiman, 2001). In addition, they are non-parametric/probabilistic, and do not require the specification of the form of a function to be fitted to the data, as is necessary for other competing procedures (e.g., non-linear regression) (Breiman, 2001). In contrast to artificial neural networks, once decision-tree models have been built, they can be converted to statements that are implemented easily in most computer languages, without requiring a separate interpreter. Moreover, decision-trees can indicate the relative weight of each predictor variable in explaining the training data, while bivariate analysis demonstrates only the implication of a couple of predictor variables against the target variable. Decision trees also have excellent prediction capabilities (Breiman, 2001); however they have been criticized for overfitting and poor performance on small datasets (McKenzie and Ryan, 1999).

The decision-tree method is increasingly being used in thematic mapping from remotely sensed data (Huang and Jensen, 1997; Friedl et al., 1999) and habitat modelling in ecology (Michaelsen et al., 1994; Kandrika, 2008). In soil science, the decision-tree method has been used to create a map of soil types based on field investigation from a small reference area (Lagacherie et al., 1995), to improve existing soil and geological maps (Bou Kheir et al., 2008a), to model individual soil properties (Zhou et al., 2003), and to predict soil erosion occurrence (Bou Kheir et al., 2008b). However, the potential of decision-trees to contribute to the field of soil pollution (by heavy metals)/climate change has received little attention. In this context, this study proposes systematic regression/classification tree-models to predict the spatial distribution of soil Cu contents and SOC classes, based on the analysis of environmental parameters likely to impact soil Cu concentrations/ SOC classes and quantification of their weights using Geographic Information Systems (GIS) in northern Lebanon and Denmark. They comprise a set of rules to classify (predict) a dependent target variable [Cu concentration in mg kg^{-1} or SOC class (organic or mineral)], using the values of independent predictor environmental variables (both natural and anthropic). The predictive Cu/SOC maps resulting from the conversion of the best decision-tree models, at 1:50,000 cartographic scale, serve as inventories useful for land use management and environmental decision-making.

Materials and methods

Soil samples collection and laboratory analysis

A sampling program of surface soil from 200 sites in Lebanon and 1541 in Denmark reflecting the different land uses was established. The Lebanese sampling was partly done in spring, when snowmelt increases the availability of running water – as a means of mobilizing contaminants. It was completed in summer, when drier conditions allow a higher concentration of the contaminants. The Danish sampling was based on four different existing field surveys to represent the studied area in Denmark.

The field sites in the Lebanese case study were chosen by random stratified sampling method to cover all landscape units that differ by at least one of the following variables: geological substrate, soil type, slope gradient and land cover/use (Bou Kheir et al., 2004). These landscape units were determined by combining the corresponding GIS layers. Additional sites were also sampled, if the covered area of a given landscape unit was important. A sampling density of one sample per km^2 was used. Geographic locations of all Lebanese sampling points (200) were determined using a global positioning system (GPS) with 10 m precision. The collected soil samples were then stored in polyethylene bags for transport and storage. These samples were air-dried in an oven at 50 °C for three days and subsequently sieved through a 2.0 mm polyethylene sieve to remove stones, coarse materials and other debris. Soil subsamples (around 20 g) were placed in a mechanical agate grinder and finely ground (5200 mm). The ground soil samples were analyzed for copper using an aqua-regia digestion method. Approximately 0.5 g of the soil samples was weighed and placed in pre-cleaned Pyrex test tubes. Concentrated nitric acid (8 ml) and 3 ml of concentrated perchloric acid were added. The mixtures were heated in an aluminum block at 200 ºC for 3 hours, until they were completely dry. After the test tubes were cooled, 10.0 ml of 5% HNO_3 was added and heated at 70 °C for an hour with occasional mixing. Upon cooling, the mixtures were decanted into polyethylene tubes and centrifuged at 3500 rpm for 10 min. Copper concentrations of the solutions were measured using inductively coupled plasma-atomic emission spectrometry (ICP-AES; Perkin-Elmer 3300 DV).

The collected Danish samples (around 25 bulk samples at each site) in two of the existing surveys [Danish Soil Classification (1975) and the Danish Profile Investigation (1990)] were taken within a radius of 50 m from a depth of 0–30 cm (plough layer). These samples were air-dried at room temperature and passed through a 2 mm soil sieve. Concentrations of soil organic carbon (SOC) were determined by the combustion method in a LECO induction furnace, converted to % Soil Organic Matter (SOM) using a factor of 1.72. The other two surveys (ochre classification and well database performed in 1985) gave categorical information on parent material (e.g. peat, sand, silt and clay). This parent material information was reclassified into organic and mineral soils. In order to increase the number of samples used in the modeling process, the continuous soil organic matter (SOM) obtained in the former surveys was converted to a categorical variable (organic/mineral soil occurence) using 10% SOM as a cut off value (commonly used in Denmark). With less than 10% SOM, soils are classified as mineral; and with more than 10% SOM, soils are considered organic.

Collection of predictor environmental parameters explaining Cu/SOC accumulation

Soil Cu/SOC accumulation depends on local site-specific conditions (e.g.,

parent material, soil properties, etc.) as well as on the type of land use and land management (De Temmerman et al., 2003; Remon et al., 2005). For this reason, in the Lebanese regression-tree analysis, fifteen environmental parameters were selected as independent variables, whereas the values of Cu pollution were dependent variables. While in the Danish classification-tree analysis, thirteen environmental parameters were considered as predictors and the classes of SOC (mineral/organic) were regarded as the target variable.

The generated parameters in the Lebanese case study, i.e. parent material, soil type, pH, hydraulic conductivity, organic matter, stoniness ratio, soil depth, slope gradient, slope aspect, slope curvature, distance to drainage line, land cover/use, proximity to roads, nearness to cities, and surroundings to waste areas were extracted from satellite imageries, digital elevation models (DEMs), ancillary maps and/or field observations. These parameters were chosen according to our field observations, and most of them were used to build predictive models of Cu variation in similar (prevailing in Mediterranean environments) or dissimilar environmental conditions (Facchinelli et al., 2001; Zhang et al., 2011). Parent material and soil type were extracted from scanned and registered geological/soil maps of Lebanon (Dubertret, 1945; Gèze, 1956). Soil pH, hydraulic conductivity and organic matter content were analyzed, respectively, by soil suspension in water and chlorhydric acid (ratio 1:2), double rink, and oxidation with potassium chlodide ($K_2Cr_2O_7$). Soil depth was measured through a sounding by an auger at each site. Stoniness ratio (which is the relative proportion of stones on the soil surface) was determined by visual observations with five classes: < 5%, 5–35%, 35–65%, 65–95%, and > 95%. A digital elevation model (DEM) was generated for the Lebanese area from topographic sheet maps at a scale of 1:20,000 with elevation contour intervals of 10 m (DGA, 1963). The established Triangular Irregular Network (TIN) was then converted to a grid of 25-m pixel resolution. This resolution was chosen to match the planimetric and altimetric accuracies. Four terrain attributes were then derived from the constructed DEM using specific ArcView software algorithms: slope gradient (angle), slope aspect, slope curvature, and drainage networks. The influence of drainage was given to the buffer zone up to a distance of 50 m from the closest drainage line (Saha et al., 2002). Thus, five classes were determined in the Lebanese study area, ranging from less than 50 m and more than 200 m. The land cover/use parameter was estimated through visual interpretation of high resolution IKONOS imageries (1 m) acquired in October 2008. Fifty-eight land cover/use classes were plotted according to CORINE/ENICOR (Coordination des Informations sur l'ENvironnement/ENV.IN.COR.) Land Cover methodology (level 4), belonging to five major categories: (1) natural vegetation cover, (2) agricultural lands, (3) bare lands, (4) water bodies, and (5) human practices. The class of human practices is reflected by discontinuous and continuous urban and industrial areas and road networks (with vehicle-related activities). For that, a buffer zone of 50 m around cities/boundaries and roads was selected, and five classes were distinguished for each (i.e., nearness to cities and proximity to roads) ranging from less than 50 m to more than 200 m from the road. The concentration of copper may also result from burning of waste in the environment. The influence of waste areas on Cu accumulation can reach several meters to several kilometers from the point source depending on the industry involved, and it is not easy to determine the distance affected. Here, 50 m, 100 m, 150 m, 200 m, and more than 200 m were selected as the buffer distance around the waste areas.

While in the Danish case study, nine primary (elevation, slope angle, slope aspect, plan curvature, profile curvature, tangent curvature, flow direction, flow accumulation, and specific catchment area) and one secondary (steady-state topographic wetness index) topographic parameters were generated from Digital Elevation Models (DEMs) acquired using airborne LIDAR (Light Detection and Ranging) systems. The latter seem effective and reliable means of terrain data collection in relatively large areas with cloudy weather conditions (Baltsavias, 1999; Brian et al., 2007; Schmitt et al., 2007; Liu, 2008). The established triangular irregular network (TIN) was converted using a TOPOGRID algorithm to an ArcGIS grid of 1.6-m pixel resolution. This resolution was chosen to match the planimetric and altimetric accuracies of LIDAR systems. In order to increase the efficiency in terms of storage and manipulation, and to acquire homogeneity and standardization with used ancillary maps, the constructed high-resolution DEM was coarsened in this study to 25-m resolution. The produced elevation surface (DEM) would still contain several spurious elements, usually classified either as sinks or peaks (one or two cells below or above the local surface). The errors vary between 0.1 m and 4.7 m in a typical 25 m DEM (Tarboton et al., 1991). Although many authors agree that sinks and peaks may actually represent the true nature of topography (Chorowicz et al., 1992), they may act as local barriers that trap water flow and cause a major problem for drainage network extraction. To avoid this problem and before performing any hydrologic analysis, sinks in the DEM were identified and eliminated using TerraStream software (Danner et al., 2007). The topographic predictor parameters were used along with existing digital data collected from other sources (soil type, geological substrate and landscape type) to explain organic/mineral field measurements in hydromorphic landscapes of the chosen Danish area.

Decision-tree analysis of Cu/SOC distribution

The field survey data were split into two files, one compiling 80% of the field samples (160 Lebanese sites and 1233 Danish sites) used in the modelling process, and another one comprising 20% used in the validation phase (40 Lebanese sites and 308 Danish sites). All mentioned predictor environmental parameters were overlaid with the field samples point-theme-layer. This overlaying has permitted defining for each of the field samples the related parametric classes, that the field samples lie spatially into.

Different sets of un-pruned Lebanese regression-tree models (214) and Danish classification tree-models (186) were explored on the collected field data. In the Lebanese case, the trees were constructed using all of the environmental parameters, (ii) all soil parameters only, and (iii) selected pairs of parameters. While in the Danish case, the trees were developed using (i) all of the environmental parameters, (ii) the primary morphological/ hydrological parameters, (iii) selected pairs of parameters, and (iv) excluding each parameter at one time from the potential pool of predictor parameters.

Once the trees have been developed, they encode a set of decision rules that define the range of conditions (values of environmental parameters) best used to predict each Cu value/SOC class. The process is recursive, growing from the root node (complete data set) to the terminal nodes in a dentritic fashion (Friedl et al., 1997). The trees created are usually very large with multiple terminal nodes, meaning that the models are intimately fitted on the training data (Lagacherie et al., 1995). Each terminal node is assigned the label of the majority class (Bou Kheir et al., 2010). Splits or rules, defining how to partition the data, are selected based on information statistics that measure, how well the split decreases impurity (heterogeneity or variance) within the resulting subsets (Breiman, 2001). The number of splits to be evaluated is equal to $2^{(k-1)}$ -1, where k is the number of categorical classes of predictor parameters (Loh and Shih, 1997). We considered differences in the value of a continuous variable up to 1% of the whole range, which is equivalent to ten thousand classes (Loh and Shih, 1997).

