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Volume VI, Issue 2, February 2010

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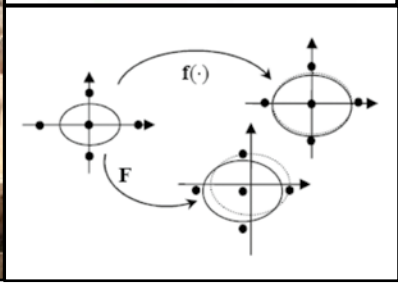

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Bal Krishna, Editor
bal@mycoordinates.org

Defining civil PNT requirements

To support the expanding demands for PNT services into the future, civil PNT requirements need to be identified

John W Lavrakas, President, Advanced Research Corporation, Newport, Oregon, USA
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Today, the civil positioning, navigation, and timing (PNT) community needs a clear and concise statement of PNT needs. This statement should incorporate all aspects of PNT services and all applications and modes of PNT use. With such a statement, providers of PNT technology and services will be better able to plan for, develop, and implement their PNT services. While I offer my thoughts on this need for the United States, the arguments I present are useful for consideration by other nations as well.

The tremendous success in GPS has brought to the fore a common positioning and timing capability, as well as universal reliance on these services. Along with this increased reliance on GPS has come more stressing demands in PNT services, such as landing aircraft in all weather conditions, implementation of positioning accuracy with integrity for intelligent transportation applications, and PNT services in urban environments.

The United States and other nations have been looking at ways to consolidate these needs to reduce unique solutions and promote a more general approach, in which common services are used for many, though not all, positioning and timing needs. In order to determine which common services must be applied, a unified statement of needs is required. This can be provided in a PNT requirements document.

The challenge of civil requirements

For years, the US military has had a formal process for collecting and documenting requirements. In this process each military branch is asked to identify its mission shortfalls, that is, those capabilities not met by current equipment or services. These are called operational requirements. These operational requirements are rolled into a common document, called the capability development document, which is used as the basis for procuring systems, equipment and services to meet operational needs. The US military recognized early on that despite the diversity in missions of its many service branches, there is much commonality in what these service branches do, and thus military leaders encouraged the development of common solutions.

US civil agencies have typically not followed this model, however. Historically, each agency is separate from the others, having differing missions and objectives. US government departments and agencies were created at different times and for different purposes. Some departments began quite early, such as the Departments of Agriculture (1862) and Commerce (1903). Others came later as needs developed, such as Transportation (1966) and Homeland Security (2002). Each has by and large operated independently of the others, and in ways that fit its own purpose and scope. With the common PNT service provided by GPS, however, came the common purpose of civil agencies to balance their needs against those of the military. In the mid-1990's after GPS became operational, the US Government took steps to preserve through executive order and law the dual use nature of GPS to serve both military and civil interests. The White House under President Bill Clinton formed the Interagency GPS Executive Board to oversee the policy matters of GPS, and assigned to the US Department of Transportation the role of coordinating the needs of the civil departments and agencies. This was strengthened by US law in 1998 when Congress enacted US Code Title 10 Section 2281 directing the US Government to sustain and operate GPS for military and civilian purposes. The White House under President George W. Bush extended the

role of the Department of Transportation to cover all space-based PNT services in 2004 with the establishment of the Space-Based Positioning, Navigation, and Timing Executive Committee to replace the Interagency GPS Executive Board.

The US Department of Transportation was placed then into a somewhat artificial leadership role in the area of space-based PNT services. By use of the word "artificial", I do not mean its authority was not real, but rather that its role was "unusual", not following the normal protocol between US government agencies. The US Department of Transportation's leadership role in PNT is somewhat that of "herding cats", for despite the authority granted the US Department of Transportation, each department and agency still tends to pursue its own goals and interests. In fact, in areas other than PNT, seldom do civil departments and agencies have to unify in purpose, motive, and implementation. Thus despite this effort for unity, the civil agencies continue to operate separately and uniquely in support of their own mission needs.

So even though GPS began as a uniform PNT service, each department overseeing its own areas of interest (e.g., aviation, maritime, space) has developed unique augmentations to GPS to support its own particular mission. The FAA developed the Wide Area Augmentation System, or WAAS, to support aviation users in the US national airspace. The US Coast Guard developed the Maritime DGPS service to support maritime users in US coastal waterways and inland river valleys.

The Federal Railroad Administration advocated for the expansion of the US Coast Guard system into a Nationwide DGPS service to support railway applications. The US Department of Commerce through its National Oceanic and Atmospheric Administration's National Geodetic Survey implemented the Continuously Operating Reference Stations (CORS) network to support surveying applications. And the National Aeronautics and Space Administration has implemented a global differential GPS service to meet the needs of its department's space and terrestrial research. The pattern is clear. Each agency has adopted GPS, yet each has uniquely adapted it to meet the specific needs of its constituent user base.

What has actually occurred, however, is that these augmentation systems have expanded to support users outside their original sphere. WAAS is used in agriculture. The Nationwide DGPS service supports agriculture, emergency service, and transit needs. The CORS network is used by the National Weather Service to determine precipitable water vapor. And the NASA global differential GPS service is employed by land-based scientists worldwide in research and scientific investigations benefiting our planet. The systems and services overlap each other like threads of a cloth, tightly woven together and covering the world with space-based PNT services.

The Federal Radionavigation Plan

In 1980, the US Government began the process of unifying the radionavigation-based PNT services used by the disparate military and civil government agencies through the publication of the Federal Radionavigation Plan. Issued biennially, this document provides a unified statement of the needs and capabilities for radionavigation services for US military and civil agencies, - whether for aviation, maritime, highway, rail, timing, or static and dynamic precise positioning applications.

Perhaps as an indicator of the difficulty in coordinating among all these departments and agencies, the release dates of the Federal Radionavigation Plan are telling. Although congressional direction has been to issue these documents "not less often than every two years", two of the last three issues have been late, with the 2005 edition arriving four years after the 2001 edition, followed by the 2008 edition three years later. Clearly this is a difficult job.

Despite these difficulties, there is much benefit to coordinating and harmonizing agency needs. When government departments and agencies work together, they can establish and attain common objectives more easily and with greater cost savings and efficiencies.

The US National PNT architecture

The most recent effort to coordinate between the various departments and agencies has been the National PNT Architecture development, intended to unify the military and civil interests and needs for PNT services. This effort has been in progress since 2006. The architecture development resulted in a set of recommendations to guide US policy in growing its PNT capability over the next 20 years. It was developed with the cooperation of 31 US government departments and agencies having a stake in PNT services. The National PNT Architecture team identified an overarching strategy of "Greater Common Denominator", meaning the US Government would support the development of common PNT services and capabilities while accommodating specialized solutions which otherwise would be either inefficient or inappropriate to provide using a common solution. This strategy is a head nod to the practical effect the common GPS service has had to users worldwide for over 20 years. Prior to GPS, precision navigation systems were high cost and often limited in range and capability. GPS was a game-changer, in which PNT users were given access to precise, low-cost PNT services anywhere. With the advent of GPS came its rapid incorporation into numerous applications, -- surveying, timing, maritime operations, aviation, land navigation, and agriculture, to name a few. GPS thus became the first instantiation of a "greater common denominator" approach in PNT, in which everyone had access to a core service with a common interface.

A civil PNT requirements document

While the National PNT Architecture has taken steps to unify US Government strategy and vision, practical steps are still needed to move PNT into the future. While the military moves forward with their

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capability development document, there is yet no single document that consolidates all PNT needs of civil departments and agencies. Is such a document needed? If there is to be any progress towards unifying the development and deployment of PNT services, the answer must be Yes.

I do not think the issue is so much about harmonizing all the applications between the various civil missions. After all, what the aviation community needs in operating aircraft is radically different from the needs of the surveying community. The issue rather is how to move forward with new common PNT services, most notably those provided in areas where space-based radionavigation services today are not available. These are predominantly in urban areas and inside buildings. As it had done with GPS, the US Government may be able to develop and operate a common PNT service for urban areas or inside buildings. Or perhaps it can foster the development of this capability by commercial interests, in much the same way it has supported the development and use of the airwaves for cellular voice and data services.

One significant way the US Government can know what is needed by its populace is to collect in one place the current and future PNT needs of civil users. This can be done by the development of a civil PNT requirements document. Civil agencies should overcome their predilection to "go it alone", and seek to cooperate in a way to provide a uniform and consistent statement of PNT needs for all users.

Features to consider

As the US Government looks to document these needs, I believe there are several key areas to consider.

Support for the larger mission. There will be a tendency for civil agencies to focus only on their user needs, and to secure solutions that are very narrow in focus. This attention to their user base is well placed, but if left to such a narrow focus, it threatens to scuttle the opportunity to serve the larger mission of PNT services. The lessons of GPS, the ultimate "greater common denominator" PNT service, should not be lost. If the US Department of Defense had not taken the radical step to offer a dual-use service that could be used by civil as well as military users, then the renaissance of GPS would not have occurred, and this readily accessible, ubiquitous service would not exist today. But provide it they did, and the world is better for it. Failure to learn this lesson could result in another "dark age" period in which the development and deployment of PNT capabilities becomes unnecessarily arduous and limited in capability.

Standardized definitions. Need for standardized definitions of PNT services, notably positioning and timing accuracy, availability, continuity of service, integrity (including alarm limit and time to alert), and coverage area. There is a tendency for individual applications to use their own lingo when describing their needs. The value to standardization of definitions is that it provides a common set of metrics against which PNT services can be developed and evaluated against. Although individual agencies may not think in these terms, they should support the transformation of application unique formats and services into this normalized set of definitions.

Time phased needs. In defining needs, consider capabilities that meet not only current PNT needs, but future needs. For example, the GPS L5 signal came out of the desire to support aviation needs into the new century. Likewise, future highway needs require accurate positioning with integrity and improved map databases, to alert drivers of dangerous curves, approaching traffic stops, and congested areas. Eventually with further refinement of PNT services there could even be autonomous vehicle operation. Some needs are immediate, some will be required within the next ten to twenty years, and some may not occur for forty years or more.

Implementation independence. When defining needs, the scope of the need must be independent of a solution. It is not appropriate to state that a need is for "better WAAS" or "better Nationwide DGPS", or even improved GPS. The need should rather be stated in a form that describes the accuracy required, the availability of the accuracy, the area of operation and so on. How the need can be implemented would be determined later once the individual PNT needs have been identified.

Conclusion

To support the expanding demands for PNT services into the future, civil PNT requirements need to be identified. Civil agencies and departments can do this by supporting a standardized set of terms for PNT services, and state their needs without regard to how they will be implemented. This method worked well for the US military in developing and fielding GPS, and it will work well for civil departments and agencies in fostering the next generation of PNT services in years to come. The efforts being made by the United States to define PNT requirements can be adopted by other countries as well to support a universal statement of civil PNT requirements.

The opinions expressed in this article are those of the author and do not reflect those of the US Government or any of its departments or agencies.

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MISSION 2020

India needs the Land Titling project 'yesterday'! not tomorrow or day after

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Consider the scenario, date.1.1.2020: "Mr A buys property in Meerut, city in Uttar Pradesh (UP), India from Mr B in Dec 2019. The ownership-title that Mr B is the Owner, is guaranteed by the Government Registrar. As a matter of fact, all the properties with the names of their owner (s) are recorded centrally In the computer in the office of Land Survey Department of UP. the location like trees and wells, etc are all photographed on an aerial photograph. The coordinates of the building have also been recorded taking the halp of the most accurate technology of global positioning system (GPS). Central survey organization, an offshoot of the Survey of India and NSDI, had been entrusted with this titling project, which started in 2010."

Do you agree, with the above scenario? Doubtful? You don't have to be. Many countries of the developing world, namely, Thailand Vietnam and Philippines have finished substantial part of their land titling project United Kingdom have also enacted Land Registration Act, 2004.

Compare with the present status

Land Registration Act, 1908

Only documents are registered under this Act. Interestingly, for argument sake, Taj Mahal can be gifted by Mr.A to Mr.B and the gift deed can be registered. The property is only 'described' by the 'delineation' details of the boundary. The proper location in survey terms (coordinates) are not stated. Law Commission, in its sixth report, 1957 did take up this subject but made recommendations only to improve the provisions of the Act (Registration Act). Nowhere we find the 'vision' of guaranteeing the ownership of the property. It is this lacuna, a mega-one, (of absolute ownership) which is being addressed in this paper.