The algorithm used for evaluating the quality of the constructed trees is the Gini splitting method, which is considered as the default method (Breiman, 2001). The Gini coefficient is used to measure the degree of inequality of a variable in terms of frequency distribution. It ranges between 0 (perfect equality) and 1 (perfect inequality). The Gini mean difference (GMD) is defined as the mean of the difference between each observation and every other observation (Breiman, 2001) (Eq. 1):

$$GMD = \frac{1}{N^2} \sum_{j=1}^{N} \sum_{K=1}^{N} \left\{ \left| X_j - X_K \right| \right\} \qquad (1)$$

where X is cumulative percentage (or fractions) and their respective values (j and k) and N is the number of elements (observations).

Pruning the constructed trees is necessary to prevent the models from being over-fit to the sample data, and to reduce tree complexity. We used cost-complexity pruning with an independent data set (a pruning data set) to produce a plot of training error rate versus tree size (Safavian and Norvig, 1991). The cost complexity pruning method guarantees to find the best (with respect to misclassification cost) pruned tree of a specific size (number of terminal nodes) of an initial un-pruned decision tree (Breiman, 2001; Bui et al., 2006).

Construction and validation of the Cu concentrations/SOC maps

Using the preferred Lebanese regression-tree model (having the highest predictive power, and the lowest number of terminal nodes and predictor parameters as well) and the favored Danish classification-tree, predictive maps of Cu concentrations and organic/inorganic landscapes were produced under a GIS environment through the application of the prediction tree rules. These maps were validated (using MSEs, error matrices, etc.) based on field surveys using the independent datasets.

Results and discussion

Tree-model evaluation

The Lebanese regression tree-model based on soil pH and surrounding the waste areas showed the highest predictive power, classifying 77% of the data correctly, and pruned to twelve terminal nodes. This model is easy to understand and fast to use for making predictions (given the fact that the surrounding of waste areas can be easily and quickly constructed whenever satellite imageries are available, which is the case in most countries).

The Danish classification-tree model (Fig. 1) based on soil type and steady-state topographic wetness index (CTI) showed the highest predictive power, classifying 68% of the data correctly and pruned to fourteen terminal nodes. The CTI proved to have a significant contribution to the estimation of hydromorphic organic landscapes since it is a predictor of zones of soil saturation, and organic carbon often accumulates in lowland (concave) soils for two reasons: (1) on steep slopes, dry soil conditions prevail due to more rapid removal of water causing an important decrease in soil organic carbon, and (2) concave slopes can concentrate more water and sediments indicating the potential accumulation of a large quantity of soil organic carbon (SOC).

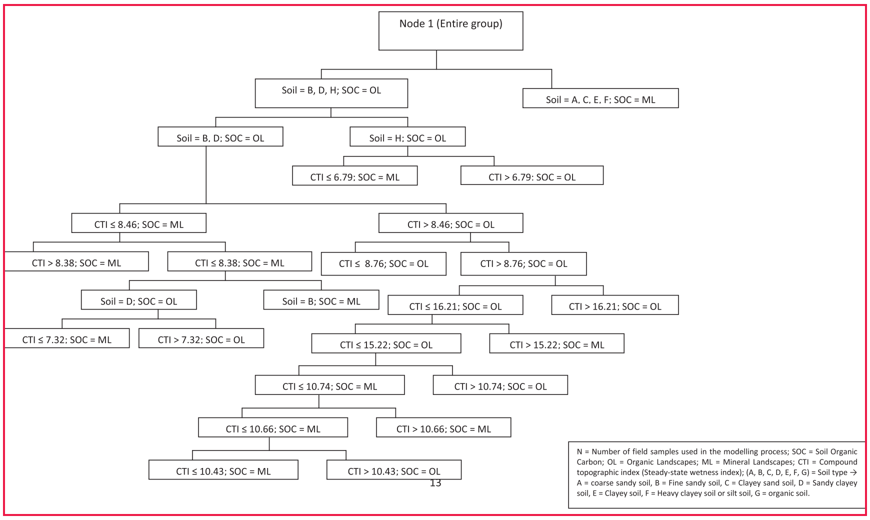

Figure 1: Classification-tree model based on the combination of soil type and steady-state wetness index for predicting the spatial distribution of hydromorphic organic landscapes.

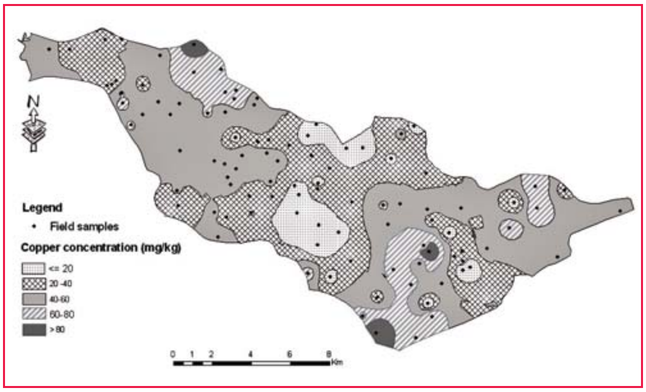

Figure 2: Predicted copper concentration map of the study area produced using the regression-tree model based on the combination of soil pH and surrounding to waste areas.

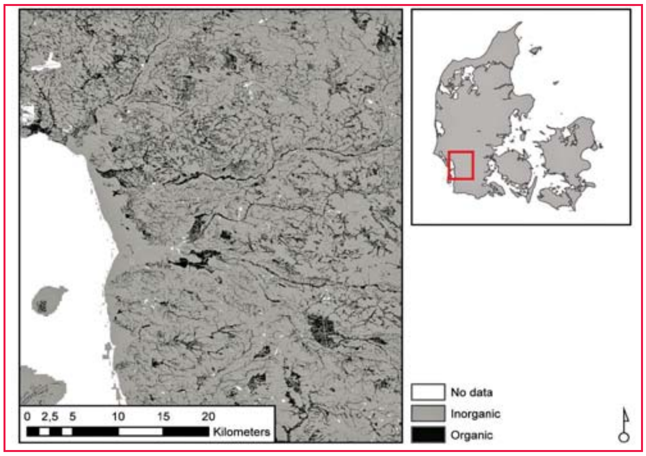

Figure 3: Map showing the distribution of hydromorphic organic landscapes in the chosen study area within Denmark.

Map production and validation

The predictive concentration map of copper (Fig. 2), at a 1:50,000 cartographic scale, was produced using the results of the preferred regression-tree model (based on soil pH and surrounding to waste areas). In this map, class 3 (with a Cu concentration ranging between 40 and 60 mg kg^{-1}) covers the largest area (44%) being dispersed in the studied region. This indicates a widespread higher risk of contamination, if no remedial measures are applied. Classes 4 (high contamination) and 5 (very high contamination) occur in 15% of the area, but they have a far larger impact, since they are distributed as patches in densely populated areas. The predicted Cu values were verified against test data, and the mean squared error was low (being equal to 0.28). The overall accuracy of the predictive quantitative copper (Cu) map produced using this tree-model (at 1:50,000 scale) was estimated to be ca. 80%.

The produced predictive map of organic/ inorganic landscapes (Fig. 3) at 1:50,000 cartographic scale using the classification tree-model based on the combination of soil type and steady-state wetness index, indicates that 7.5% of the wetlands in the Danish study area correspond to organic landscapes, and 92.5% to mineral (inorganic) landscapes. The confusion matrix between the measured organic/ mineral soil occurence' classes and the modelled ones indicates a good overall accuracy of ca. 75%. This accuracy value is different from the explained variance of the preferred classification-tree model (68%), since it is dedicated to validate all adopted approaches combining the integration of soil survey collection, geomorphometrical analysis and decision-tree modeling.

Advantages of the constructed Cu/SOC decision-tree models

Many aspects of GIS decision-trees make them appealing models to use in predictive environmental pollution/climate change mapping. It is clear that the built trees performed significantly the prediction of Cu concentrations/SOC classes, and supplied some additional advantages like the speed and objectivity of the results. These Cu/SOC decision-trees are useful for integrating and determining the exact weights of a wide variety of predictor environmental parameters (both nominal and continuous). They can be extrapolated to other areas and countries (like Saudi Arabia) if the functional capacities of GIS are used, because they allow the integration of several parametric maps (e.g., parent material, soil type, slope gradient, etc.) for producing a landscape unit map, on which Cu/SOC measurements can be determined.

The preferred regression-tree model (with the highest predictive capacity – 77% and the lowest number of terminal nodes) has defined a map of copper concentration with five classes for a region situated in the northern part of Lebanon (195 km^2). Such a map is unavailable in Lebanon, as well as in many other countries. It represents the result of modelling from environmental characteristics, and can meet the scientific needs of researchers and decision-makers for exploring land management scenarios.

The concept of regression-tree modelling can also be tested for other heavy metals (e.g., lead, cadmium, nickel, etc.), if their concentrations in mg kg^{-1} are measured. Because the availability of digital environmental parameters to serve as predictor variables in predictive heavy metals models (including copper) will vary from one location to another, the flexibility of regression-trees is very attractive.

Limitations of the proposed Cu/ SOC decision-tree models

The proposed decision-tree methodology can only be used in situations, where environmental parametric maps and field/ laboratory measurements of heavy metals/ SOC values exist, and the resulting predictions will only have significance in areas composed of similar landscape. The analysis of the explained variance for the built decision tree-models suggests their possible improvement using enhanced scale/ resolution of environmental parameters, or other parameters yielding a finer detail and subtle relationships in Cu/SOC distribution and accumulation such as soil structure, soil compactness, soil permeability, slope length, etc. The use of more advanced topographic DEM indices such as the quasi-dynamic wetness index, stream power index or others as extracted from remote sensing data (e.g., Normalized Difference Wetness Index, Soil-Adjusted Vegetation Index, etc.) may contribute to explaining also additional variance of the built Cu/SOC decision-trees.

Although the chosen scale (1:50,000) seems to be sufficient for estimating the

Cu concentrations/SOC classes to consider strategies for land protection, the produced predictive maps can be improved for more localized contamination /climate change assessment, if more detailed datasets are available, including higher resolution satellite imageries and DEMs, as well as more detailed parameter layers, that serve for producing the landscape unit map among which field measurements were conducted. The fact that some of the investigated environmental parameters appear critical in tree-model formation for this dataset can be advantage in decision-tree analysis. Some authors have criticized the tendency of decision-tree models to produce stepped prediction surface (Gessler et al., 1995). Such a situation can result from mixing predictor variables with different scales and/or data types, or can be the result of individual variable splitting rules defined by the model. Mixing different environmental parameters can result in decreasing or increasing the error rates, and for this reason 214 regression-trees and 186 classification-trees were constructed in this study to derive the critical Cu/SOC-influencing parameters in the overall tree-modelling (in terms of predictability), that have to be included in the regression/classification-tree analysis for predicting Cu concentrations/SOC classes.

Conclusions

The constructed regression/classification-tree models enabled, for the first time, mapping of predicted Cu concentrations/SOC classes in Lebanon and Denmark at a scale of 1:50,000, based on environmental characteristics (e.g., parent material, soil type, slope gradient, land cover/use, etc.). The decision-tree analysis also provides insight into the environmental parameters that are most responsible for driving Cu/SOC content in soils. In our study, soil pH and surrounding the waste areas were the main parameters associated with high accumulation of soil Cu. Soil type and steady-state topographic wetness index – proved to be the most important variables for predicting SOC (indicator of climate change), indicating that complex or secondary topographic variables show stronger relationships to organic/mineral soil occurrence than primary topographic attributes.

Applying the preferred decision-tree models (with the high predictive capacity and lowest number of nodes) is relatively simple and practical, and may be used in other countries. It is certainly of significant interest to local governments and municipalities. It will serve several development projects concerned with improving the environmental conditions, and the quality of living. Its immediate benefit would be for decision-makers and planning managers, as it does not require a lot of effort while investigating land degradation, especially environmental deterioration and community vulnerability.