Major and lasting advantages of land –titling system

Land titling project (LTP) will provide lasting and epoch making advantages to the nation. Some of those are:

Assured ownership of the property

The government, after due diligence, will guarantee the ownership. This will greatly enhance the trustworthiness of the thousands of land-transactions taking place in the country. People will have secure land-tenure, devoid of all hassles. Compare this with million of man day lost in going to courts, notices in the press and spending loads of money.

Reduce litigation regarding land and property

Look at these alarming figures!
At one time (1980) West Bengal state had 80,000 writ petitions pertaining to only land related cases which keep going on and on for years. Consider the backlog in terms of all, the states and involved people. 'Pucca Registry' will greatly reduce land – related cases through better land tenure. Banks will find it easier to offer credit as it is already happening for regular Patta Holders .

Quality of life

The project on Land Titling is not only a technology project but it is indeed, a people-project guaranteeing major improvements in quality of life. Crores of low/high income persons alike will benefit from it. In Thailand where the fruits of such a project have reached the masses prove a better quality of life.

Super objectives of the project

- To create a state –wide, computer based, State Property Register acting as a source of providing information on the ownership of land / property in its final basis.

- The time taken to get the desired information/certificate should not exceed four hours (half-day) at the designated office (say, Tehsildars office)

- The process of obtaining the desired certificate should involve minimum legal support from professional community.

- Proper provisions will be made to update/ revise the records.

Sub-objective(s)

Municipal corporation, panchayat and such like organizations will be provided opportunity for strengthening the system.

Role of modern land-information technologies (LIT)

LIT will play a major role in laying the strong foundation to the whole concept and operational methodologies of the Titling –Project. Specifically:

Field control on the ground

The laid-down accuracy will be such so as to withstand the requirement of most accurate measurement (area, length, etc).The requirements of the permanent – control points on the ground should meet the required imputs for relaying the boundary etc. of the plot. Undoubtedly, GPS will be the mainstay.

Survey of topographical details

Boundaries, topographical features and permanent objects/marks.

Revision policy of surveyed information and secondary data.

Criteria for surveys

Lessons based on the experience of

Thailand –Titling project are to be incorporated in Indian project. Some of these points are mentioned below:

- In case, it becomes necessary, the property boundary should be recreated/relocated on the ground. It implies that adequate number of permanent markers/witnesses should be deliberately left on the ground.

- The accuracy-specifications of the survey should be able to cater to the cost of land, present and future and operations, for example, land – acquisition, etc.

- The technology and operations should be so designed so as to cater to the revision cycle, changes on the ground due to nature (floods etc.) or man –made activities e.g. mutations, transfer, sale, etc.

Recommended LIT

A methodology for undertaking modern cadastral surveys has already been suggested by the author in 2005. (2). It is briefly described as under.

Aerial photography of the area on 1:20,000 scale is recommended.

GPS Control – Differential GPS; all Tri-junctions, (permanent marks/pillars on the ground) are to be ground controlled. Sketches of all GPS control points to be made for helping photogrammetric process.

Photogrammetric process

Aerial triangulation (or similar process) combined with the Digital terrain models is to be completed. Photogrammtric rectification, plotting or Digital Orthophotos are to be prepared. Terrain will dictate the choice of technical process.

Cadastral records

Revenue authorities should take over this important operation. The fact remains that this is the most important phase of the project.

Legal operations

Allocating ownerships and preparation of records/certificates etc. putting information on computers.

Optional (yet important) information about land

- Heights of objects can be determined.

- Information about soils, vegetation, drainage, geology, etc. can be picked up with an eye on GIS mapping.

Unique Identity number to each plot/property in India

Government of India has already constituted unique identification authority (see box no 2). The idea behind this scheme is to provide unique number to each individual citizen of India. A similar plea is being made under the land titling project, to allot a unique plot number to each property in India irrespective of whether the property is rural or urban. The system should be based on GPS coordinates. It will one day, be possible to see the plot/building on internet for any place in India. The author has suggested that NSDI and Survey of India, in their newly evolved role, should, perhaps, take this as their objective. Space does not permit full discussion of this point. But surely, Survey of India, true to its name in real sense, will get connected directly to each land / property holder in India.The above mentioned land and property data-base will provide reliable, useful, timely inputs to many schemes including land acquisition and taxation. For USA plots, try zellow.com.

Historical facts

The survey responsibility of cadastral (revenue) surveys was delegated to the state land surveys department in 1905. Consequently, the technology of surveys remained stagnant; without inputs from modern technology of aerial photography, photogrammetry, GPS,GIS etc. It in only in eighties (1981) that some thoughts on computer applications combined with aerial photography were given to produce revenue (patwari) maps – example from Madhya Pradesh. Currently, computerization of land records is being carried out throughout India.

What other countries are doing in land-titling?

Some lessons

Thailand

Government of Thailand (Land Survey Department) was assisted by Australian Aid Agency in undertaking the project for land titling in 1981. The project was designed, inter alia, to produce cadastral surveys and to issue title deeds. This project was recognized as one of the most successful projects by the United Nations. It met all the objectives including establishment of Land Evaluation Authority.

Vietnam, Phillipines and Russia also have progressed well in the issue of Land Titles. There were initial difficulties pertaining to the institutional complexities of land ownership due to political doctrines. Russian project is, incidentally, managed by USA Aid Agency. These projects are well referenced on internet under Land Titling Projects.

Lesson from foreign projects

Some lessons are very vivid and inspire confidence that replication of Land Titling Projects are bound to succeed, if proper thinking in conceptualization, implementing, institution building and participation of all stake-holders is ensured. Most important factor for success is whole – hearted support from highest echelon of the Goverrnment.

To enumerate further, some other lessons are:
The time and money spent on court procedures presently in acquiring the title .is much more than evolving a simple procedure for Land Title Project. The benefits are widespread through the community.

The base is already available in the form of Land Survey Departments. The departments have to be guided, channelized, equipped, trained and mentored to deliver the result.

Most importantly, Government's strong will is required as it happened in

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NAREGA (National rural employment guarantee act) project in India.

Special points for urban properties

In principle, the main features of Land Titling Project will be fully applicable to the properties in urban areas. It is however, obvious that more rigorous methods of survey will be required. This is because of higher value of land. Surveys will have to be more accurate. Consequently, those technologies which give more accurate results will be employed. Some specific discussion is, therefore, needed.

Survey technology

In urban areas even 1 square foot of land has value. it in not only in terms of money but is also important to sort out encroachments and boundary disputes in courts. The technology of photogrammetry, in its accurate application, is capable of mapping even 10cm of ground. A larger scale of aerial photography, say, 1:6000 is recommended as compared to 1:20,000 for rural areas. In many cases in India, the mapping has been done on 1:1000 scale. Photogrammetry is a proven technology in India. It is also a fact that urban areas comprise conglomeration of buildings or close cluster of settlements which create shadows on an aerial photograph. In such cases, a partial map (whatever can be done) by photogrammetry can be produced. The partial map can be computed by filling in missing portions by ground methods.

Land use of town

Town planners need this information which can be obtained from aerial photographs and verification on the ground.

GPS control points and leveling bench marks

It is a prudent idea to create a close mesh of GPS and Level-Bench Marks in a big town. Engineers will need these points for their projects.

Environmental bench – marking of towns

Aerial photographs provide excellent data-base for these environmental teatures and vegetations and other environment features like lakes, etc.

Concept of ownerships of multi-storeyed apartments, shops etc.

Multistoreyed buildings are common feature of a town. How do we determine the legal records, unique-property numbers? The problem can be solved by adopting space ownerships practices. the subject can be studies further keeping in view of the system adopted in Mumbai. Our practices could be compared with what is followed in western countries and Australia. Indeed, this could be a subject for further research under titling project.

Nilekani's unique individual number

Unique identification authority (UIA) is headed by Mr Mandan Nilekani, former CEO of famous Infosys. He is evolving a unique identification number for each citizen of India. Taking the cue from this UIA, it will be prudent that there should be a unique identity of all land and property in India. GPS technology will of course, be the mainstay of the system. How will this be evolved should be a matter of research, technical discussions and seminars.

External catalyst organizations will expedite the Land Titling Project

The titling-project will definitely need.to record the experience of other countries. We may have to borrow their experts. In such a case, it will be wise to have some collaborations with World Bank, Asian Development Bank or similar organizations. Even funding may be possible through these organizations. It is also experienced that foreign collaborative project gains momentum, priority and acceptability by our own government department in central, state or level.

Making a beginning

A good beginning could be made by the Ministry of Rural Development by creating an Advisory cum Steering Committee on the subject. After all Titling Project is a follow up of land records project under the Rural Development ministry. The committee may be constituted on a broad-base comprising academics and practitioners.

Conclusion

India needs the Land Titling project 'yesterday'! not tomorrow or day after. We need to make a good beginning through a Steering Committee, as mentioned, who will identify the main 'pillars' and the 'milestones' of the project. This is a mega-project which is expected to bring major change. Therefore all the principles of management of change will be applicable to this project also. The project should be evolved in such a way that is not only 'right' but is 'acceptable' to all, especially rural people.

A brand new project always generates need for training, research, standards and reference. Letthese be started on a sound footing. The research action can even be started now, ahead of titling project. The State Departments of Land Surveys have all the knowledge and wisdom. These must be utilized. There is no of a fresh technology. Every system/ technological input has been tested and tried in India. If properly managed, nurtured and monitored, the project on land-titling is bound to succeed.

References

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Misra, P; Cadastral Surveys in India, June 2005, Coordinates

Misra P; Cadastral Surveys in India-A critique, Seminar on cadastral survey organized by gisdevelopment Oct,2000

Searches on internet provide immense information on the subject.

GNSS support to Canine search and rescue

osmografo® is an innovative technological aid for search and rescue teams using rescue dogs.

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Head of GNSS Advanced Systems Division (GMV)
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Manuel Prieto
GNSS Engineer at GMV, Madrid
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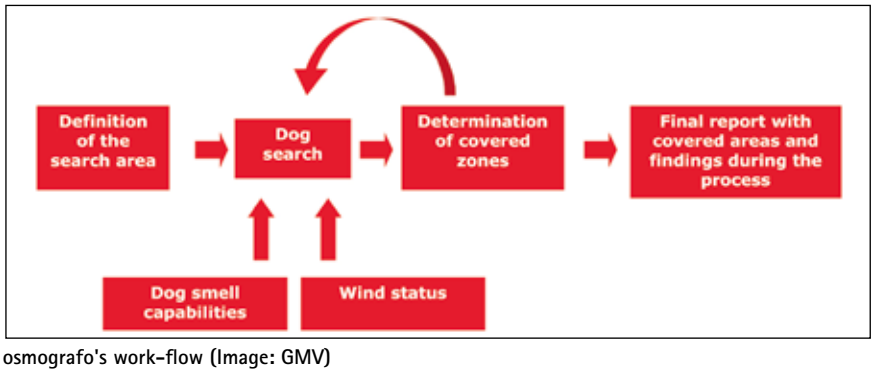
Earthquakes, landslides, avalanches, collapsed buildings… There are many situations in which people could suddenly become trapped and unable to free themselves without the assistance of search and rescue professionals.

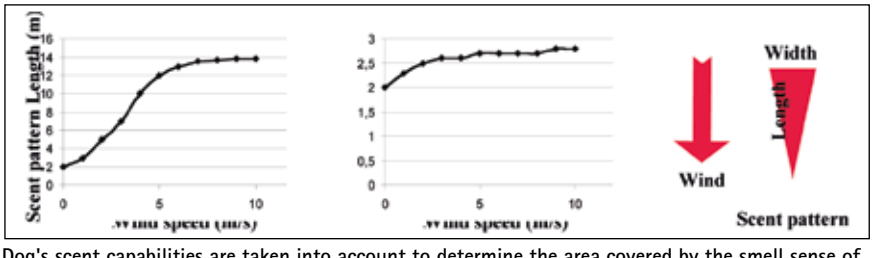
In response to those situations, and to help rescue teams locate and save people in need in the shortest possible time, the company GMV has patented and developed the *osmografo*®, GNSS-based support system for rescue operations that uses canine (K9) search teams.