Continuing analysis of this environmental database will consist of comparing decision-tree modelling approach with other sophisticated techniques (e.g., fuzzy logic, artificial neural networks, stepwise regression, trend surface analysis, regularized smooth spline, etc.) for explaining the heavy metals'/SOC' spatial variation. Future work will also seek to gather additional environmental data, so we can examine whether or not other environmental parameters (with finer scales/resolutions) can predict the distribution of Cu concentrations/SOC classes with greater precision and reliability. This is an area rich with implications for possible future research involving prevention, protection and mitigation of contaminated areas by heavy metals.

References

Baltsavias, E.P., 1999. A comparison between photogrammetry and laser scanning, *PRS*, 54(2–3), 83–94.

Breiman, L., 2001. Decision-tree forests. Machine Learning, 45(1), 5–32.

Bou Kheir, R., Girard, M.-C., Khawlie, M., 2004. Use of a structural classification OASIS for the mapping of landscape units in a representative region of Lebanon. *Canadian Journal of Remote Sensing*, 30(4), 617–630 (in French).

Bou Kheir, R., Chorowicz, J., Abdallah, C., Dhont, D., 2008a. Soil and bedrocks distribution estimated from gully form and frequency: a GIS-based decision-tree model for Lebanon. Geomorphology, 93, 482–492.

Bou Kheir, R., Abdallah, C., Runnstrom, M., Martensson, U., 2008b. Designing erosion management plans in Lebanon using remote sensing, GIS and decision-tree modeling. *Landscape and urban planning*, 88, 54-63.

Bou Kheir, R., Bøcher, P.K., Greve, M.B., Greve, M.H., 2010. The application of GIS based decision-tree models for generating the spatial distribution of hydromorphic organic landscapes in relation to digital terrain data. *Hydrology and Earth System Sciences*, 14(6), 847-857.

Brian, E., Roth, K., Clint Slatton, M., Cohen, J., 2007. On the potential for high-resolution lidar to improve rainfall interception estimates in forest ecosystems. *Front Ecological Environment*, 5(8), 421–428.

Bui, T.H., Zwieu, J., Poel, M., Nijholt, A., 2006. Toward affective dialogue modeling using partially observable markov decision processes, Proceedings of workshop emotion and computing, 29th Annual German Conference on Artificial Intelligence, edited by: Reichardt, D., Levi, P., and Meyer, J. C., Bremen, Germany, 47–50, June 2006.

Chorowicz, J., Ichoku, C., Riazanoff, S., Kim, Y.J., Cervelle, B., 1992. A combined algorithm for automated drainage network extraction. *Water Resources*, 28(5), 1293–1302.

Danner, A., Yi, K., Mølhave, Th., Agarwal, P.K., Arge, L., Mitasova, H., 2007. TerraStream: from elevation data to watershed hierarchies. Proceedings of the 15th International Symposium on Advances in Geographic Information Systems (ACM GIS).

DGA, 1963. Topographic maps at a scale 1:20.000. Direction of Geographic Affairs, Republic of Lebanon.

De Temmerman, L., Vanongeval, L.B., Hoenig, M., 2003. Heavy metal content of arable soil in Northern Belgium. *Water, Air and Soil Pollution*, 148, 61-76.

Dauwe, T., Janssens, E., Eens, M., 2006. Effects of heavy metal exposure on the condition and health of adult great tits (Parus major). *Environmental Pollution*, 140(1), 71-78.

Dobos, E., Micheli, E., Baumgardner, M. F., Biechl, L., Helt, T., 2000. Use of

combined digital elevation model and satellite radiometric data for regional soil mapping. *Geoderma*, 97, 367-391.
Dubertret, L., 1945. Geological Maps of Lebanon at 1:50.000 Scale. Ministry of Public Affairs, Republic of Lebanon.
Friedl, M.A., Brodley, C.E., 1997. Decision-tree classification of land cover from remotely sensed data. *Remote Sensing of the Environment*, 61, 399–409.
Friedl, M.A., Brodley, C.E., Strahler, A.H., 1999. Maximizing land cover classification accuracies produced by decision trees at continental to global scales. *IEEE Geosciences Remote*, 37, 969–977.
Facchinelli, A., Sacchi, E., Mallen, L., 2001. Multivariate statistical and GIS-based approach to identify heavy metal sources in soils. *Environmental Pollution*, 114, 313–324.
Gèze, B., 1956. Soil map of Lebanon at a scale of 1:200.000, Explicative Note. Republic of Lebanon. Ministry of Agriculture, Beirut, Lebanon.
Gessler, P.E., Moore, I.D., McKenzie, N.J., Ryan, P.J., 1995. Soil landscape modeling and spatial prediction of soil attributes. *International Journal of Geographic Information Systems*, 9, 421-432.
Gessler, P.E., Chadwick, O.A., Chamran, F., Althouse, L.D., Holmes, K.W., 2000. Modelling soil-landscape and ecosystem properties using terrain attributes. *Soil Science Society of American Journal*, 64, 2046–2056.
Hengl, T., 2009. A practical guide to geostatistical mapping. 2nd Edt., University of Amsterdam, 291p, http://spatial-analyst.net/book/GstatIntro.
Huang, X., Jensen, J.R., 1997. A machine-learning approach to automated knowledge-base building for remote sensing image analysis with GIS data. *Photog. Eng. & Remot. Sens.*, 63, 1185-1194.
Huang, M., Zhou, S., Sun, B., Zhao, Q., 2008. Heavy metals in wheat grain: assessment of potential health risk for inhabitants in Kunshan, China. *Science of the Total Environment*, 405(1-3), 54-61.
IPCC, 2000. Land-use, land-use change, and forestry, in: Land-use, landuse change, and forestry, edited by: Watson, R. T., Noble, I. R., Bolin, B., Ravindranath, N. H., Verardo, D. J., and Dokken, D. J., A special report to the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, Cambridge, UK, 1–51.
Kandrika, S., 2008. Land use/land cover classification of Orissa using multi-temporal IRS-P6 awifs data: a decision tree approach. *International Journal of Applied Earth Observation and Geoinformation*, 10(2), 186-193.
Kumar Sharma, S., Madhoolika, A., Fiona, M., 2008. Heavy metal (Cu, Zn, Cd and Pb) contamination of vegetables in urban India: A case study in Varanasi. *Environmental Pollution*, 154 (2), 254-263.
Lagacherie, P., Legros, J.P., Burrough, P.A., 1995. A soil survey procedure using the knowledge of soil pattern established on a previously mapped reference area. *Geoderma*, 65, 283–301.
Lewis, S., Donkin, M.E., Depledge, M.H., 2001. Hsp70 expression in Enteromorpha intestinalis (Chlorophyta) exposed to environmental stressors. *Aquatic Toxicology*, 51, 277-291.
Lin, Y.P., Teng, T.P., Chang, T.K., 2002. Multivariate analysis of soil heavy metal pollution and landscape pattern in Changhua County in Taiwan. *Landscape and Urban Planning*, 62, 19–35.
Liu, X., 2008. Airborne LiDAR for DEM generation: some critical issues. Progress of Physical Geography, 32(1), 31–49.
Loh, W.Y., Shih, Y.S., 1997. Split selection methods for classification trees. *Stat Sinica*, 7, 815–840.
Manzoor, S., Munir, H.S., Shaheen, N., Khalique, A., Jaffar, M., 2006. Multivariate analysis of trace metals in textile effluents in relation to soil and groundwater. *Journal of Hazardous Materials*, A137, 31–37.
McKenzie, N.J., Ryan, P.J., 1999. Spatial prediction of soil properties using environmental correlation. *Geoderma*, 89, 67–94.
Michaelsen, J., Schimel, D.S., Friedl, M.A., Davis, F.W., Dubayah, R.C., 1994. Regression-tree analysis of satellite and terrain data to guide vegetation sampling and surveys. *Journal of Vegetation Science*, 5, 673–686.
Moore, I.D., Gessler, P.E., Nielsen, G.A., Peterson, G.A., 1993. Soil attribute prediction using terrain analysis. *Soil Science Society of America Journal*, 57, 443–452.
Remon, E., Bouchardon, J.L., Cornier, B., Guy, B., Leclerc, J.C., Faure, O., 2005. Soil characteristics, heavy metal availability and vegetation recovery at a former metallurgical landfill: Implications in risk assessment and site restoration. Environmental Pollut.ion, 137(2), 316-323.
Safavian, S.J., Norvig, P., 1991. A survey of tree classifier methodology. *IEEE T. Syst. Man. Ct. A*, 21, 660–674.
Saha, A.K., Gupta, R.P., Arora, M.K., 2002. GIS-based landslide hazard zonation in the Bhagirathi (Ganga) valley, Himalayas. *International Journal of Remote Sensing*, 23(2), 357–369.
Scull, P., Franklin, J., Chadwick, O.A., 2005. The application of classification tree analysis to soil type prediction in a desert landscape. *Ecological Modeling*, 181, 1–15.
Schmitt, N.P., Rehm, W.F., Pistner, T., Zeller, P., Diehl, H., Nave, P., 2007. The AWIATOR airborne LIDAR turbulence sensor. *Aerospace Sci. Technol.*, 11(7–8), 546–552.
Tarboton, D.G., Bras, R.L., Rodriguez-Iturbe, I., 1991. On the extraction of channel networks from digital elevation data. *Hydrological Processes*, 5, 81–100.
Zheng, N., Wang, Q., Zhang, X., Zheng, D., Zhang, Z., Zhang, S., 2007, Population health risk due to dietary intake of heavy metals in the industrial area of Huludao City, China. *Science of the Total Environment*, 15(1-3), 96-104.
Zhang, H.H., Chen, J.J., Zhu, L., Li, F.B., Wu, Z.F., Yu, W.M., Liu, J.M., 2011. Spatial patterns and variation of soil cadmium in Guangdong Province, China. *J. Geochem. Explor.*, 109, 86-91.
Zhou, Z.Y., Xu, H.W., Wang, M.J., 2003. Soil organic matter mapping based on classification-tree modeling. *Acta Pedo. Sin.*, 40, 801-808.

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PENTAX
W-800
Reflectorless
WinCE Total Station
A truly integrated system
G3100-R1
Positioning System
Precision satellite surveying,
with wireless communications
R-2500DN
Reflectorless Total Station
w/built-in digital camera
Capture the full picture!
BL-100
Digital
Automatic Level
Increase your Efficiency!

Development of an AIS Transmit Architecture

This paper describes the ASM transmit architecture and the testing that has been done to date to validate this architecture

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The Automatic Identification System (AIS) is an autonomous and continuous broadcast system that exchanges maritime safety/security information between participating vessels and shore stations. In addition to providing a means for maritime administrations to effectively track the movement of vessels in coastal and inland waters, AIS can be a means to transmit information to ships in port or underway that contributes to safety-of-navigation and protection of the environment. This includes meteorological and hydrographic data, carriage of dangerous cargos, safety and security zones, status of locks and Aids to Navigation (AtoNs), and other port/waterway safety information.

In the United States, it is intended that this additional information be transmitted from shore-side AIS base stations in a binary message format as part of an overall e-Navigation strategy. The Committee on the Marine Transportation System (CMTS) e-Navigation Strategic Action Plan ("e-Navigation Strategic Action Plan" 2012) quotes the International Maritime Organization (IMO) definition of e-Navigation as:

"e-Navigation is the harmonised collection, integration, exchange, presentation and analysis of maritime information onboard and ashore by electronic means to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment"

AIS capabilities are recognized as critical parts of the US e-Navigation strategy in the CMTS e-Navigation Strategic Action plan. To implement these capabilities, the United States Coast Guard (USCG) Research and Development Center (RDC) has been working on an AIS Transmit Project since 2007 to research what additional information is required by AIS users, to recommend how the information should be transmitted, and to test transmission of this information at test bed sites. In order to transmit the information, it must be formatted into standard messages, called Application-Specific Messages (ASM). As part of the AIS Transmit Project, several new ASMs have been defined and prototype methods have been developed for message creation, routing, queuing, transmission and monitoring.

In general, ASMs are either created by a person (such as Vessel Traffic Service (VTS) operators, lock operators, or Sector Command Center (SCCs) watchstanders), or retrieved from an information data source (such as the National Oceanographic and Atmospheric Administration's (NOAA) Physical Oceanographic Real Time System (PORTS) or United States Army Corps of Engineers (USACE) lock operations databases). This information is then formatted into ASMs based upon accepted standards. Once formatted, messages are prioritized, geographically identified, and queued for transmission. As part of the queuing process, the AIS Very High Frequency (VHF) Data Link (VDL) must be monitored and feedback provided to the queuing process to adjust message output. Once formatted, the ASMs are sent to the AIS base station or AIS AtoN unit for transmission.

The identification of the processes led to the development of a prototype AIS Transmit architecture which includes the use of an ASM Manager and an

AIS network controller or "AIS router" that is used to route data between the Physical Shore Stations (PSSs)/AIS Base Stations (BSs) and the various clients (database storage, Geographic Information System (GIS) displays, etc.).

In order to have a cohesive, flexible and robust AIS transmit system that meets all users' requirements, an AIS transmit architecture needs to be fully defined. This paper proposes such an architecture and describes the various components of that architecture including an ASM Manager to implement the queuing and prioritization algorithms. Results of base station testing and how the results impact the transmit architecture are also presented. Additionally, the paper presents a mapping of AIS transmit message types onto the recommended transmit methodology based upon the results of RDC testing. Finally, the paper briefly presents the various US test beds that have been used to develop these processes and architetectures.

AIS Transmit Architecture

RDC has developed a proposed AIS architecture that is in alignment with International Standards. This is described in the sections below after first detailing the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) and IMO reference architecture for e-Navigation.

IALA Reference Architecture

The 1998 IMO Performance Standards for AIS ("Recommendation on Performance Standards for an Universal Shipborne Automatic Identification System (AIS)" 1998) state:

1.2 The AIS should improve the safety of navigation by assisting in the efficient navigation of ships, protection of the environment, and operation of Vessel Traffic Services (VTS), by satisfying the following functional requirements:

1. in a ship-to-ship mode for collision avoidance;
2. as a means for littoral States to obtain information about a ship and its cargo; and
3. as a VTS tool, i.e. ship-to-shore (traffic management)

This was expanded upon by the International Telecommunication Union Radiocommunications Sector (ITU-R) in the preamble to Recommendation M.1371 ("ITU-R M.1371-4" 2010)

The ITU Radiocommunication Assembly considering (...)

b) that the use of a universal shipborne AIS allows efficient exchange of navigational data between ships and between ships and shore stations, thereby improving safety of navigation;

d) that although this system is intended to be used primarily for surveillance and safety of navigation purposes in ship to ship use, ship reporting and vessel traffic services (VTS) applications, it may also be used for other maritime safety related communications, provided that the primary functions are not impaired;

f) that this system is capable of expansion to accommodate future expansion in the number of users and diversification of applications, including vessels which are not subject to IMO AIS carriage requirements, aids to navigation and search and rescue;

And further noted in IALA Recommendation A-123, on "The Provision of Shore Based Automatic Identification System (AIS),"("IALA A-123 Ed 2" 2007) which states "National Members and other appropriate authorities should therefore consider the provision of an AIS shore infrastructure so that the full benefit of the system can be realized in terms of navigation safety and protection of the environment."

IALA Recommendation A-124, "On The AIS Service" ("IALA A-124 Ed 2.1" 2012) provides a service model for the AIS-based shore service component of e-Navigation. The details are described in the various Appendices to A-124. Figure 1 shows the layered structure for this service. The three main functional layers are the Service Management Layer (AIS Service Management Layer or AIS-SM), the Logical Layer (AIS Logical Shore Station or AIS-LSS), and the Physical Layer (AIS Physical Shore Stations or AIS-PSS). Each layer is comprised of "the service component itself, which provides the required functionality in terms of AIS specific data processing; the supporting components and resources, which are exclusively used by the AIS Service, such as computers and local networking devices, i.e. the so called service-owned infrastructure; and the Human Machine Interfaces (HMI) to allow for (remote) access to Technical Operation Personnel."

The AIS-Service Manager (SM) (described in more detail in Appendix 11 ("IALA A-124 Appendix 9-10-11" 2012) provides for the management of the entire AIS service. This includes configuration and monitoring of all components and an HMI for technical personnel to do the configuration and monitoring.

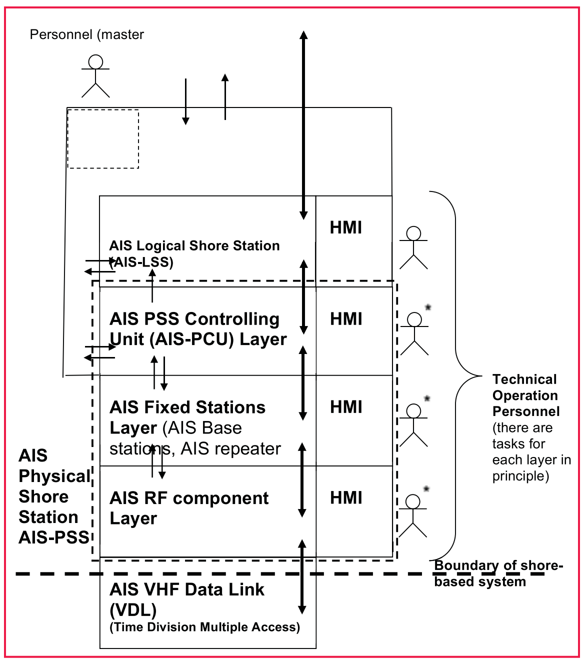

Figure 1: Layered Structure of AIS Service (Structure model of the AIS Service, Figure 4 from ("IALA A-124 Ed 2.1" 2012))

The AIS-Logical Shore Station (LSS) (described in more detail in Appendix 9 ("IALA A-124 Appendix 9-10-11" 2012) acts as a software router for AIS data going to and from the clients and the AIS PSS Controlling Units (AIS-PCU). It is responsible for the management of client and AIS-PSS connections, filtering of data on either or both connections, and data logging.

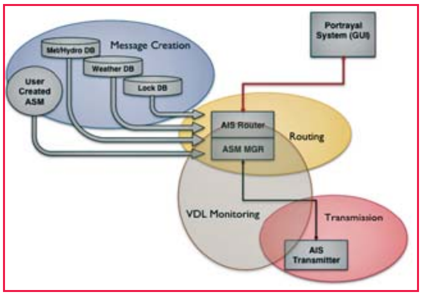

Figure 2: AIS Transmit Processes

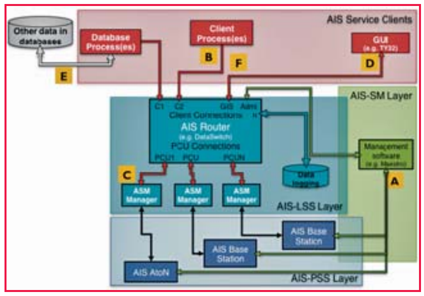

Figure 3: Proposed AIS Transmit Architecture

The AIS-Physical Shore Station (PSS) (described in more detail in Appendix 10 ("IALA A-124 Appendix 9-10-11" 2012) "is an abstract concept that encompasses multiple real physical elements of a shore-based AIS Service." The major components of an AIS-PSS are: an AIS-PCU that is in charge of controlling one or more AIS fixed stations; at least one AIS fixed station (base station, limited base station, AtoN, or repeater station) that provides the interface to the VDL; and an agent of the AIS-SM to allow for configuration and monitoring of the AIS-PCU and AIS fixed station(s). In some cases all of this functionality can be rolled into one physical component.

Proposed Transmit Architecture

One of the major outcomes of the test beds was the identification and quantification of the processes needed in order to create and transmit ASMs: Message Creation, Routing, Transmission, and VDL Monitoring. This is shown in Figure 2. **Message creation** could be accomplished automatically from a database (of met/hydro, weather or lock information for example) or user-created. If the message created is from a database, then software is needed to fetch the data and put into the correct format (AIS ASM embedded into a National Maritime Electronic Association (NMEA) sentence). If user-created, then software tools (preferably GUI-based) are needed to put the desired information into the ASM. **Message routing** involves both the queue process and rules-based prioritization. This is not available off-the-shelf currently so additional software (ASM Manager) is needed to accomplish this. **Message transmission** involves routing the message to the correct transmitter (AIS base station, AtoN, or perhaps limited base station) according to the area the content of the message applies to or in order to reach the intended addressee (auto or user-specified). **Monitoring** is VDL loading monitoring to ensure that the number of messages desired to be transmitted do not overload the VDL.

The identification of these processes led to the development of a prototype AIS Transmit architecture, which includes the use of an ASM Manager to perform the processes that are not available in off-the-shelf applications and equipment; and an AIS network controller or "AIS router" that routes data between the Physical Shore Stations (PSSs)/AIS Base Stations (BSs) and the various clients (database storage, Geographic Information System (GIS) displays, etc.). This proposed transmit architecture for AIS (shown in Figure 3) is based on the IALA model described above. Each of the major components of the proposed architecture is described in the following sub-sections.

Information Routing Notes (see letters in Figure 3, the AIS message types are explained in Table 1, the ASM Function Identification (FI) is explained in Table 2, the Designated Area Code (DAC) used in the ASM is 367):

A. The AIS Service Manager (AIS-SM) is used to program the AIS PSS Controlling Unit (AIS-PCU); i.e. base stations, for AIS Messages: 4, 17 (opt), 20, 23 (opt) and 24 (opt). The AIS-PCU generates AIS Messages 7/13 automatically upon receipt of AIS Message 6/12. The AIS-SM also programs AIS AtoNs for AIS Message 21 (opt) or AIS-PCU for AIS Message 21 (Opt. Synthetic or Virtual AtoN).
B. Client Processes collect information from Users and generate NMEA sentences to initiate (telecommands) AIS Messages: 10, 15, 16, 22, and 23(opt). Client Process could be part of a GUI. Various clients could also be used for messages 25/26, and 21.
C. ASM Manager(s) receive messages from AIS router and from NOAA PORTS, feeds managed stream of NMEA Sentences to AIS-PCU to generate AIS Messages: 6, 8, 12, 14, and 25/26.
D. User creates ASM in a client process or GUI, these are embedded in NMEA sentences and sent to ASM Manager (DAC/FIs: 367/22, 367/35, 367/29, etc.)
E. Database processes retrieve data, format into ASMs embedded in NMEA sentences and forward to AIS Router for transmission (DAC/FIs: 367/22, 367/35, 367/29)
F. Text messages (should be limited to safety-related information and not used often) could be created by various client processes or by a GUI

AIS Router

The primary component that implements the AIS-LSS is an "AIS Router;" so called, because it is responsible for routing the AIS data between the AIS service clients and the AIS-PSS. A market survey conducted by RDC identified four major commercial vendors that supply AIS Routers as part of their AIS shoreside network software (Johnson and Gonin 2013). All of the software packages allow for multiple client connections (examples shown across the top of the box in Figure 3 above); each client connection typically has username and password authentication although this is not required in all cases. Each client can be configured for different levels of access and data stream filtering (both send and receive). The software also manages multiple connections to AIS data streams; either from other AIS Routers (in a regional or national hierarchy) or from AIS-PSSs. All of the software packages implement data stream filtering on these connections as well. Different vendors offer different features, but in general they all fully implement the required capabilities of an AIS-LSS.

The other major component of the AIS-LSS is the data logger. This is implemented by all of the vendors in a separate software component that works in conjunction with the AIS Router. Typically this is done using an Oracle or Structured Query Language (SQL) database, but in some cases, flat files are used as well.

AIS Router Test Results

RDC conducted testing on the four AIS routers identified in the market survey (Kongsberg C-Scope, Gatehouse AIS, Transas AIS Network, and CNS DataSwitch). Copies of each of software were obtained and installed on a test bed at RDC, running the software on the same computers to allow relative performance comparisons. The systems were run through a series of tests that can be characterized into two categories: basic and performance. The tests were designed to assess the performance of the systems in regards to routing functionality and the criteria that the project sponsor thought most important: raw throughput speed and maximum number of clients possible. Database storage, analytics, and display capabilities were **not** evaluated, although all of the systems have these capabilities.