Victim	Alive or unknown	Deceased	Test
Undetected			T
Detected	V	V	T
Confirmed	V	V	T
Start of rescue	V	V	T
End of rescue	V	V	T
Potential victim	V		
Nonexistent victim marked as potential	V		

Table 1



osmografo's work-flow (Image: GMV)



Dog's scent capabilities are taken into account to determine the area covered by the smell sense of the dog (Image: GMV)

It seamlessly integrates dog positioning data with environment data such as wind direction and speed to determine areas covered by the dog's smell. The system reads the dog's positioning information and integrates it with wind data to build a map of the scent covered area in real time as it happens. The system offers support for the operative needs and procedures of canine Search And Rescue (SAR) teams.

K9 SAR and the role of the wind

Canine teams are used worldwide for rescue operations, for which the dogs receive rigorous training on locating victims. The dogs rely on their keen sense of smell in combination with their training in order to scout the devastated region and detect the telltale scent of a human being trapped amongst the wreckage. The dog moves within the search area following its nose and the instructions of its handler. When it detects the scent of a trapped person it indicates the area where it believes the person is by remaining in the area and barking or using other indicators that it has been taught.

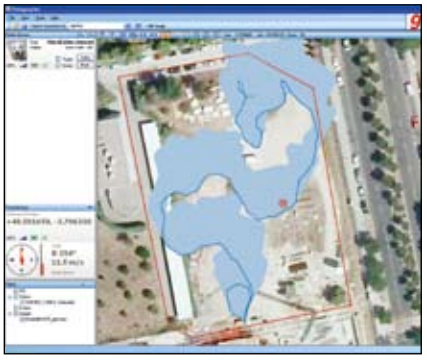
In the search and rescue process the wind is a key factor that can aid the dog by allowing it to cover large areas much more rapidly and efficiently. With a moderate wind of a few kilometres per hour, the olfactory range of the dog can grow to up to a few dozen meters. This allows the dog to cover the entire search zone in fewer passes.

When the total number of victims is unknown then the responsibility for determining that an area has been completely covered falls to the rescue operation coordinator. This decision will initiate a change of search area or

the use of heavy machinery to clear the debris. In both cases the consequences could be fatal if there are undetected survivors that remain within the area.

This decision currently relies solely on the technologically unaided opinion of one person. To determine whether there are areas that remain unsearched, the coordinator has to remember all routes the teams have travelled and the direction and speed of the wind. This in practice requires spending more time in any one zone than should be necessary in order to ensure that the zone has been fully searched before moving on to look for other victims, for whom any delay could be fatal.

The handler directs the dog to an area pending to be searched.



The central application of the osmografo® includes information on connected terminals, wind properties, area searched and victims found.

osmografo® received the Spanish National Award to the Best Product for Emergencies 2006-07

osmografo® received the award Galileo Masters 2009

GNSS support to K9 SAR

In response to this challenge, GMV has developed the osmografo®, an innovate system that assists the rescue coordinator in determining whether an area has been fully searched by the canine teams. The name of the product has been selected to stress its main functionality, namely to represent the smell (osme, οσμη after the Greek). The system consists of a GPS tracking device attached to the dog that sends its position to a central monitoring unit and includes meteorological sensors that measure the speed and direction of the wind. It can be calibrated during training sessions to map the dog's olfactory range as a function of the existing wind parameters.

During a rescue operation, the central monitoring unit of the osmografo® records the wind characteristics and routes taken by the dog and shows in real time the effective area that has been covered. It compiles all of the search information from every team and displays the total area covered by the rescue squad at any moment. This provides invaluable support to the rescue coordinator for determining what areas have been fully searched and what areas have yet to be covered. In addition to these basic functions, the system has the ability to support the training of the dogs, handlers and coordinators by analysing in detail their training sessions and helping them to improve their search techniques.

System Components

The main components of the system are:

- Several wireless collars with GPS positioning capability
- A wireless wind sensor with GPS positioning capability
- A computer running a software application
- A wireless communication device connecting all components to the computer

All components have been designed for easy packing, transport and deployment on the field. The collars are light enough for all dogs and are equipped with a breakaway buckle for the dog's safety. This way the collar is automatically detached if caught in something.

The system has been designed to work in collapsed areas with absence of any telecommunication infrastructure. All provided wireless communications is autonomous without need of external resources. The collar device and the anemometer device send data wirelessly over long ranges using ISM radio bands. No internet connection is needed for operation and everything is battery operated.

Data is received in real time at the operator's computer and visualized in an integrated way. This includes generation and addition of smelled areas as the dog's trajectory is being done. Personalised smell characteristics are defined for each dog and maintained in a database by the application. The operation coordinator can define a target area of interest and have an overview of the zone coverage. It is then possible to determine unsearched regions and act accordingly by alerting the handlers or introduce additional dogs to finish the search. The system has been developed in close cooperation with K9 Non-governmental organisation (NGO) IAE (Intervención, Ayuda y Emergencias, Valencia, Spain) to capture user needs and provide field testing.

Support for rescue teams

The software has been tailored to support rescuer's needs in a variety of ways.

The application supports the usual points of interest but also introduces special markings devoted to victims. As part of the focus on operative requirements, each victim or point of interest has a location but also events associated with it. The list of predefined events includes those commonly used during a collapsed area search and rescue operation as shown in Table 1. The used symbols are inspired by FEMA US&R Recommended Marking System. Several dog trajectories, searched areas, victims and events can be added up for coverage analysis. Support has been added for hiding places, victims and other special events.The operation's reports are automatically generated by the application for activity traceability and documentation. The report describes search operation aspects including:

- Target zone description
- Aerial georeferenced photography, maps (if added)
- Percentage of target area covered
- Participants (dogs, handlers)
- Trajectories, including associated wind data
- Victims
- Points of interest
- Events
- Hiding places per training zones
- Comments (taken on-field and afterwards)

All relevant data is maintained in a database allowing for later use such as export, search, comparison, etc.

In addition to operational activities, the system can be used for training, certification and research. During training, the user can be assisted in the process of learning to read wind and dog smell capability. The handler can compare its understanding of the coverage with the one actually achieved. It is also possible to train the feeling of coverage of the search area with different dogs. The storage of a database of activities, data and progress is an important factor for dogs and handlers evolution assessment. During certification, the system can be a technological aid to rigorously trace and check the performance of dogs and handlers. The technology has also been used to further explore the influence of environment in dog's capabilities as well as research on human mistakes in estimation of coverage.

History and Awards

The system concept was first proposed in mid 2006, after email interaction between GMV engineers and volunteers from the NGO IAE; a few months later

The application tightly integrates dog positioning information with wind information in real time.

Field tests conducted in summer 2009.

the feasibility tests were conducted in the training field of this organization. Early in 2007, the patent was filed by GMV, and the development project defined and started. The first operational prototypes were tested in field in summer 2009, and a few improvements were introduced after the tests. The official international presentation of the prototypes was done in September 2009. Currently, the commercial version of the product is in preparation. The technology has been awarded several prizes. It received the Spanish National Award for the Best Product for Emergencies 2006-07, the award for one of the best 100 ideas in 2009, given by the economic magazine *Actualidad Económica*, and the overall prize in the European Satellite Navigation Competition, Galileo Masters 2009. In this competition it also received the prize for the best application in the region of Madrid and the Special Topic Prize *Support to life*.

Summary

osmografo® is an innovative technological aid for search and rescue teams using rescue dogs. It does not substitute but provides added value to expert rescuers in their operation and decision making process. The system is fit to user requirements, not just technical, but operationally. Particular fit to dog characteristics with a safe detachable collar of right size and weight.

This product, 100% funded by GMV as an internal R&D project, provides unprecedented combination of GNSS positioning, wind measurement and dog smelling capabilities in a simple, yet powerful aid to SAR teams. Human judgement, animal senses and technological aids are used together for the support of human life.

Acknowledgments

GMV is in debt with the K9 SAR non-governmental organization ONGD Intervención, Ayuda y Emergencias, (www.iae.org.es), for their invaluable support in the definition of the user needs and the test phase.

Land Administration for Sustainable Development

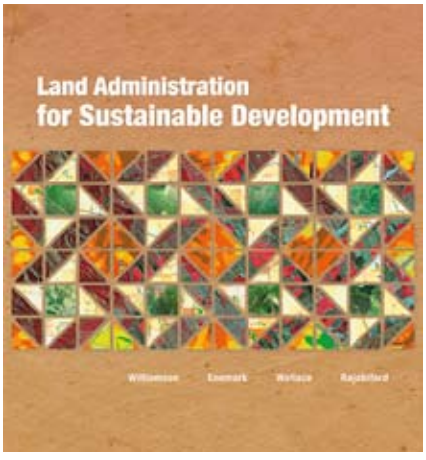
Land Administration for Sustainable Development examines global land administration systems at different levels of maturity. This examination elucidates how countries can establish basic infrastructure for the implementation of land-related policies and land management strategies that will help ensure social equality, economic growth, and environmental protection. Through its presentation of a holistic view of land management for sustainable development, this book outlines basic principles of land administration applicable to all countries and their divergent needs. Land Administration for Sustainable Development is a resource for professors and students of land planning, land administrators, land planning managers, and government officials.

Ian Williamson is a professor of surveying and land information at the University of Melbourne, Australia. Williamson has authored or coauthored more than 400 articles on topics of cadastre, geographic information systems, land administration, and spatial data infrastructures in both developed and developing countries.

Stig Enemark is a professor of land management at Aalborg University, Denmark. Enemark is president and an honorary member of the International Federation of Surveyors as well as past president and an honorary member of the Danish Association of Chartered Surveyors.

Jude Wallace is a land policy lawyer who is a senior research fellow at the Center for Spatial Data Infrastructures and Land Administration at the University of Melbourne. Her specialties range from improving the most modern land administration to developing pro-poor land strategies.

Abbas Rajabifard is a professional land surveyor and chartered engineer, who is an associate professor of spatial data infrastructure and director of the Center for Spatial Data Infrastructures and Land Administration at the University of Melbourne. Rajabifard is president of the Global Spatial Data Infrastructure Association. *www.esri.com/esripress*

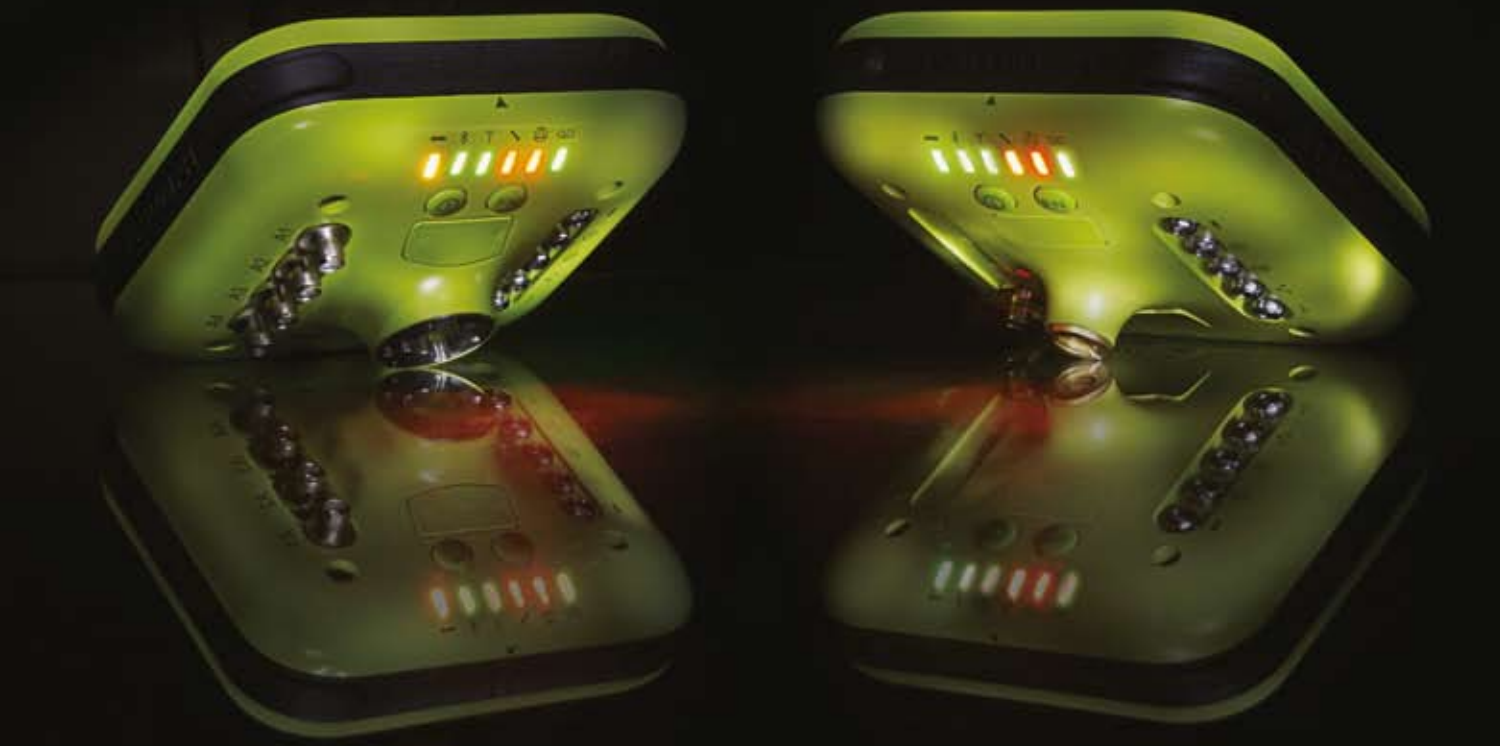


ISBN: 9781589480414 2009 512 pages $49.95 ($36.46 at www.amazon.com)
Publisher: ESRI Press Academic (January 1, 2010)