Complete details on the testing performed can be found in (Johnson and Gonin 2013) but the results are summarized here. From a performance standpoint, any of the four commercial systems would be suitable for the AIS router. The overall aggregate traffic load in the United States in 2013 was about 600 messages per second. The systems tested could support from 3,900 to 17,000; all well above the current maximum. The numbers of clients supportable ranged from 35 to 250. CNS supported the most; however, all of the other systems have scalable client modules that would allow for expansion to almost an unlimited number of clients by adding client modules (the reported client counts are for a single instance of the client server modules). How many clients are **required**, has not been determined.

The study only assessed performance for a few specific criteria; all of the commercial software has much more functionality than that assessed. Much of this functionality would be important for the overall system, and some of the functionality would impact the performance results. For example, setting different filters for each client increases the Central Processing Unit (CPU) loading; especially if geographic filters are used. One of the lessons learned from the study was that the system settings can be critical to performance. Another was that an overall architecture for an AIS network that supports full two-way communications needs to be developed. Part of this architecture design needs to include trade-offs on data flow and data storage at the local, regional, and national levels. For example, most of the vendors in this study would recommend downsampling the data as it is aggregated at the regional and then national levels and only store the full time-rate data at the local (or at most regional) levels. Additionally, in order to specify the hardware and software, the maximum number of clients required to be supported at each connection level (local, regional, national) needs to be determined. This nationwide architecture is **not** reflected in Figure 3.

ASM Manager

The ASM Manager is software that adds additional necessary functionality to the “AIS router.” This is not available off-the-shelf currently, so software was developed to layer this functionality on top of an AIS router. This program was designed to shield the message creator from the details of the base station locations and manage ASM transmissions by performing the following functions:

1. Ensures messages are valid before transmission.
2. Ensures that no more than the user-specified number of slots is used for transmission in each minute in order to minimize the transmit loading on the VDL.
3. Allows for user-specified priorities along with prioritization based upon message type and content.
4. Determines if a message should be transmitted from a given transmitter based upon location.
5. Ensures messages are transmitted.
6. Keeps messages in queue until acknowledgement is received from the BS.
7. Allows for acknowledgement to be routed back to user.
8. Manages the repetition of messages that need to be retransmitted on a periodic basis.

ASM Manager accepts Broadcast Binary Message (BBM) and Addressed Binary Message (ABM) sentences containing environmental messages, waterways management messages, text messages and geographic notices from various data feeds such as the DataSwitch. ASM Manager stores those messages in its internal queue. At periodic intervals (from 4 – 60 seconds), ASM Manager forwards the ASMs on to the Base Station for transmission. ASM Manager prioritizes and limits the maximum number of messages that are output each interval based upon its configuration parameters (maximum number of messages in a report and maximum number of reports per interval).

ASM Manager has a built-in mechanism for detecting and purging expired messages. All messages receive a time-stamp upon delivery to ASM Manager. In addition, ASM Manager parses the date and time of incoming environmental and geographic notice messages and uses that time for detecting message expiration. For other message types, time of reception is used for detecting expired messages. The expiration period for geographic notice messages is decoded from the binary message. For other message types the expiration period is specified in the configuration file. Expired messages are purged from the queue prior to sending data to the transmitter.

ASM Manager decodes station ID, data type and sub-type for received messages. If a message with the same station ID and data type and sub-type and same DAC (either 366 or 367) and same FI (either 1, 22, 29, 33, or 35) is already in the message queue, it is replaced with the updated information. Message priority, number of times the message was delayed, number of times the message failed to transmit and the next send time are carried over from the obsolete message to the updated message.

ASM Manager sorts messages by user-specified priority and limits the number of messages that are transmitted every minute (set via configuration parameters), so as not to overload the VDL. The message base priority can vary from 1 to 10, with 10 being the highest priority. Messages that fail to transmit or are delayed (due to too many messages in the queue), have their priority boosted by 1 for each time the message is delayed or fails transmit (while its base priority remains the same). If a message is transmitted successfully, its fail-to-transmit and delay counters are reset, so its priority returns to the base priority. Since the AIS VDL is organized into 1-minute frames, ASM Manager nominally sends out messages once a minute; however this can be adjusted to an interval of 4 to 60 seconds to meet operational needs.

ASM Manager monitors the AIS base station feedback for ABK acknowledgements that indicate success or failure of message transmission. In case a message is not acknowledged, that message gets put back into the transmit queue and its failed transmit counter gets incremented. Messages that fail to transmit are scheduled for retransmit in the next transmit cycle.

ASM Manager can accept metadata along with the ABM/BBM sentence (repeat rate, priority, and area of transmission) in PRDC,ATH sentences. ASM Manager can filter out messages by area of transmit specified in PRDC sentence if filtering is turned on. PRDC and ABM/BBM sentences are expected to adhere to the following sequence: [optional PRDC][BBM 1 of x]...[BBM x of x].

ASM Manager checks for various error conditions and in case of errors, it generates email alerts about the outages. To reduce the number of emails, a single email alert notice is generated in a 24-hour period that contain all errors and alerts that occurred since the last email was generated.

ASM Manager provides configurable monitoring and logging capabilities and an interactive user interface. The user interface allows turning on and off display of the message queue (before and after each transmit), display of message information, deleting messages from the queue, and stopping program operation.

AIS-PSS Layer

Although the IALA model for the AIS-PSS layer includes an additional AIS-PCU sub-layer, the USCG R&D installations do not use this. Any functionality of the AIS-PCU layer is handled by the AIS Fixed Stations. In the case of the Tampa test bed this is an L-3 Protec base station. For the Columbia River, this is two SAAB R-40 base stations. Louisville is currently a SAAB R-40 base station but this is being transitioned to an L-3 Protec. The Stellwagen Bank

Table 1: AIS Message Types

ID#	AIS Message Description
1,2,3	Position Reports – autonomous, assigned, or interrogated
4	**Base Station Report – UTC/ date, position, slot number.**
5	Class A Report - static and voyage related data
6, 7, 8	**Binary Message (ASM) – addressed, acknowledge or broadcast**
9	SAR aircraft position report
10, 11	**UTC/Date - enquiry and response**
12, 13, 14	**Safety Text Message – addressed, acknowledge or broadcast**
15	**Interrogation – request for specific messages**
16	**Assignment Mode Command**
17	**Binary Message – DGNSS Correction**
18,19	Class B Reports – position & extended
20	**Data Link Management – reserve slots**
21	**AtoN Report – position & status**
22	**Channel Management**
23	**Group Assignment**
24	Class B Static Data
25	**Binary Message (ASM)– single-slot**
26	**Binary Message (ASM) – multi-slot (STDMA)**
27	Long-range AIS broadcast message

Table 3: Mapping of AIS Messages to Transmit Methods.

		Method		
AIS MSG	**Description**	**1**	**2**	**3**
4	base station report	R	N	N
6	addressed binary message	N	R	R[1]
8	broadcast binary message	N	R	R[2]
10	request Universal Time Coordinated (UTC) date/time	N	R	O
12	addressed safety-related text	N	R	O
14	broadcast safety-related text	N	R	O
15	request for specific message(s) (base station will generate an ABK for this so gives additional status)	N	R	O
16	assignment mode	N	R[3]	R[4]
17	Differential Global Navigation Satellite System (DGNSS) corrections broadcast	R	N	N
20	data link management	R	N	N
21	AtoN	R[5]	R[6]	R[7]
22	channel management	R[8]	R[9]	N
24	extended base station information	R	N	R[10]
25	short unscheduled binary transmission	N	R	O
26	scheduled binary transmission	N	R	N

(Footnotes)

[1] If a virtual MMSI is needed.

[2] If a virtual MMSI is needed.

[3] Especially if assigning slots that then need to be reserved.

[4] For assigned rate mode only.

[5] If only a few virtual or synthetic aids, with static parameters.

[6] For virtual or synthetic aids, with parameters that need to be changed by the client application periodically – perhaps due to monitoring.

[7] For virtual or synthetic aids, if too many for the base station to manage using other methods.

[8] If using Area-based channel management.

[9] If used for specific station channel management.

[10] If base station does not support sending the message automatically.

Table 2: Valid Function Identifiers for DAC 366/367

FI	Description
16	Passenger and Crew Count
17	Synthetic Targets Message
22	Geographic Notice USCG
29	Linked Text
33	Environmental USCG
35	Waterways Management USCG
55	USCG Encrypted Text Message
56	USCG Encrypted Position Report
57	USCG Encrypted Static Data
58	USCG Encrypted Target of Interest
63	Water Level

test bed uses an L-3 AtoN transmitter. The USACE LOMA system also uses L-3 AtoN transceivers. Configuration of these transceivers is accomplished either through the AIS Service Manager or directly through the AIS AtoN transceiver.

Mapping AIS Transmit Messages to Architecture

AIS has been very successful in providing VTS and other shore facilities with vessel position and identification information, but in addition AIS can be a very effective tool for communication between shore stations and vessels. AIS accomplishes this by utilizing the capability of pre-formatted standard messages and AIS binary messages or application-specific messages (ASM). For clarification purposes, transmit capability is defined to include both broadcast *and* addressed AIS messages. The current AIS specification, ("ITU-R M.1371-4" 2010) defines 27 different AIS messages shown in Table 1. Some of these message types can be grouped into categories applicable to AIS transmit: message types 4, 17, 20, and 24 are base station messages; message types 10, 11, 15, 16, 20, 22, and 23 can be considered *telecommands* that can be used by a VTS for channel management; message types 12, 13, and 14 can be used for safety-related text messages; and message types 6, 7, 8, 21, 25, and 26 are binary messages that can be used for information transfer. Table 2 provides the valid function identifiers for DAC 366/367; these are the messages currently used in the United States.

Message Transmission Options

There are three ways to have a base station transmit an AIS message; each method has pros and cons, and some AIS messages are better suited to certain methods. Each of the methods and the recommended AIS messages are described in the following subsections. The methods

Figure 4: Tampa Transmitter and Receiver Sites

recommended for each transmit message type are summarized in Table 3.

Method 1: Base Station Programming

A typical base station (such as the L-3 Protec) can be programmed to generate some AIS messages automatically. The AIS-SM layer does the programming – whether this is third-party software such as CNS's Maestro or the base station vendor's software (e.g., L-3 Base Station GUI). The messages are configured and assigned to a repetitive transmit schedule. Slots can also be reserved for these messages. There are some AIS messages that would be difficult to create and/or manage by one of the other two transmit methods and so should be sent using this method. The messages that fall into this category are: AIS messages 4, 17, 20, 21[5], 22[8], and 24.

Method 2: NMEA Sentence Programming

A base station supporting NMEA 4.0 can be configured to transmit most AIS messages using various NMEA sentences. In this case a client application could create the appropriate NMEA sentences and send them through the network to the base station. The base station uses the information in the sentences to create and transmit the AIS messages. Most messages that a base station can transmit can be configured and sent in this manner. The advantage of this method vs. Base Station Programming is that a client application (not just the AIS-SM) could request the transmission of the AIS message. The advantage of this method vs. Directly Created AIS Messages is that this method does not require the client to know anything about the VDL or the current slot map; the base station handles that when it creates the AIS messages from the information in the NMEA sentences. The messages that are recommended to use this method are: AIS messages 6, 8, 12, 14, 15, 16[3], 21[6], 22[9], 25, and 26.

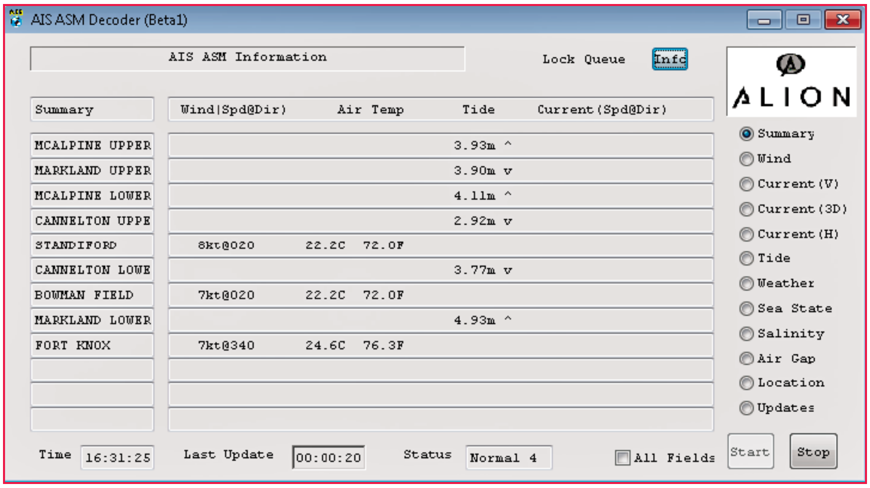

Figure 5: AIS ASM Message Decoder GUI

Method 3: Directly Created AIS Message

A base station can be forced to transmit any AIS message by embedding the AIS message in a VDM sentence and sending that to the base station. This allows tremendous flexibility; however, it puts the entire burden of the AIS message creation and VDL management onto the client. The L-3 Protec base station and L-3 AIS AtoN will generate a TFR sentence that reports the status of the VDM message delivered to the transceiver (e.g., whether it was successfully scheduled for transmission) back to the client which is very helpful; however, this is not required by the NMEA standard and thus cannot be expected with all AIS transceivers. There are several AIS messages that would be very difficult to create and manage using this method, and thus are not recommended for this transmission method (AIS 4, 17 and 20 for example). The messages that **are** recommended to use this method are: AIS messages 6[1], 8[2], 16[4], 21[7], and 24[10].

US Test Beds

The AIS Transmit project's primary test bed is located in Tampa, FL. The project also expanded to include demonstrations and trials in the Stellwagen Bank, MA, Louisville, KY and the Columbia River, OR. This work has been reported on previously in (Gonin and Johnson 2009; Johnson 2009; Johnson, Wiggins, and Gonin 2012; Burns et al. 2011; Gonin et al. 2009) but is summarized in the following sub-sections.

Tampa Bay, FL

The Tampa VTS test bed was installed and commenced operation in September 2008. The Tampa Bay Pilots and Tampa VTS (operated by the USCG and Tampa Port Authority) have been very supportive partners. The test bed personnel are able to create and deliver binary messages, which mariners can use aboard ship. This information provides the pilots with better situational awareness of met/hydro conditions in the port area and has been used for decision support (go/no-go decisions). The primary source of data has been PORTS; this data is transmitted over the VDL using the Environmental ASM. The ASMs are sent to the AIS base station in Largo, FL that is shared with the VTS operations system (Norcontrol™ software by Kongsberg). The Nationwide AIS (NAIS) receiver at Palmetto is used as the monitor site. Figure 4 shows the locations of the base station (upper left) and the receiver (lower right) relative to Tampa Bay. The Tampa Pilots use a text display of the data on their Portable Pilot Units (PPUs) (similar to Figure 5). The Tampa test bed has been the primary test site to evaluate

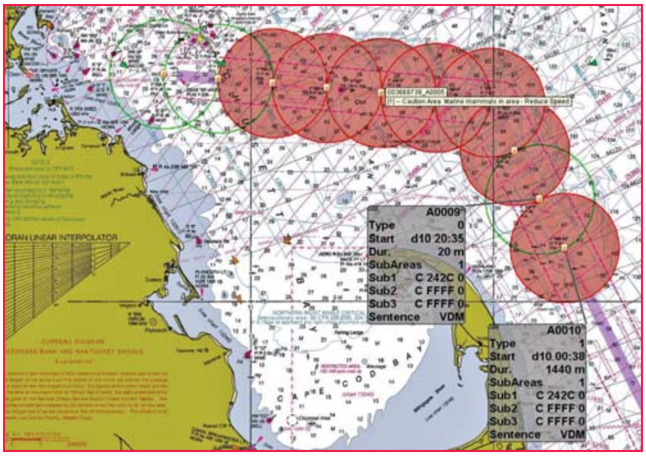

Figure 6: Stellwagen Bank Demonstration Area (Red circles indicate whales present; green circles indicate no whales detected)

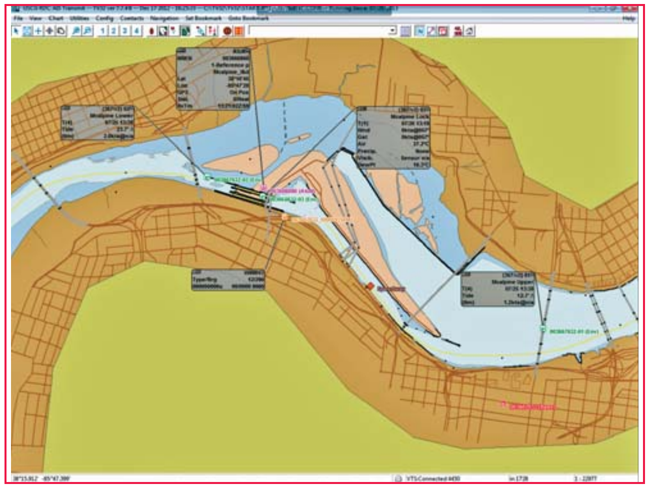

Figure 8: TV32 software display for Louisville

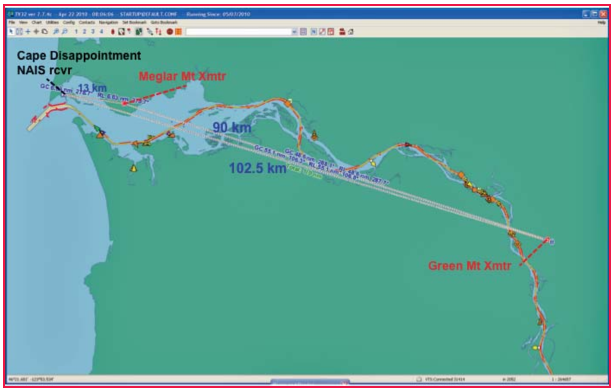

Figure 7: Columbia River Demonstration Diagram Showing Transmitter Locations

processes and performance for future implementation at all Coast Guard VTS sites. The testing done in Tampa has enabled an understanding of the transmit processes and driven the development of the proposed transmit architecture.

Stellwagen Bank

The Stellwagen Bank demonstration has been a joint effort between RDC and NOAA Stellwagen Bank National Marine Sanctuary (NMS) (with University of New Hampshire (UNH) and Cornell University support). The location of this test bed is shown in Figure 6. The goal of this effort is to broadcast via AIS an indication of the presence or absence of right whales in the vicinity of the 10 acoustic monitoring buoys so that ships can slow down if there are whales in the area. The AIS broadcast portion of the demonstration started in September 2008. The user equipment side (NMS/UNH responsibility) started operation in earnest with an iPad application (WhaleAlert) in 2012. NOAA NMS is the overall lead for this effort. Cornell is responsible for the operation of the acoustic buoys; they receive the acoustic signature data from the buoys via an Iridium satellite link and process it to determine if right whales are present or not. This information goes into their database where it can be accessed and viewed over the Internet. UNH provides software support and wrote the code that retrieves the right whale data from Cornell's database and provides Geographic Notice ASMs to the ASM Manager. An AIS AtoN unit is used as the transmitter (this was substituted for the original base station in Jan 2011). The NAIS receivers in the Boston area are used as monitor sites.

Columbia River

The Columbia River Demonstration started as a joint effort between the RDC, the Columbia River Pilots (COLRIP), and the US Department of Transportation, Volpe Center; as of Aug 2010, the Volpe Center assumed responsibility for the AIS transmit operations in the Columbia River as part of their contracted support to the COLRIP. There are two AIS base stations (Green Mountain and Meglar Mountain) which are operated in repeater mode so that all traffic received by each base station is retransmitted. COLRIP and Volpe are responsible for monitoring system performance and VDL loading using data feeds from the two transmitter sites. RDC conducts monitoring on an ad hoc basis using the NAIS receiver at Cape Disappointment. A chart showing relative positions of the transmitters/receiver is shown in Figure 7. The Columbia River Pilots actively use the environmental data as part of their operations. They use Volpe-supplied TV32 software as their Personal Pilot Units and like the geographically tied text display. The test bed with two transmitters in a repeater mode provided some valuable experience in repeater operation and VDL impacts. This is documented in (Johnson 2010).

Louisville, KY

A test bed was established in Louisville in 2011 in order to develop and test new sources of environmental data for transmission such as river current sensors and river gauge sensors and to test the usage of the Waterways Management (WM) ASMs and assess their usefulness. The transmitter is an AIS base station located in Louisville, KY that is used by the VTS. This test bed was also the first to be set up using the new transmit architecture and processes. Although this provided a good test bed for developing the new architecture software, only some of the phase I test goals were met. The biggest hold-up was the lack of fully functioning user software. This limited

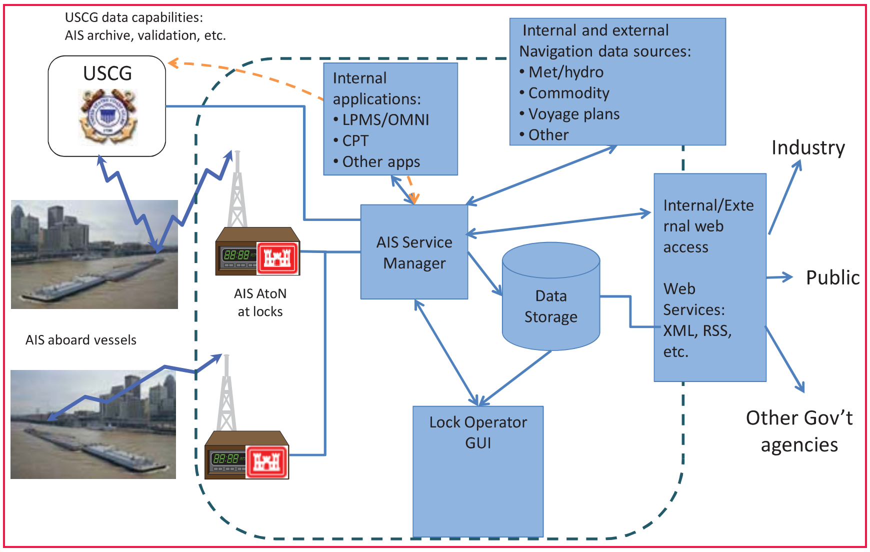

Figure 9: USACE LOMA System overview

RDC's ability to collect feedback from the mariners on the usefulness of the messages. In order to complete the assessment processes, the decision was made to conduct a Phase II test at Louisville.

The primary goals of the second phase are to fully test the Waterways Management ASM and to assess usefulness from the mariner's point of view. To enable this RDC has worked with two software manufacturers, CEACT and RosePoint to get their software updated to support the decoding and display of the ASMs. Phase II commenced operation on 1 July 2013. A survey of mariners involved was conducted on 14-15 August 2013. Since none of the stakeholders had used the new ECS software with display of the ASMs yet, the discussions focused on what data would be useful. Also, various portrayal examples were shown to the stakeholders so that they could give their opinions on the various options.

This test bed is also being used to prototype a transmit architecture for the USACE. The USACE is in the process of implementing the Lock Operations And Management (LOMA) system using AIS AtoN transmitters at each of their locks along the US inland rivers (see Figure 9). The goal is to transmit information such as pool depth, water currents, and lock queue information from these AIS AtoNs using ASMs. Research is also underway into creating models of the currents based upon dam gate opening settings; this information will then be transmitted as well.