TRIUMPH 1
TRIUMPH – 4X
216 channels

JAVAD
WWW.JAVAD.COM

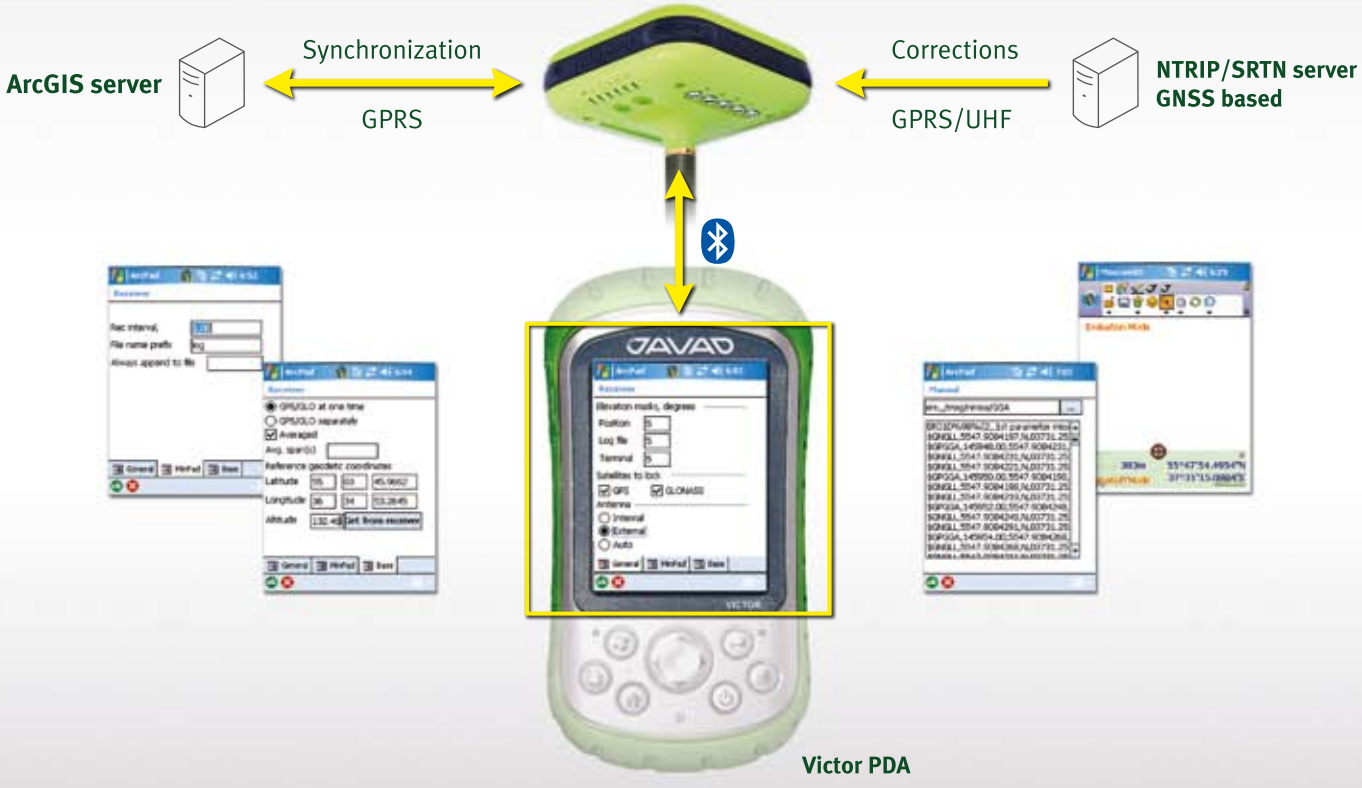
JAVAD ArcPad Extension
in focus



JAVAD ArcPad Extension

In response to a long-standing request from ESRI, JAVAD GNSS is pleased to announce that ArcPad users can now communicate directly with ESRI ArcGIS Server via our Triumph receiver so no additional devices (external radio) or settings are required. Real-time centimeter-level positioning is now possible in the field for ArcPad users.

- JAVAD ArcPad Extension enhances the spectrum of ArcPad's surveying capabilities by adding state of the art JAVAD GNSS solutions. JAVAD ArcPad Extension provides a full range of functions to control the GNSS receiver and manage the surveying process.
- JAVAD ArcPad Extension establishes a connection to the receiver via serial, USB, or Bluetooth and configures the base station parameters that govern the RTK and UHF radio setups, and GSM modem settings.

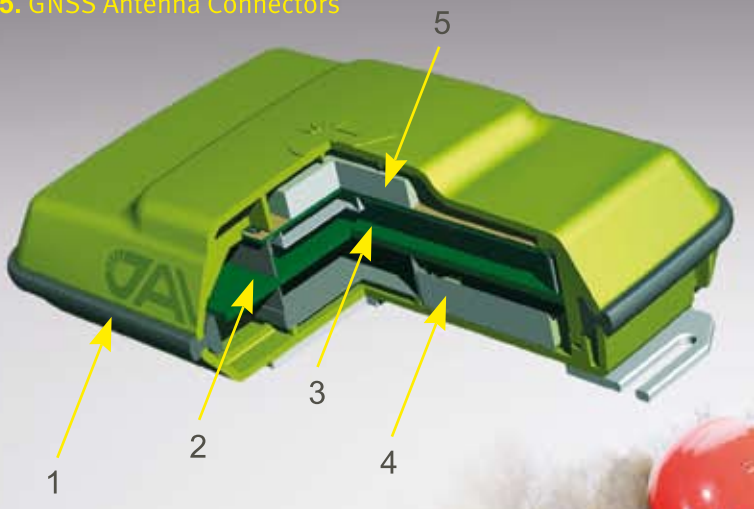


- Quality control of real-time positioning results are assured in the field. The JAVAD GNSS Victor PDA displays the status/process progress continuously via the Bluetooth connection to the receiver.
- Advanced RTK accuracy and ArcPad vector/raster map visualization capabilities deliver reliable object positioning and a new level of job control in the field.
- JAVAD ArcPad Extension is an optimal ESRI-compatible solution for a wide variety of civil engineering or cartography tasks where centimeter level accuracies are required. At the core of this solution lies highly integrated JAVAD GNSS technology optimized for use with ESRI's GIS software.

Please see www.javad.com for details.

Actual size

1. Guard Bumper
2. Bluetooth/GSM Antenna
3. GNSS Receiver, Power Board, GSM/Bluetooth and Memory
4. Rechargeable li-Ion Battery
5. GNSS Antenna Connectors



GISmore

stand-alone or inside the hat

Bluetooth wireless connection to GISmore

- GPS L1
- Galileo E1
- GLONASS L1
- 100 Hz update rate
- 100 Hz update rate
- RAIM
- WAAS/EGNOS
- Rechargeable Li-Ion Battery
- GNSS Antenna
- GSM Module
- Bluetooth® Interface
- Bluetooth/GSM Antenna

GISmore receiver is based on our TRIUMPH Technology implemented in our TRIUMPH Chip. For the first time in the GNSS history we offer very powerful GIS field mapping receiver with up to 100 Hz RTK, 216 channels of single frequency GPS, Gallileo and GLONASS in a small attractive, sturdy, and watertight box.

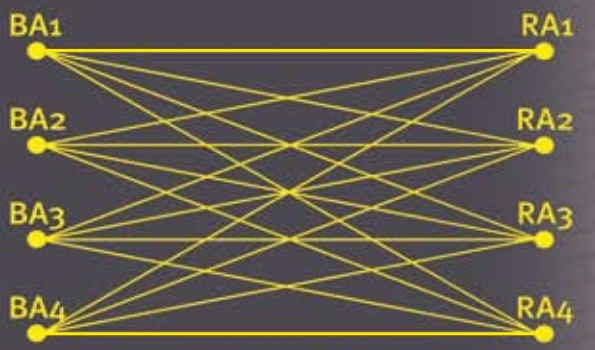
Many ways to use

GPS + GLONASS + Galileo

TRIUMPH 1

4x4... ALL WILL DRIVE... RTK!

TRIUMPH-4x



4 base — 4 rover, 16 baselines

Please see www.javad.com for details

Software solutions for all tasks

Justin

A comprehensive Survey and GIS software

Justin has integrated native tools to use ESRI or MapInfo cartography windows.

It can import data files as well as whole folders. Justin employs special technique to process high rover data rates (up to 100 Hz) using low base data rates. Other features include single epoch static solution, manual postprocessing with time line chart, using vertical profile to filter out suspected data and scientific data analysis and viewer.

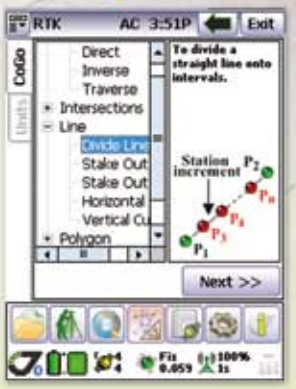
Victor

Victor is pre-loaded with our Tracy field software. When turned on, Victor automatically connects to TRIUMPH-1, TRIUMPH–4X or GISmore via its internal Bluetooth and guides you through field operations. It manages the GNSS receiver and modem operations automatically.

- **Lightweight (17 ounces; 482 grams) magnesium case with easy-to-grip over-molding**
- **Operating temperature -22°F to 122°F (-30°C to 50°C)**
- **Connectivity via built in Bluetooth, USB Host and Client, plus 9-pin RS-232 and optional WiFi and Modems**
- **Rechargeable, field replaceable, Li-Ion battery**
  It operates for more than 20 hours on one charge (3 to 5 hours of charging time)

Giodis

Full-featured office post-processing software



Support for survey and stakeout projects

Static, Fast Static and Stop&Go surveying

Configuration of all hardware

Tracy

A versatile and powerful field software

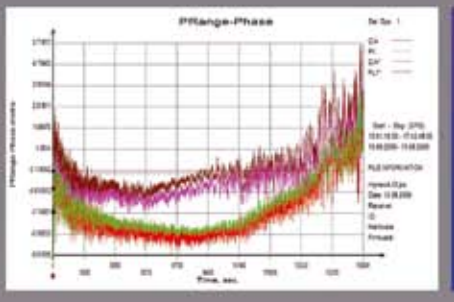
Software for Windows Mobile OS to control receivers, automated GNSS post processing surveying tasks (Static, Fast Static, Stop&Go, Data Acquisition), and to perform RTK survey and stakeout tasks.