Conclusions

The USCG and the USACE have accumulated quite a bit of experience with AIS transmit operations from operating various test beds within the U.S. This knowledge has been used to formulate a recommended architecture to facilitate the creation and dissemination of eMSI using the AIS network. This architecture includes an ASM Manager, which adds capability to the LSS layer that are not currently present: namely to ensure delivery of ASMs, to efficiently manage the VDL, and to prioritize messages to fit within the amount of VDL authorized by the Competent Authority.

References

Burns, William, Gregory W. Johnson, Irene M. Gonin, and Lee Alexander. 2011. "Testing of AIS Application-Specific Messages to Improve U.S. Coast Guard VTS Operations." In *eNavigation Underway*. Copenhagen, Denmark.

"e-Navigation Strategic Action Plan." In. 2012. Washington, DC: The US Committee on the Marine Transportation System.

"Functional Description of the AIS Service components (AIS-PCU, AIS-LSS & AIS-SM)." In. 2012. Saint Germain en Laye, France: International Association of Marine Aids to Navigation and Lighthouse Authorities.

Gonin, Irene, Gregory Johnson, Ruslan Shalaev, Brian Tetreault, and Lee Alexander. 2009. "USCG Development, Test and Evaluation of AIS Binary Messages for Enhanced VTS Operations." In *Institute of Navigation, International Technical Meeting (ION-ITM 09)*. Anaheim, CA.

Gonin, Irene M., and Gregory W. Johnson. 2009. "Phase 1 Summary Report on AIS Transmit Project (Environmental Message)." In. New London CT: USCG Research & Development Center.

Johnson, Gregory, and Irene Gonin. 2013. "Initial Test and Evaluation of AIS Network Controllers." In. New London, CT: USCG Research & Development Center.

Johnson, Gregory W. 2009. "Final Summary Report on AIS Transmit Capability for USCG VTS Centers." In. New London, CT: USCG Research & Development Center.

———. 2010. "AIS Transmit VDL Loading Summary Report." In. New London, CT: USCG Research & Development Center.

Johnson, Gregory, Mark Wiggins, and Irene Gonin. 2012. "Operational Framework for AIS Transmit." In. New London, CT: USCG Research & Development Center.

"on the AIS Service." In. 2012. Saint Germain en Laye, France: International Association of Marine Aids to Navigation and Lighthouse Authorities.

"The Provision of Shore Based Automatic Identification System (AIS)." In. 2007. Saint Germain en Laye, France: International Association of Marine Aids to Navigation and Lighthouse Authorities.

"Recommendation on Performance Standards for an Universal Shipborne Automatic Identification System (AIS)." In. 1998. London: International Maritime Organization.

"Technical Characteristics for an Automatic Identification System using Time Division Multiple Access in the VHF Maritime Mobile Band." In. 2010. International Telecommunications Union, Radiocommunication Sector.


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Galileo update

Galileo increases the accuracy of LBS

Tests conducted by Rx Networks and the European GNSS Agency (GSA) confirm that Galileo provides real added value to citizens using Location Based Services (LBS). When used in addition to GPS and/or GLONASS, Galileo proved to significantly improve accuracy in challenging environments.

Conducted in such real-world environments as urban canyons and indoors, each test consisted of a three hour data capture of the GNSS signals which was later replayed to produce hundreds of fixes using a multi-constellation GNSS receiver from STMicroelectronics. These difficult environments pose significant challenges in regards to location accuracy due to multipath and obstructed views of satellites. However, because people often use location based services within these environments, it is important that accuracy be improved.

The results showed that adding Galileo on top of GPS and GLONASS (widely available in smartphones today) improves the accuracy of location fixes when indoors or in urban canyons. As expected, the GPS+Galileo combination did not exceed the performance of GPS+GLONASS, due primarily to there only being four Galileo satellites available at the time of the testing. The performance of Galileo with GPS or other GNSS will further improve in the future, as more Galileo satellites are launched. *www.gsa.europa.eu*

CSR SiRFstarV Architecture Secures Live Position Fix from Galileo Satellites

CSR plc's leading SiRFstarV™ architecture has established a position fix using Galileo satellites. Its SiRFstarV 5ea Quad-GNSS receiver acquired, tracked, and used signals from the four Galileo satellites currently in orbit to produce position fixes in Germany.

Galileo support is required to implement the European Commission's (EC) recently mandated eCall emergency response system for light vehicles, which will automatically send emergency notification messages from these vehicles when involved in an accident. The EC's objective is to have a fully functioning eCall service safeguarding the European Union by late 2015, and CSR's SiRFstarV is one of the few GNSS receivers that can support the eCall Galileo requirement.

A minimum of four satellites is required to make a position fix in three dimensions – longitude, latitude and altitude. The Galileo constellation's four satellites are currently visible from Earth at the same time for only two to three hours each day, so currently a position fix can only be obtained during this period. The frequency of position fix availability, however, will increase as the European Space Agency deploys more satellites and as additional ground stations become operational. The full range of Galileo positioning, navigation and timing services is expected to be available in 2018. *www.csr.com*

Next Generation of GPS Navigation for iPhone

Sygic has just introduced the next generation of its GPS Navigation application, available on App Store. Update for Android users will be released in the second half of this year. The new native application, the result of three years' worth of work, was completely remade from the ground up.

This version is the fourth full overhaul of Sygic's navigation experience in the 10 years of the company's existence. *www.webwire.com*

HERE plans to acquire Medio Systems for creating cognitive maps

HERE has announced plans to acquire Medio Systems, a Seattle-based company that provides real-time predictive analytics solutions.

Building on Medio's 'smart data' asset enables HERE to create contextual maps and location services that change according to the situation to provide highly personalised and predictive experiences for people and businesses. That could mean delivering individual restaurant recommendations to someone ready for lunch, giving drivers routes that match their driving style based on real-time conditions or helping businesses personalize their customer offerings.

Police officers charged over GPS tracking of partner

Two West Australian police officers have pleaded not guilty to charges of unlawfully using a tracking device to monitor the movements of one of their partners. It was alleged the men installed a Global Positioning System (GPS) on a car belonging to the partner of one of them, to monitor the woman's movements while the men were away on holidays in the north of the state in 2012.

It was further alleged that the men used data from the GPS to generate a detailed report of the woman's movements over a 16-day period. *Source: ABC News*

SPOT 7 launched

The SPOT 7 Earth-observation satellite, designed and developed by Airbus Defence and Space, was launched on 30 June by a Polar Satellite Launch Vehicle from the Satish Dhawan Space Centre in India. It will now join the orbit in which its twin, SPOT 6, and the very-high-resolution observation satellites Pléiades 1A and 1B are located, and will be positioned at 180° in relation to SPOT 6.

Tests scheduled to integrate UAS into the national airspace

Rockwell Collins and the NASA have scheduled risk reduction tests that will eventually enable unmanned aircraft systems UASto safely operate in the national airspace. The NASA-owned Lockheed S-3 Viking and the University of Iowa Operator Performance Laboratory's Beechcraft Bonanza aircraft will serve as surrogates for UAV during two phases of testing. The first part of the test will demonstrate the ability of unmanned aircraft to hand off communications from one tower to another. The second part of the test will demonstrate the ability of a single tower to communicate to multiple aircraft. The waveform being developed can support multiple channels from a single ground transmitter, enabling multiple aircraft to be simultaneously served, according to local operational needs. *www.rockwellcollins.com*

BP to fly drone over land in US

US aviation regulators last month gave oil company BP the first commercial license to fly a drone aircraft over land. The Federal Aviation Administration gave BP and unmanned aircraft system (UAS) builder AeroVironment permission to use a drone for surveys of oil exploration and pipeline areas in Alaska's Prudhoe Bay area.To get permission to fly, the companies must show their drones would not affect security and that they would be in the public interest. A number of public agencies have already been authorized to fly drones for public service purposes, such as for security, rescue or weather forecasting.

India's PSLV successfully launches French satellite SPOT 7

The Polar Satellite Launch Vehicle (PSLV) has successfully launched the French SPOT-7 imaging satellite. The PSLV vehicle also carried five other small payloads along with the French satellite. This included Canada's CanX-4 and CanX-5, Germany's AISSat-1, and Singapore's two-satellite experiment VELOX-1. *ISRO*

New Romanian drone regulation raises questions among users

Romanian authorities have decided that drones weighting less than 150 kilos should be registered and insured before being used in Romania. According to official reasoning, until 2016, the European Union regulations cover drones bigger than 150 kilograms, while those under this weight remain subject to national regulations. The law does not apply to drones with weight under 1 kilogram, unless they have equipment for filming and data transmission. *www.romania-insider.com*

China's domestic navigation system accesses ASEAN market

Three model satellite stations based on China's domestically made Beidou navigation system were shown to the public recently in an industrial estate in Thailand, the first step of Beidou into the ASEAN market. It is a part of a cooperative agreement signed between China and Thailand. Li Deren, chairman of the Wuhan Optics Valley Beidou Geo-Spatial Information Industry Co., LTD, a participant in the project. They will form a network covering all areas of the country, and expand into other ASEAN countries and regions. *www.globalpost.com*

GLONASS-M launched

On June 14th, Russia launched their next GLONASS navigation satellite via a Soyuz launch vehicle. The satellite—GLONASS-M 55. This was the second launch of a GLONASS navsat this year by Russia... there are eight spacecraft in three orbital planes, with 24 such satellites required to bring total worldwide service to the GLONASS system. Within a few weeks, this new satellite will become operational, complete with L1 and L2 navigation signals, as well as the transmission of L3 frequency band experimental navigation system signals (CDMA, rather than FDMA). *www.satnews.com*

Glonass stations in BRICS states to boost competitiveness

The deployment of Glonass in BRICS member countries will boost the network competitiveness, Russian Foreign Ministry Ambassador at Large, executive secretary of the interdepartmental commission for Russian membership in the G20 and the BRICS Group Vadim Lukov said.

"A project of the sort implemented in collaboration with BRICS countries will strengthen the global nature of our network and add to its competitiveness on the retail market. The market of BRICS countries boasts 3 billion consumers, and many of them consume satellite services," *http://voiceofrussia.com/*

Russia, US expected to agree on GLONASS, GPS stations

Russian Deputy Prime Minister Dmitry Rogozin hopes Russia and the United States will agree on deployment of GLONASS and GPS stations before September 1.

"I hope we have been heard not only in navigation departments, but first of all in Washington. I hope we will find full understanding by September 1, or we will have to do something with the stations," Rogozin told recently.

"Despite some difficulties we have with the United States, we believe it is necessary to continue cooperation," the deputy prime minister stressed.

Russia Mulls Privatizing ERA-GLONASS Emergency Network

The Russian government will consider privatizing the state-owned ERA-GLONASS emergency calls network, according to the Russian newspaper Kommersant. A plan to privatize ERA-GLONASS, a real-time satellite service for reporting and responding to traffic accidents, was recently discussed at a Kremlin meeting attended by President Putin's chief of staff Sergei Ivanov. *http://en.ria.ru/*

Tribals use GPS to claim forest land rights in India

Amid their struggle to get forest land rights in Gujarat, India tribals have found a friend in a gadget that gives convincing evidence about their claims over land under the Forest Rights Act. The tribals have started using GPSdevices to mark and measure the lands they till in the forest areas. The process of such mapping had begun a couple of years ago, but today it has become a regular exercise in several pockets in south and central Gujarat to map plots cultivated by tribals. Such has the success and word of mouth publicity of the experiment that activists and non-governmental organizations (NGOs) in Odisha, Jharkhand, Chhatisgarh and Bihar asked those involved in the process to demonstrate it. http://timesofindia.indiatimes.com/

ONS creates single source of open data using Esri

The Office for National Statistics (ONS), UK has used open source tools and GIS mapping software from Esri to create a single source of statistical data that can be easily accessed by staff and the public. The ONS' Open Geography Portal (OGP) was created in response to the UK government's push for open data, the most recent census in 2011, which required a large amount of data to be put online, and the European INSPIRE Directive. *www.computerworlduk.com*

The Unlikely History of the Origins of Modern Maps

GIS technology has opened up new channels of understanding how the world works. But where did it begin?