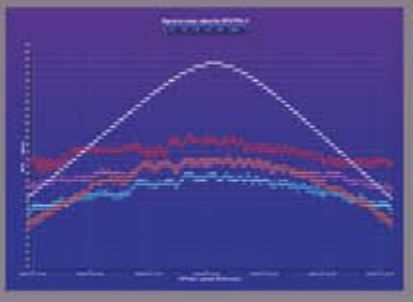
Javad eliminates GPS SVN 49 anomalies

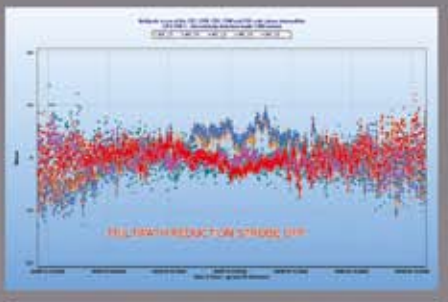
The anomalies in the recently launched SVN49(PRN1) was a chance to demonstrate the advanced multipath reduction capabilities of JAVAD GNSS Triumph technologies.

Figure below shows SNV49 (PRN1) code-minus-phase plot for usual correlator (magenta - C/A code, brown - P/L1 code) and for “mpnew” (red - C/A code, green - P/L1 code), which shows almost all anomalies and satellite multipath are removed.

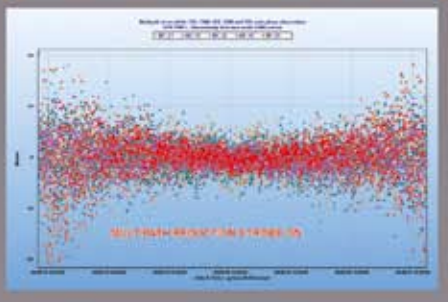
Figures below also describe the multipath performance of a pair of Triumph-1 receivers we ran in a zero baseline test. The left figure depicts the code multipath errors of the GPS PRN1 pseudoranges measured by the receiver with the ‘normal’ strobe enabled. The right figure shows the code multipath as estimated for the second receiver, where the optimized multipath reduction strobe was enabled. The center screenshot displays the signal-to-noise ratios and elevation angles of GPS SVN49 over the time interval analyzed.

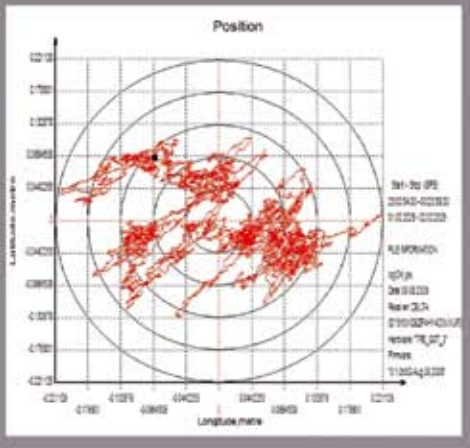






The optimized multipath mitigation technique implemented in our Triumph technology allows nearly complete compensation for the satellite-induced multipath anomalies that would otherwise badly affect GPS SVN49 measurements. The same multipath reduction capabilities which removed the SVN49 multipath anomalies can remove the multipath effects which are a major source of error in precision positioning.





JAVAD GNSS receivers tracked all current and future Galileo satellite signals

JAVAD GNSS receivers successfully tracked all Galileo satellites from Spirent simulator and produced Galileo-only and triple satellite (Gps+Glonass+Galileo) positions. Up to 27 satellites were tracked simultaneously.

The experiments were performed jointly by Spirent and JAVAD GNSS.

Sat	(Fn)	El	Az	C/A	P1	P2	TC	Count	F_C/A	F_P1	F_P2	Use
Gps	1	29	--	46	0	0	63	3818	0xA153	------	------	Y(0)
Gps	3	24	--	47	0	0	86	4986	0xA153	------	------	Y(0)
Gps	6	37	--	46	0	0	86	4986	0xA153	------	------	Y(0)
Gps	11	14	--	44	0	0	77	4622	0xA153	------	------	Y(0)
Gps	14	20	--	45	0	0	86	4986	0xA153	------	------	Y(0)
Gps	16	78	--	49	0	0	86	4986	0xA153	------	------	Y(0)
Gps	18	7	--	47	0	0	86	4986	0xA153	------	------	Y(0)
Gps	19	10	--	48	0	0	86	4986	0xA153	------	------	Y(0)
Gps	20	7	--	47	0	0	4	272	0xA153	------	------	Y(0)
Gps	22	38	--	47	0	0	86	4986	0xA153	------	------	Y(0)
Gps	31	23	--	45	0	0	86	4986	0xA153	------	------	Y(0)
Gln	6(-2)	24	--	51	0	0	87	4986	0xA153	------	------	Y(0)
Gln	7(-1)	28	--	51	0	0	87	4986	0xA153	------	------	Y(0)
Gln	9(1)	21	--	50	0	0	87	4986	0xA153	------	------	Y(0)
Gln	10(2)	75	--	52	0	0	87	4986	0xA153	------	------	Y(0)
Gln	11(3)	44	--	50	0	0	81	4911	0xA153	------	------	Y(0)
Gal	71	18	--	50	0	0	86	4986	0xA153	------	------	Y(0)
Gal	78	18	--	50	0	0	81	4892	0xA153	------	------	Y(0)
Gal	79	30	--	49	0	0	86	4986	0xA153	------	------	Y(0)
Gal	83	23	--	48	0	0	59	3572	0xA153	------	------	Y(0)
Gal	84	70	--	49	0	0	86	4986	0xA153	------	------	Y(0)
Gal	85	58	--	50	0	0	84	4986	0xA153	------	------	Y(0)
Gal	86	13	--	49	0	0	86	4986	0xA153	------	------	Y(0)
Gal	89	33	--	50	0	0	85	4986	0xA153	------	------	Y(0)
Gal	90	35	--	51	0	0	86	4986	0xA153	------	------	Y(0)
Gal	91	11	--	51	0	0	86	4986	0xA153	------	------	Y(0)
Gal	97	8	--	50	0	0	29	1742	0xA153	------	------	Y(0)

Other Receivers

ALPHA

- Internal battery
- Charger
- GSM
- Bluetooth

for: TR-G3, TR-G2T, TR-G3T

Front panel connectors:

Power Input + serial port A + USB + Antenna

Back panel connectors:

Can have up to 3 connectors of 1-PPS · Event Marker · IRIG · GSM Antenna (without Bluetooth antenna).

When Bluetooth antenna is installed only one extra connector can be installed.

Example 1: BT Antenna + GSM Antenna
Example 2: 1-PPS output + Event Marker + GSM Antenna

DELTA

for: TRE-G2T, TRE-G3T, Duo-G2, Duo-G2D, Quattro-G3D

Front panel connectors:

Option 1: Power Input + Serial A + Serial B + Serial C + Antenna

Option 2: Power Input + USB + Serial A + Serial C + Antenna

Options 3: Power Input + USB + Serial A + Serial C + Ethernet

Back panel connectors:

Can have up to 4 connectors of 1-PPS A · 1-PPS B · Event A · Event B · Antenna · CAN · IRIG B

Example: 1-PPS A + 1-PPS B + Event A + Event B

SIGMA

- Internal battery
- Charger
- Modem
- GSM
- Bluetooth

for: TRE-G2T, TRE-G3T, Duo-G2, Duo-G2D, Quattro-G3D

Front panel connectors:

Can have Power Input · Second Power Input · USB · Serial A · Serial B or C · Ethernet

and up to 4 connectors of 1-PPS A · 1-PPS B · Event A · Event B · Antenna · CAN · IRIG · RS422

Back panel connectors:

Can have SIM door and GSM Antenna connector and up to 4 connectors of 1-PPS A · 1-PPS B · Event A · Event B · Antenna · IRIG · Modem Antenna · Bluetooth Antenna

Example: GSM Antenna + SIM door + 1-PPS A + 1-PPS B + Event A + Modem Antenna

Fuzzy strong tracking unscented Kalman filter

An alternative state estimation technique called the fuzzy strong tracking unscented Kalman filter has good potential as the GPS/INS navigation state estimation technique

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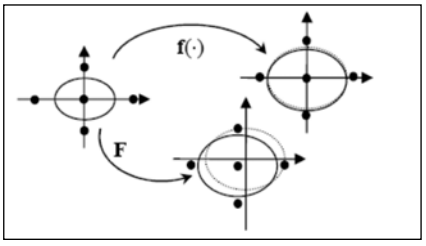

Figure 1: Illustration of properties of UKF and EKF (Li et al. 2006)

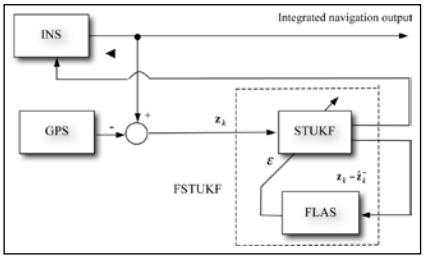

Figure 2: Two-dimensional GPS/INS integrated navigation using the FSTUKF

The Global Positioning System (GPS) (Brown and Hwang 1997; Farrell and Barth 1999; Gelb 1974) and inertial navigation system (INS) have complementary operational characteristics and the synergy of both systems has been widely explored. An integrated GPS/INS system is typically carried out through the extended Kalman filter (EKF). The EKF is the approximate nonlinear filters which linearizes the system and measurement equations about a single sample point with the assumption that the a priori distribution is Gaussian. The EKF uses first order Taylor series expansion, which can be improved by higher order approximations at the expense of computational burden.

The unscented Kalman filter (UKF) (Wan and van der Merwe 2000; Wan and van der Merwe 2001; Simon 2006) has been developed in the context of state estimation of dynamic systems as a nonlinear distribution (or densities in the continuous case) approximation method. The UKF is superior to EKF both in theory and in many practical situations (Jwo and Lai 2008). The algorithm performs the prediction of the statistics with a set of carefully chosen sample points, referred to as the sigma points employed to propagate the probability of state distribution, for capturing mean and covariance of the system (Julier et al. 2000; Julier and Uhlmann 2002). The series approximations in the EKF algorithm can lead to poor representations of the nonlinear functions and probability distributions of interest. The UKF can capture the states up to at least second order approximation.

The adaptive Kalman filter (AKF) (Mehra 1972; Mohamed and Schwarz 1999; Ding, et al. 2007; Hide, et al. 2003) has been one of the strategies to prevent divergence problem due to modeling errors. A relatively new adaptive filter proposed by Zhou and Frank (1996) is called the strong tracking Kalman filter (STKF), which has several important merits: (1) strong robustness against model uncertainties; (2) good real-time state tracking capability, no matter whether the system has reached steady state or not; (3) moderate computational load. In the same way, a filter called the strong tracking unscented Kalman filter (STUKF) is developed based on the combination of UKF and STKF, leading to the STUKF.

The conventional approach for determining the softening factors relies on personal experience or computer simulation using a heuristic searching scheme. A new approach called the fuzzy strong tracking unscented Kalman filter (FSTUKF) is suggested. In the algorithm, the fuzzy logic reasoning system (FLAS) (Sasiadek, et al. 2000; Jwo and Lai 2009) based on the Takagi-Sugeno (T-S) model (Takagi and Sugeno 1985) is incorporated into the STUKF. The fuzzy reasoning system is constructed for obtaining suitable softening factors according to the time-varying change in dynamics. By monitoring the innovation information, the FLAS, as the filter's internal mode, is employed for dynamically adjusting the softening factors based on the fuzzy rules so as to enhance the estimation accuracy and tracking capability.

The proposed FSTUKF scheme is applied to the loosely-coupled GPS/INS navigation processing to improve the navigation estimation accuracy at the high dynamic regions while preserving/without sacrificing the precision at the lower dynamic regions. The performance of the proposed FSTUKF method is compared to those of the EKF, UKF, and STUKF approaches.

The Unscented Kalman Filter

The nonlinear filters deal with the case governed by the nonlinear stochastic difference equations:

$$\mathbf{x}_{k+1} = \mathbf{f}_k(\mathbf{x}_k) + \mathbf{w}_k \quad (1a)$$

$$\mathbf{z}_k = \mathbf{h}_k(\mathbf{x}_k) + \mathbf{v}_k \quad (1b)$$

where the state vector $\mathbf{x}_k \in \Re^n$, process noise vector $\mathbf{w}_k \in \Re^n$, measurement vector $\mathbf{z}_k \in \Re^m$, and measurement noise vector $\mathbf{v}_k \in \Re^m$. The vectors $\mathbf{w}_k$ and $\mathbf{v}_k$ are zero mean Gaussian white sequences having zero crosscorrelation with each other:

$$\mathbf{E}[\mathbf{w}_k \mathbf{w}_i^{\mathrm{T}}] = \begin{cases} \mathbf{Q}_k, & i = k \\ 0, & i \neq k \end{cases}; \quad \mathbf{E}[\mathbf{v}_k \mathbf{v}_i^{\mathrm{T}}] = \begin{cases} \mathbf{R}_k, & i = k \\ 0, & i \neq k \end{cases}; \quad \mathbf{E}[\mathbf{w}_k \mathbf{v}_i^{\mathrm{T}}] = \mathbf{0} \quad (2)$$

for all i and k

The discrete-time extended Kalman filter algorithm is summarized:

1. Initialize state vector and state

covariance matrix: $\hat{\mathbf{x}}_0^-$ and $\mathbf{P}_0^-$

2. Compute Kalman gain matrix:

$$\mathbf{K}_k = \mathbf{P}_k^- \mathbf{H}_k^{\mathrm{T}} [\mathbf{H}_k \mathbf{P}_k^- \mathbf{H}_k^{\mathrm{T}} + \mathbf{R}_k]^{-1} \quad (3)$$

3. Update state vector:

$$\hat{\mathbf{x}}_k = \hat{\mathbf{x}}_k^- + \mathbf{K}_k [\mathbf{z}_k - \mathbf{h}_k(\hat{\mathbf{x}}_k^-)] \quad (4)$$

4. Update error covariance

$$\mathbf{P}_k = [\mathbf{I} - \mathbf{K}_k \mathbf{H}_k] \mathbf{P}_k^- \quad (5)$$

5. Predict new state vector and state covariance matrix

$$\hat{\mathbf{x}}_{k+1}^- = \mathbf{f}_k(\hat{\mathbf{x}}_k^-) \quad (6)$$

$$\mathbf{P}_{k+1}^- = \mathbf{\Phi}_k \mathbf{P}_k \mathbf{\Phi}_k^{\mathrm{T}} + \mathbf{Q}_k \quad (7)$$

where the linear approximation equations for system and measurement matrices are obtained through the relations

$$\mathbf{\Phi}_k \approx \left. \frac{\partial \mathbf{f}_k}{\partial \mathbf{x}} \right|_{\mathbf{x} = \hat{\mathbf{x}}_k^-}; \quad \mathbf{H}_k \approx \left. \frac{\partial \mathbf{h}_k}{\partial \mathbf{x}} \right|_{\mathbf{x} = \hat{\mathbf{x}}_k^-} \quad (8)$$

In the EKF, the state distribution is approximated by a Gaussian random variable (GRV), which is then propagated analytically through the first-order linearization of the nonlinear system. Wan and van der Merwe (2000) pointed out that this will introduce large errors in the true posterior mean and covariance of the transformed GRV and lead to suboptimal performance and sometimes filter divergence. The basic premise behind the UKF is it is easier to approximate a Gaussian distribution than it is to approximate an arbitrary nonlinear function. Instead of linearizing using Jacobian matrices as in the EKF and achieving first-order accuracy, the UKF uses a deterministic sampling approach to capture the mean and covariance estimates with a minimal set of sample points.

The UKF was first proposed by Julier, et al. (1995) to address nonlinear state estimation in the context of control theory. The state distribution is also approximated by a GRV, but is represented using a minimal set of sample points. These sample points are carefully chosen so as to completely capture the true mean and covariance of the GRV. When the sample points are propagated through the true nonlinear system, the posterior mean and covariance can be captured accurately to the 2nd order of Taylor series expansion for any nonlinear system. One of the remarkable merits is that the overall computational complexity of the UKF is the same as that of the EKF (Wan and van der Merwe 2000).

The first step in the UKF is to sample the prior state distribution, i.e., generate the sigma points through the unscented transformation (UT) (Julier, et al. 2000; Julier, 2002; Julier and Uhlmann 2002), which is a method for calculating the statistics of a random variable which undergoes a nonlinear transformation. The basic premise is that to approximate a probability distribution is easier than to approximate an arbitrary nonlinear transformation. The mapping of the UKF versus that of the EKF, through the transformation of nonlinear function **f**(.) and its Jacobian/Hessian, can be illustrated by Figure 1 (Li et al. 2006). The dot-line ellipse represents the true covariance; the solid-line ellipse represents the calculated covariance. The UKF approach estimates are expected to be closer to the true values than the EKF approach.

Consider an n dimensional random variable $\mathbf{x}$, having the mean $\hat{\mathbf{x}}$ and covariance $\mathbf{P}$, and suppose that it propagates through an arbitrary nonlinear function $\mathbf{f}$. The unscented transform creates $2n+1$ sigma vectors $\mathbf{x}$ (a capital letter) and weighted points W, given by

$$\mathbf{X}_{(0)} = \hat{\mathbf{x}} \quad (9)$$

$$\mathbf{X}_{(i)} = \hat{\mathbf{x}} + (\sqrt{(n+\lambda)\mathbf{P}})_i^T, \quad i = 1,...,n \quad (10)$$

$$\mathbf{X}_{(i+n)} = \hat{\mathbf{x}} - (\sqrt{(n+\lambda)\mathbf{P}})_i^T, \quad i = 1,...,n \quad (11)$$

$$W_0^{(m)} = \frac{\lambda}{(n+\lambda)} \quad (12)$$

$$W_0^{(c)} = W_0^{(m)} + (1 - \alpha^2 + \beta) \quad (13)$$

$$W_i^{(m)} = W_i^{(c)} = \frac{1}{2(n+\lambda)}, \quad i = 1,...,2n \quad (14)$$

where $(\sqrt{(n+\lambda)\mathbf{P}})_i$ is the ith row (or column) of the matrix square root. $\sqrt{(n+\lambda)\mathbf{P}}$ can be obtained from the lower-triangular matrix of the Cholesky factorization; $\lambda = \alpha^2 (n+k) - n$ is a scaling parameter; α determines the spread of the sigma points around $\hat{\mathbf{x}}$ and is usually set to a small positive (e.g., $1e\text{-}4 \leq \alpha \leq 1$); k is a secondly scaling parameter (usually set as 0); β is used to incorporate prior knowledge of the distribution of $\bar{\mathbf{x}}$; $w_i^{(m)}$ and $w_i^{(c)}$ are the weighs for the mean and covariance, respectively, associated with the i*th* point.

The sigma vectors are propagated through the nonlinear function to yield a set of transformed sigma points,

$$\mathbf{y}_i = f(\mathbf{X}_i) \quad i = 0,...,2n \quad (15)$$

The mean and covariance of $\mathbf{y}_i$ are approximated by a weighted average mean and covariance of the transformed sigma points as follows:

$$\bar{\mathbf{y}}_u = \sum_{i=0}^{2n} W_i^{(m)} \mathbf{y}_i \quad (16)$$

$$\bar{\mathbf{P}}_u = \sum_{i=0}^{2n} W_i^{(c)} (\mathbf{y}_i - \bar{\mathbf{y}}_u)(\mathbf{y}_i - \bar{\mathbf{y}}_u)^T \quad (17)$$

The implementation algorithm of UKF is summarized as follows:

1. The transformed set is given by instantiating each point through the process model

$$(\zeta_k^-)_i = f((\mathbf{X}_k^-)_i), \quad i = 0,...,2n$$

2. Predicted mean $\hat{\mathbf{x}}_k^- = \sum_{i=0}^{2n} W_i^{(m)} (\zeta_k^-)_i$

3. Predicted covariance

$$\mathbf{P}_k^- = \sum_{i=0}^{2n} W_i^{(c)}[(\zeta_k^-)_i - \hat{\mathbf{x}}_k^-][(\zeta_k^-)_i - \hat{\mathbf{x}}_k^-]^T + \mathbf{Q}_k \quad (18)$$

4. Instantiate each of the prediction points through observation model $(\mathbf{Z}_k^-)_i = \mathbf{h}((\zeta_k^-)_i)$

5. Predicted observation $\hat{\mathbf{z}}_k^- = \sum_{i=0}^{2n} W_i^{(m)}(\mathbf{Z}_k^-)_i$

6. Innovation covariance

$$\mathbf{P}_{vv} = \sum_{i=0}^{2n} W_i^{(c)}[(\mathbf{Z}_k^-)_i - \hat{\mathbf{z}}_k^-][(\mathbf{Z}_k^-)_i - \hat{\mathbf{z}}_k^-]^T + \mathbf{R}_k \quad (19)$$

7. Cross covariance

$$\mathbf{P}_{xz} = \sum_{i=0}^{2n} W_i^{(c)}[(\zeta_k^-)_i - \hat{\mathbf{x}}_k^-][(\mathbf{Z}_k^-)_i - \hat{\mathbf{z}}_k^-]^T \quad (20)$$

8. Performing update

$$\mathbf{K}_k = \mathbf{P}_{xz}\mathbf{P}_{vv}^{-1}$$
$$\hat{\mathbf{x}}_k = \hat{\mathbf{x}}_k^- + \mathbf{K}_k(\mathbf{z}_k - \hat{\mathbf{z}}_k^-)$$
$$\mathbf{P}_k = \mathbf{P}_k^- - \mathbf{K}_k\mathbf{P}_{vv}\mathbf{K}_k^T$$

The Strong Tracking Algorithm

Zhou and Frank (1996) proposed the concept of strong tracking Kalman filter. In the algorithm, the time-varying suboptimal scaling factor is incorporated, for on-line tuning the covariance of the predicted state. As a type of AKF, the STF is essentially a nonlinear smoother algorithm that employs suboptimal multiple fading factors (Xia, 1994), in which the softening factors are involved.

Based on the idea as in the AKF, the synthesis of UKF and strong tracking filter leads to the strong tracking unscented Kalman filter (STUKF). As in the STKF, suboptimal fading factors are introduced into the nonlinear smoother algorithm:

$$s_{i,k} = \frac{tr[\eta\mathbf{V}_k - \varepsilon\mathbf{R}_k]}{tr[\mathbf{P}_{vv}]} = \begin{cases} s_{i,k}, & s_{i,k} > 1 \\ 1, & s_{i,k} \le 1 \end{cases} \quad (21)$$

$$\mathbf{V}_k = \begin{cases} \upsilon_0\upsilon_0^T \\ \dfrac{[\rho\mathbf{V}_{k-1} + \upsilon_k\upsilon_k^T]}{1+\rho}, \quad k \ge 2 \end{cases} \quad (22)$$

The covariance matrix needs to be updated the following way. The new $\mathbf{P}_k^-$ needs to be modified and can be obtained by multiplying (18) by the factor $\mathbf{s}_k$:

$$\mathbf{P}_k^- = \mathbf{S}_k\left\{\sum_{i=0}^{2n} W_i^{(c)}[(\zeta_k^-)_i - \hat{\mathbf{x}}_k^-][(\zeta_k^-)_i - \hat{\mathbf{x}}_k^-]^T + \mathbf{Q}_k\right\} \quad (23)$$

Similarly, the covariance matrix $\mathbf{P}_{vv}$ and $\mathbf{P}_{xz}$, as represented by (19) and (20), respectively, can also be modified and rewritten as

$$\mathbf{P}_{vv} = \mathbf{S}_k\left\{\sum_{i=0}^{2n} W_i^{(c)}[(\mathbf{Z}_k^-)_i - \hat{\mathbf{z}}_k^-][(\mathbf{Z}_k^-)_i - \hat{\mathbf{z}}_k^-]^T + \mathbf{R}_k\right\} \quad (24)$$

$$\mathbf{P}_{xz} = \mathbf{S}_k\left\{\sum_{i=0}^{2n} W_i^{(c)}[(\zeta_k^-)_i - \hat{\mathbf{x}}_k^-][(\mathbf{Z}_k^-)_i - \hat{\mathbf{z}}_k^-]^T\right\} \quad (24)$$

where $\mathbf{S}_k = diag(s_1, s_2 \ldots s_m)$. One approach is to assign the scale factors as constants. When $s_i \le 1$ $(i=1,2,\ldots,m)$, the filtering is in a steady state processing while $s_i > 1$, the filtering may tend to be unstable. For the case $s_i = 1$, it deteriorates to the standard Kalman filter. The fading factor matrix $\mathbf{S}_k$ is dependent on three parameters, including (a) η; (b) the forgetting factor (ρ); (c) and the softening factor (ε). The range of the forgetting factor $0 < \rho \le 1$ is used. The softening factor is utilized to improve the smoothness of state estimation. A larger (with value no less than 1) leads to better estimation accuracy; while a smaller ε provides stronger tracking capability. The value is usually determined empirically through computer simulation and $1 \le \varepsilon \le 5$ is commonly selected.