Efforts to explain what GIS actually is almost invariably wax philosophical. At its most essential, GIS is a system for marrying data sets with geography. But it can better be understood as the product of a specific historic moment whose fruit is just coming to bear – a moment arising from the spontaneous amalgam of diverse technologies reaching their apparent apotheosis. And it began when a young Roger Tomlinson—and others—wanted to geographically assess more information than ever before. While the rise of digital culture has served to erode countless boundaries in traditional disciplines, that corrosion partially began in an airplane in 1962 with the predicament of getting gobs of information into one little map. *Source: Smithsonian.com*

Proteus completes satellite-derived forest inventory pilot in Abu Dhabi

Proteus has completed a demonstration project using satellite imagery to inventory tree plantations in the Emirate of Abu Dhabi. The tree mapping pilot is a spin-off of a larger Emirate-wide habitat and land use/land cover (LULC) project now being spearheaded by Proteus. In the pilot, the Proteus team processed multispectral data collected by DigitalGlobe's WorldView-2 commercial imaging satellite to identify the species and conditions of individual

trees within the pilot area. It managed the project in which GMV of Spain performed image processing and automatic tree extraction with local ground-truthing support from Nautica Environmental Associates in Abu Dhabi. The Environment Agency – Abu Dhabi (EAD) requested the pilot as it seeks to find an efficient and cost-effective way to monitor the forest stands. *www.proteusgeo.com*

12 schools integrate GIS in Abu Dhabi

A new system to incorporate GIS in maths and science curricula across 12 schools in the capital has made students more interested in environmental conservation and engineering. During the programme's first roll-out phase, grade six and 12 students used GIS to study and explore the various uses of this technology in collecting, analysing and comparing data. The Abu Dhabi Education Council (Adec) delegated a number of activities for the various schools to carry out in order to put the GIS into practice. *http://gulfnews.com/*

Qatar selects IBM for smarter road and drainage infrastructure

Qatar Public Works Authority (Ashghal) has selected enterprise IT vendor IBM to provide better road and drainage infrastructure in Qatar. It will will supply the new system to enhance the quality of services, safety and green efforts in Qatar. Ashghal and IBM will deploy an Enterprise Asset Management Solution (EAMS) to manage the operation and maintenance of roads and drainage networks and multiple effluent and water treatment plants. The project is in line with the Qatar National Vision 2030. *www.infotechlead.com*

Orbit launches SpyMeSat iPhone app

Orbit Logic has launched iPhone version of its SpyMeSat mobile app that will offer in-app purchase of recent high resolution satellite imagery. For providing this image, it has recently signed an agreement with DigitalGlobe, which maintains high resolution satellite imagery archive, which SpyMeSat users will now be able to tap into.

New version of Trimble® Business Center released

Trimble has introduced a new version of its powerful office software suite used by surveyors and geospatial professionals for processing and analyzing geospatial data—Trimble® Business Center. Version 3.21 introduces new coordinate reference systems and a specialized Advanced Drafting module, which enables faster project turnaround and better decision making.

The optional Advanced Drafting module adds highly customizable templates and simplified selection tools, which are designed to reduce the time required to generate high-quality deliverables, such as geospatial maps and corridor cross-sections. *www.trimble.com*

New Firmware for LabSat 3 – Introducing Remote Control

Racelogic have released new firmware to allow LabSat 3 to be controlled remotely via Ethernet, giving LabSat users an efficient method of end of line testing. Remote operation through a LAN connection is now possible via simple Telnet text commands, or using a Microsoft .NET API which will allow you to develop your own control software.

In addition, the new firmware features the ability to start a scenario from any point within the recording. *www.racelogic.co.uk*

Inertial Navigation System with Embedded GPS/GNSS by KVH

KVH Industries, Inc has recently introduced TACNAV(R) 3D, a highly accurate inertial navigation system designed for battlefield vehicles. It is the latest product in KVH's TACNAV line of tactical navigation systems. The fiber optic gyro-based INS provides full 3D navigation and an embedded GNSS. Its modular tactical design and flexible architecture allow it to function as either a standalone inertial navigation solution or as the core of an expandable, multi-functional battlefield management system. It is designed to provide navigation for light armored vehicles, both wheeled and tracked, medium and heavy combat vehicles, and main battle tanks. *www.kvh.com*

Leica News

Pegasus released

With Pegasus:Two, Leica Geosystems introduces its next generation vehicle independent mobile mapping platform. By calibrating imagery and LiDAR point cloud data, the Pegasus:Two delivers highly accurate and economical geospatial data in a 360° spherical view while providing two methods for extracting data – either through LiDAR or via photogrammetry.

Leica Viva GNSS Unlimited Series

With the launch of the Leica Viva GNSS Unlimited Series, customers can make a safe investment with future-proof GNSS receivers and smart antennas. Offering a flexible design, the Viva GNSS sensors can be easily upgraded for maximum performance whenever needed. Its range now fully supports the Chinese BeiDou navigation system. It can even provide BeiDou-only and Glonass-only high-precision positioning. The unlimited series additionally includes a future upgrade to a GNSS board with more than 500 channels and will serve users' needs beyond 2020.

GeoMoS Now!

Leica GeoMoS Now is a new web-based application that is part of the Leica Geosystems monitoring solution and enables on-the-go visualisation and analysis of structural and ground movement monitoring data. It enables users to view and analyse monitoring data anytime and anywhere from any smart device, such as a computer, tablet or mobile phone. *www.leica-geosystems.com*

Second-Generation GNSS RTK Rover by Altus

Altus Positioning Systems has introduced its new APS-NR2 RTK surveying receiver. It is Altus' second-generation RTK rover, building on the highly successful APS-3 product series. It features an easily accessible on-board Web interface and integrated Wi-Fi for easy remote configuration and status monitoring, as well as Bluetooth for real-time data streaming, providing true cable-free operation. In parallel to RTK positioning, data can be recorded on a removable 2 GB SD memory card for post-processing. *www.altus-ps.com*

GEO-KOMPSAT-2 to have Northrop Grumman navigation system

Northrop Grumman has been awarded a contract from the Korea Aerospace Research Institute (KARI) to provide space inertial reference systems for the GEO-KOMPSAT-2 space satellite program. It will provide its Scalable Space Inertial Reference Units (Scalable SIRU) for the GEO-KOMPSAT-2A and -2B satellites. The Scalable SIRU(TM) supplies rotation rate data that enable the stabilisation, pointing and attitude control of satellites and space vehicles. The contract includes an option for one additional unit to be exercised by July 2015 for the KOMPSAT-6 program.

Multi-Constellation GNSS Timing Antennas by Tallysman

Tallysman has announced the addition of the TW3740/TW3742 Multi-Constellation GNSS Timing Antennas to its catalogue of high performance antennas. Both are wideband GNSS antennas that provide accurate reception for all upper L- band GPS, GLONASS, BeiDou, and Galileo signals (L1, G1, B1, B1 BOC, B1-2, E1) and associated augmentation signals (WAAS, EGNOS and MSAS). Both antenna models provide greatly enhanced multi-path signal rejection through Tallysman's advanced *Accutenna*™ technology which provides low axial ratio and improved phase centre accuracy thereby providing superior precision.

Integrated highways asset mgmt solutions by Fugro and TRL

Fugro has signed an agreement with TRL, a world-leader in transport research and consultancy, to merge data collection and asset management expertise for highways clients worldwide. They will be well placed to deliver an enhanced range of specialist services, efficiently integrated to maximise value for the asset management programmes of government departments and highways authorities. Clients will have access to world class asset management proficiency and surveying capabilities tailored for medium to large projects anywhere in the world, regardless of project complexity and logistical challenges. *www.fugro.com*

Novatel & Raco Wireless to offer Telematics Solution

Novatel Wireless, Inc. a leading provider of intelligent wireless solutions, and RacoWireless, a global provider of wireless data and location-based solutions, today announced the incorporation of Novatel Wireless' integrated product line with RacoWireless' Position Logic platform, providing a full, end-to-end aftermarket telematics solution for LATAM markets. *www.nvtl.com*

FIG Congress celebrated its silver jubilee

The 25th FIG Congress celebrated its silver jubilee with the convergence of global members in Kuala Lumpur for the 37th General Assembly in a week-long programme from 17 June - 21 June 2014, comprising of a trade exhibition, technical sessions and social activities. The congress – organised by Malaysia Convention and Exhibition Bureau (MyCEB), International Federation of Surveyors (FIG) and the Association of Authorised Land Surveyors Malaysia (PEJUTA) – was themed "Engaging the Challenges – Enhancing the Relevance" and was inaugurated by the Prime Minister of Malaysia, Najib Tun Razak. The organisers claimed that over 3,000 global FIG members were in attendance, comprising surveyors and land professionals, approximately 1,800 were international delegates.

The FIG Congress is held every four years where thousands of surveying and land professionals from across the globe meet to debate and get inspired, particularly on current developments and contributions that will allow the profession to be continually armed with knowledge and best practices to respond to social, economic, technological and environmental change for a sustainable future. *FIG*

MARK YOUR CALENDAR

August 2014

Smart Geospatial Expo
26 - 28 August
Seoul, Korea
http://smartgeoexpo.kr/eng/main

September 2014

GIS Forum MENA
8 – 10 September
Abu Dhabi, UAE
www.gisforummena.com

ION GNSS+ 2014
8-12 September
Tampa, Florida, USA
www.ion.org

GIScience 2014
Vienna, Austria
23 – 26 September
www.giscience.org

AMFM GIS Italia Conference 2014
25 September
Rome, Italy
www.amfm.it

October 2014

Second symposium on service-oriented mapping
6 - 8 October
Hasso Plattner Institute at University of Potsdam, Germany
http://somap.cartography.at

INTERGEO 2014
7 - 9 October
Berlin, Germany
www.intergeo.de

6th Asia Oceania Regional Workshop on GNSS
9-11 October
Phuket, Thailand
www.multignss.asia/workshop.html

ISGNSS2014
22 - 24 October
Jeju Island, Korea
www.isgnss2014.org

35th Asian Conference on Remote Sensing
27-31 October
Nay Pyi Taw, Myanmar
www.acrs2014.com

NZIS Conference 2014
29 Oct - 1 Nov
New Plymouth, New Zealand
www.nzisconference.org.nz/

November 2014

Trimble Dimensions 2014
3 - 5, November
Las Vegas, USA
www.trimbledimensions.com

5th ISDE Digital Earth Summit
9 - 11 November
Nagoya, Japan,
www.isde-j.com/summit2014/

4th International FIG 3D Cadastre Workshop
9-11 November
Dubai, United Arab Emirates
www.gdmc.nl/3DCadastres/workshop2014/

G-spatial EXPO
13-15 November
Tokyo, Japan
http://www.g-expo.jp/

11th International Symposium on Location-based Services
26 -28 November
Vienna, Austria
www.lbs2014.org/

December 2014

PTTI 2014: Precise Time and Time Interval Systems and Applications Meeting
1 – 4 December
Boston, Massachusetts, U.S.A.
www.ion.org/ptti/future-meetings.cfm

European LiDAR Mapping Forum
8-10 December
Amsterdam, The Netherlands
www.lidarmap.org/europe

March 2015

Locate15
Brisbane, Australia
10 – 12 March
www.locateconference.com

Munich Satellite Navigation Summit 2015
24 – 26 March
Munich, Germany
www.munich-satellite-navigation-summit.org

May 2015

RIEGL LIDAR 2015 User Conference
5 - 8, May
Hong Kong & Guangzhou, China

36th International Symposium on Remote Sensing of Environment
11-15 May
Berlin, Germany
http://www.isrse36.org

FIG Working Week and General Assembly
Sofia, Bulgaria
17 – 21 May
www.fig.net

GEO Business 2015
27 - 28 May
London, UK
http://geobusinessshow.com/

June 2015

TransNav 2015
17 - 19 June
Gdynia, Poland
http://transnav2015.am.gdynia.pl

July 2015

13th South East Asian Survey Congress
28 – 31 July, Singapore
www.seasc2015.org.sg

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