The fuzzy Logic Adaptive System (FLAS)

A FLAS mechanism can be incorporated for determining the softening factor, leading to the fuzzy strong tracking unscented Kalman filter (FSTUKF). The FSTUKF is composed of the FLAS, the strong tracking mechanism, and the UKF. The characteristics of the fuzzy adaptive system depend on the fuzzy rules and the effectiveness of the rules directly influences its performance. The defuzzification is used to provide the deterministic values of a membership function for the output. Using fuzzy logic to infer the consequent of a set of fuzzy production rules invariably leads to fuzzy output subsets. Fuzzy modeling is the method of describing the characteristics of a system using fuzzy inference rules.

The parameters for checking the degree of divergence (DOD) to identify the degree of change in vehicle dynamics need to be defined. The innovation information at the present epoch is employed for timely reflecting the change in vehicle dynamics. The averaged magnitude of innovation at the present epoch (i.e., the window size is one) can be used as the first DOD parameter:

$$\mu = \frac{1}{m}\sum_{i=1}^{m} \upsilon_i \quad (25)$$

Furthermore, the other DOD parameter ξ can be defined as the trace of innovation covariance matrix at present epoch divided by the number of measurements employed for navigation processing:

$$\xi = \frac{\upsilon_k^T\upsilon_k}{m} \quad (26)$$

where $\upsilon_k = [\upsilon_1 \ \upsilon_2 \ldots \upsilon_m]^T$, is the number of measurements. In the FLAS, the DOD parameters are employed as the inputs for the fuzzy inference engines. By monitoring the DOD parameters, the FLAS is able to on-line tune the softening factor according to the fuzzy rules, and accordingly improve the performance in terms of tacking capability and estimation accuracy.

An Experiment on GPS/INS Navigation State Estimation

The differential equations describing the two-dimensional inertial navigation state, where two accelerometers and one gyroscope are involved, are (Farrell and Barth 1999):

$$\begin{bmatrix}\dot{n}\\ \dot{e}\\ \dot{v}_n\\ \dot{v}_e\\ \dot{\psi}\end{bmatrix}=\begin{bmatrix}v_n\\ v_e\\ a_n\\ a_e\\ \omega_r\end{bmatrix}=\begin{bmatrix}v_n\\ v_e\\ \cos(\psi)a_u-\sin(\psi)a_v\\ \sin(\psi)a_u+\cos(\psi)a_v\\ \omega_r\end{bmatrix} \quad (27)$$

where [a_u , a_v] are the measured accelerations in the body frame, ω_r is the measured yaw rate in the body frame. The error model for INS is constructed by the navigation states augmented by the accelerometer biases and gyroscope drift:

$$\frac{d}{dt}\begin{bmatrix}\delta n\\ \delta e\\ \delta v_n\\ \delta v_e\\ \delta\psi\\ \delta a_u\\ \delta a_v\\ \delta\omega_r\end{bmatrix}=\begin{bmatrix}0&0&1&0&0&0&0&0\\ 0&0&0&1&0&0&0&0\\ 0&0&0&0&-a_e&\cos(\psi)&-\sin(\psi)&0\\ 0&0&0&0&-a_n&\sin(\psi)&\cos(\psi)&0\\ 0&0&0&0&0&0&0&1\\ 0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0\end{bmatrix}\begin{bmatrix}\delta n\\ \delta e\\ \delta v_n\\ \delta v_e\\ \delta\psi\\ \delta a_u\\ \delta a_v\\ \delta\omega_r\end{bmatrix}+\begin{bmatrix}0\\ 0\\ u_{acc}\\ u_{acc}\\ u_{gyro}\\ u^b_{acc}\\ u^b_{acc}\\ u^b_{gyro}\end{bmatrix}$$

(28)

which were utilized in the integration Kalman filter as the inertial error model. In (28), δn and δe represent the east, and north position errors; δv_n and δv_e represent the east, and north velocity errors; $\delta\psi$ represents yaw angle; δa_u, δa_v , and $\delta\omega_r$ represent the accelerometer biases and gyroscope drift, respectively. The measurement model is written as

$$z=\begin{bmatrix}n_{INS}\\ e_{INS}\end{bmatrix}-\begin{bmatrix}n_{GPS}\\ e_{GPS}\end{bmatrix}=\begin{bmatrix}1&0&0&0&0&0&0&0\\ 0&1&0&0&0&0&0&0\end{bmatrix}\begin{bmatrix}\delta n\\ \delta e\\ \delta v_n\\ \delta v_e\\ \delta\psi\\ \delta a_u\\ \delta a_v\\ \delta\omega_r\end{bmatrix}+\begin{bmatrix}v_{n,GPS}\\ v_{e,GPS}\end{bmatrix}$$

(29)

Assume that the differential GPS mode is used, and only the multipath and receiver thermal noise are included. Figure 2 shows the architecture of the loosely-coupled GPS/INS integrated navigation based on the FLAS-coupled STUKF mechanism. The dynamic characteristics of the vehicle can be approximately divided into two categories: (a) constant-velocity straight-line motion during four time intervals, 1~180, 361~450, 496~630 and 901~1080s, all at a speed of m/s; (b) circular motion during 181~360, 451~495 and 631~900s. The trajectory for the simulated vehicle is shown as in Figure 3. The parameters utilized in the STUKF are as follows: α=1e–4, β=2, k=0, η=0.25, ρ=0.1. The numerical efficient and stable method such as the Cholesky factorization has been used in obtaining the sigma points.

In the FSTUKF, the softening factor ε is determined by the FLAS. The philosophy for defining the rules is straightforward: (a) for the case that the DOD parameter is small, our objective is to obtain results with better estimation accuracy, and a larger softening factor ε should be applied; (b) for the case that the DOD parameter is increased, our objective is to increase the tracking capability, and a smaller softening factor should be applied. The membership functions (MFs) of input fuzzy variable DOD parameters as shown in Figure 4 are triangle MFs:

$$m(x)=\begin{cases}0 & x\le a\\ \dfrac{x-a}{b-a} & a\le x\le b\\ \dfrac{c-x}{c-b} & b\le x\le c\\ 0 & c\le x\end{cases} \quad (30)$$

The first-order T-S model has been employed. The presented FLAS is the If-Then form and consists of 9 rules.

1. IF μ is zero and ξ is zero
THEN ε is $3\mu+5\xi+8$

2. IF μ is zero and ξ is small
THEN ε is $2\mu+4\xi+5$

3. IF μ is zero and ξ is large
THEN ε is $\mu+3\xi+3$

4. IF μ is small and ξ is zero
THEN ε is $\mu+0.5\xi+0.5$

5. IF μ is small and ξ is small
THEN ε is $0.75\mu+0.3\ \xi+0.3$

6. IF μ is small and ξ is large
THEN ε is $0.5\mu+0.1\ \xi+0.1$

7. IF μ is large and ξ is zero
THEN ε is $0.1\mu+0.05\ \xi$

8. IF μ is large and ξ is small
THEN ε is $0.1\mu+0.03\ \xi$

9. IF μ is large and ξ is large
THEN ε is $0.1\mu+0.01\ \xi$

Performance comparison between UKF and EKF is shown in Figure 5; Navigation accuracy comparison for FSTUKF, STUKF and UKF is illustrated in Figure 6. A single fixed value of ε, whether larger or smaller, is not easy to fit the accuracy requirement in all types of environments and is therefore unrealistically in practical applications. Figure 7 shows the fading factors resulting from STUKF and FSTUKF, respectively. For the three regions of high dynamic environments, the fading factors using FSTUKF have been amplified at a higher rate as compared to the STUKF.

Two remarks are given concerning the experiment.

(1) In the four time intervals, 1~180, 361~450, 496~630 and 901~1080s, the vehicle is not maneuvering and is conducting constant-velocity straight-line motion. For this case, all the filters

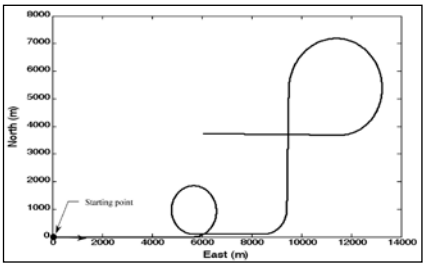

Figure 3: Trajectory for the simulated vehicle (solid) and the INS derived position (dashed).

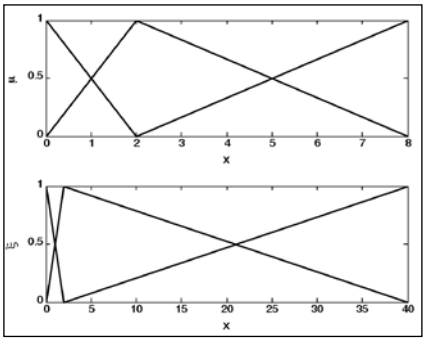

Figure 4: Membership functions of input fuzzy variables μ (top) and ξ (bottom)

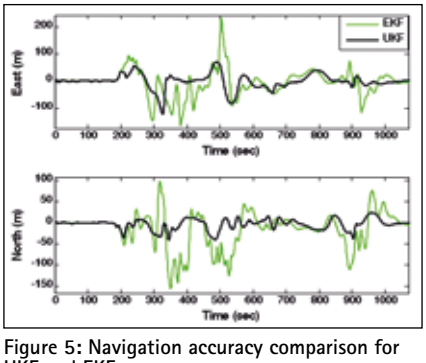

Figure 5: Navigation accuracy comparison for UKF and EKF.

Archived historic data
from Indian satellites
for last two decades

NRSC Data Centre
National Remote Sensing Centre
Phone: +91(40)2388 4422, 4423, 4425
Fax: +91(40)2387 8158, 8664
Email: sales@nrsc.gov.in
Website: http://www.nrsc.gov.in

provide equivalently good results. The navigation accuracies based on the four approaches have relatively small difference. By use of the T-S fuzzy logic, the FLAS senses smaller values of DOD parameters, and gives a larger softening factor. With large softening factors, the UKF, STUKF, and FSTUKF deteriorate to the EKF, and the navigation accuracies based on all the filters are equivalent.

(2) In the three time intervals, 181~360, 451~495 and 631~900s, the vehicle is maneuvering. The mismatch of the model leads the STUKF to larger

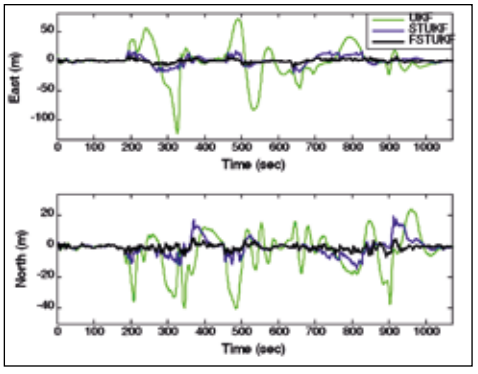

Figure 6: Navigation accuracy comparison for FSTUKF, STUKF and UKF.

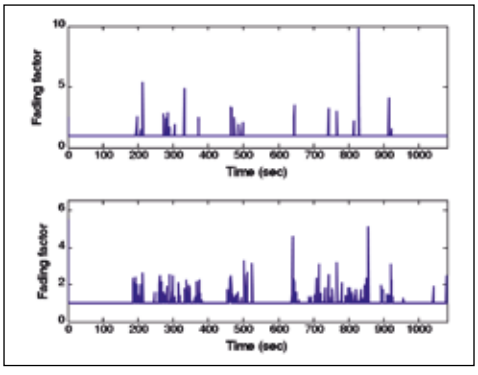

Figure 7: The fading factors given by STUKF (top), and FSTUKF (bottom).

navigation error while the FLAS timely detects the change of DOD parameter, and then reduces softening factor so as to maintain good tracking capability.

Conclusions

An alternative state estimation technique called the fuzzy strong tracking unscented Kalman filter has good potential as the GPS/INS navigation state estimation technique. The approach is designed so as to improve the navigation accuracy at the high dynamic regions while preserving/without sacrificing the precision at the lower dynamic regions.

Traditional strong tracking Kalman filter for determining the softening factors heavily relies on personal experience or computer simulation using a heuristic searching scheme. In this article, the fuzzy system has been employed to improve the STUKF performance. Through the use of fuzzy logic, the FLAS has been incorporated into the STUKF as a mechanism for timely detecting the dynamical changes and implementing the on-line tuning of the softening factors by monitoring the innovation information so as to maintain good estimation accuracy and tracking capability. Performance comparisons on EKF, UKF, STUKF and FSTUKF have been conducted. As the improved version of STUKF, the FSTUKF algorithm leads to very promising results in both navigational accuracy and tracking capability and has very god potential as an alternative navigation state estimator.

Acknowledgements

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Showcase of New GNSS Era

The First Asia Oceania Regional Workshop

Jan 25-26, 2010, Bangkok, Thailand

The First Asia Oceania Regional Workshop was held on January 25 and 26 at Sofitel Centara Grand Bangkok, Thailand. The workshop was hosted by SPAC, JAXA and GISTDA as well as supported by United Nations International Committee on GNSS (UN ICG). The workshop was attended by 195 participants from 95 organizations including GNSS providers, universities, related research institutes and agencies gathered from 18 countries.

The workshop provided the overviews of various GNSS systems. There were presentations on four Global GNSS systems GPS, Glonass, Galileo and COMPASS. The regional GNSS systems QZSS and IRNSS were also introduced. The workshop had presentations on various topics like applications presentations; GNSS infrastructure and Augmentation technologies; Precise Positioning; Ionosphric Observation; Disaster Mitigation and Management; ITS, Mapping and LBS; Timing, GIS and Space Applications. The workshop also had Group Discussion for project planning. The topics were Multi-GNSS network establishment, Precise Positioning, Disaster Mitigation and management and ITS, Mapping and LBS.

It the workshop "Asia Oceania Multi-GNSS Demonstration Campaign" was also introduced. Multi GNSS Asia (MGA) was proposed to be established in early 2010, secretariat of MGA.

The workshop was impressive in terms of its content and participation. It appeared that this initiative will go a long way to serve the interest of GNSS community of Asia and Oceana region.

Demands of GPS for ships in Philippine

Philippine-based transport group United Transport Koalisyon has urged lawmakers to use GPS for all ships to reduce maritime accidents and also save fuel. It will also help coast guard in tracking down ships in distress. *www.portworld.com*

Indian Dept of Post to install GPS in NE region

To overcome the difficulties and challenges faced in smooth and timely movement of mails and parcels across North-East India, the Department of Post has decided to install GPS to track the movements of its mail motor vehicles in this region. The system shall be operational by March 2010. *www.business-standard.com*

Protest against govt's stand on LORAN

The US federal government's decision to shut down the LORAN (Long Range Aid to Navigation) system used by fishermen and mariners in Maine is drawing protests from state officials and members of Maine's Congressional delegation. Governor John Baldacci said, "The LORAN system is needed as a back-up for GPS." In a letter to Homeland Security Secretary Janet Napolitano, he was concerned about losing the system which had proven to be cost-beneficial. Senator Susan Collins said, "It is a mistake to shut LORAN down." *www.mpbn.net*

China takes one step further towards building indigenous GNSS

China successfully launched its third orbiter into space for the Beidou or COMPASS system. The network will eventually have a total of 35 satellites, capable of providing global navigation service to users around the world by about 2020. It will provide both open and authorized services with open service being free of charge for the system's users within service area with a resolution of 10 meters for positioning, an accuracy of 10 nanosecond for time signal and an accuracy of 0.2 meter per second for speed measurement. The authorized service will be more accurate for authorized users. China will make its own global navigation system compatible and interoperable with other international competitors like U.S. GPS, GALILEO, GLONASS. The compatibility and interoperability, under the framework of the International Committee on Global Navigation Satellite Systems (ICG) and International Telecommunication Union (ITU), will make all users benefit from the progress of the satellite navigation's development. *www.chinaview.cn*

GPS gets poetic now

New cell phone device that helps illegal immigrants crossing the desert into the U.S. find water is loaded with free GPS software displays a digital compass that locates water stations installed by John Hunter, founder of the Water Stations project. The phone pinpoints "safety sites" -- such as Border Patrol station, a clinic or a church -- and includes poetry written by Amy Carroll, "Welcome you to the U.S." It has been encrypted to avoid detection by authorities. This device has been developed under Transborder Immigrant Tool project which was initiated by UC San Diego professor and activist Ricardo Dominguez and UCSD lecturer Brett Stalbaum. *www.sfgate.com*

GPS, 50th Space Wings continue improvement initiative

The U.S. Air Force GPS Wing and the 50th Space Wing are ushering in improved GPS capabilities through a new ground system software release. It includes telemetry, tracking and commanding for the new GPS IIF space vehicle and robust security improvements. The planned transition at Schriever Air Force Base is the result of extensive testing to ensure this upgrade is transparent and has no impact to military and civil users. With the pending mid-2010 launch of the first GPS IIF space vehicle, the ground system is prepared to command the new on-orbit GPS IIF capabilities which include a new navigation signal for civil users, encrypted military code, crosslink enhancements, improved navigation signal accuracy and signal power increases. www.losangeles.af.mil

Joint announcement on US–Japan GPS cooperation

The Governments of the USA and Japan convened a plenary meeting at the Department of State in Washington, D.C. to review and discuss cooperation in the civil use of the GPS and GPS augmentations, including Japan's Multi-functional Transport Satellite (MTSAT) Satellite-based Augmentation System (MSAS) and Quasi-Zenith Satellite Systems (QZSS). *http://pnt.gov*

Safer, more efficient Satellite Based Tracking System

Houston air traffic controllers are beginning to use an improved satellite-based system – Automatic Dependent Surveillance-Broadcast (ADS-B) — to more efficiently and safely separate and manage aircraft flying over the Gulf of Mexico. ADS-B, which is one of the technologies at the heart of the transformation to NextGen, brings air traffic control to the Gulf of Mexico, an area that has not had the benefit of radar coverage. Aircraft equipped with ADS-B in the region will now know where they are in relation to bad weather and receive flight information including Notice to Airmen and Temporary Flight Restrictions. Prior to ADS-B, commercial aircraft flying at high altitudes were kept as much as 120 miles apart to ensure safety. *www.faa.gov*

Qatar's inclination towards GPS technology

Qatar's traffic department will soon introduce a mobile GPS system to alert motorists in knowing in advance the busy streets at any given moment and hence avoid traffic jams. It will be made available on mobile phones with GPS through Google's Earth. *www.gulf-times.com*

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Galileo update

SSTL to handle Galileo satellites

Surrey Satellite Technology (SSTL) has been selected by ESA to supply 14 navigation payloads for the deployment phase of the Galileo satellite navigation system. SSTL is teamed with OHB–System of Bremen, Germany for the provision of these fully operational Galileo satellites. The two companies agreed to work together as a "core team" on Galileo, with OHB taking the role of prime contractor and builder of the spacecraft "bus" and SSTL taking full responsibility for the navigation payloads onboard the satellite that will form the heart of the Galileo navigation system. Each satellite will carry two different types of highly accurate atomic clocks which are used to generate navigation messages that are broadcast by the satellites directly to the users' Galileo receivers. Under the contract, SSTL will be responsible for the design, manufacture and test of these navigation payloads using equipment procured mainly from European suppliers. SSTL will also manufacture some of the electronics to interface the satellite bus built by OHB-System and the navigation payload. www.sstl.co.uk

SES ASTRA awarded second Navigation Payload for EGNOS

SES ASTRA has been awarded a second contract by the European Commission (EC) to provide hosted payload services for EGNOS. The contract was awarded following a tender by the European Commission. The new payload will operate in L-band and be located onboard SES ASTRA's new ASTRA 5B satellite that was recently ordered from EADS ASTRIUM. The satellite is scheduled for launch in the second quarter of 2013 and will be positioned at SES ASTRA's 31.5 degrees East orbital position. In addition to the payload, SES ASTRA will also provide the related ground infrastructure needed to operate the awarded payload.

Major Galileo contracts signed

Mr René Oosterlinck, ESA's Director of the Galileo Programme and Navigation-related Activities, signed the first three contracts for the Galileo full operational capability phase. This event marks the start of building the Galileo operational infrastructure. The signing ceremony took place at ESA's European Space Research and Technology Centre at Noordwijk (The Netherlands) in the presence of Mr Matthias Ruete, Director General 'Energy and Transport' of the European Commission (EC) and Mr Jean-Jacques Dordain, ESA's Director General. These contracts cover system, satellites and launch activities.

The contract signed with Thales Alenia Space (Italy) covers the industrial system support activities provided to ESA as Galileo system prime: system engineering, system performance, system assembly, integration and validation, signal-in-space engineering, security engineering and product assurance. For the space segment, and following the signature of framework contracts with OHB-System AG (Germany) and EADS at the end of 2009, the first work order signed with OHB covers the manufacture of 14 satellites, with delivery of the first satellite in July 2012, followed by two satellites every three months.

As prime contractor, OHB teamed up with Surrey Satellite Technology Limited (SSTL; UK). OHB will lead the system level activities and is responsible for the spacecraft platform. SSTL is responsible for the satellite payload. For launch services, the contract covers the provision by Arianespace of five Soyuz launchers with an upgraded Fregat upper stage, to be launched from Europe's Spaceport in French Guiana, each placing two satellites in their final orbit. *www.esa.int*

NAVTEQ on state of Navigation

NAVTEQ shared insights gleaned over the course of the past year to provide a state of the industry perspective on consumer use of navigation. The following facts emerged:

Consumer experience with navigation is double what it was just a few years ago
Globally, consumers have the most experience with portable devices
Consumers most frequently use in-car navigation systems, followed by PNDs and mobile devices
Consumers utilizing traffic services use their navigation system more than those without Interest in pedestrian navigation is real among mobile consumers. *www.navteq.com*

Location-based advertising in India

LiveVana and Lepton Software launched India's first location based advertising platform in partnership with Ybrant Digital. It enables mobile service providers and advertisers, including the ability to send advertisements and discount coupons to mobile subscribers, based on their location. *www.equitybulls.com*

Tele Atlas delivers new map of India

Tele Atlas unveiled an expanded map for India, which includes coverage of nearly 640,000 kilometres of navigable roads covering more than 75 percent of the country's urban population. *www.teleatlas.com*

TomTom entry level PND in N America

TomTom EASE is positioned as an entry level device. It embeds the home-made technologies Map Share and IQ Route as well as text-to-Speech. *www.tomtom.com*

Garmin brings car diagnostics to PNDs

Garmin unveiled ecoRoute hd a wireless device that transforms a nuvi personal navigation device into a "real-time onboard diagnostic computer". *www.garmin.com*

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Free TatukGIS Viewer v. 2 upgrade

The TatukGIS Viewer version 2 upgrade adds new features including advanced support for coordinate systems, support for additional data formats, advanced map rendering features, updated user interface, and more. *www.TatukGIS.com*

U.S. Army Geospatial Centre maps for Haiti

The U.S. Army Geospatial Centre's Hydrologic and Environmental Analysis branch compiled earthquake, water and geology maps, a number of other data sets and made them available via the AGC's public and internal Public Key Infrastructure web sites in support of U.S. humanitarian efforts to Haiti. *www.agc.army.mil*

ESRI assists Haiti Earthquake response

ESRI is working closely with the GIS community and agencies responding to the Haiti earthquake by providing software, technical support, GIS data, and personnel. It gives officials critical information using GIS for making all types of decisions. *www.esri.com*

Free online access of Chennai maps

The Chennai Metropolitan Development Authority in India has introduced a facility, which allows online access of land use maps of the Second Master Plan and the approved Detailed Development Plan. It allows prints of the maps/plans to be taken free of cost through the website http://cmdachennai.gov.in. *www.expressbuzz.com*

December 2009 GeoDataSource databases available

GeoDataSource December 2009 edition of the world cities database, structural, water and land features databases is available now. They contain detailed geographical information to power GIS applications for over 260 countries. *www.geodatasource.com*

Plans of Zimbabwe Surveyor-General Department for 2010

The Surveyor-General's Department of Zimbabwe will implement the satellite imagery for map revision and generation, resuscitation of photographic operations and the establishment of a Geodetic Information System involving the scanning of index maps and charts. It also plans to roll out the first phase of the national land audit with over 180000 farms earmarked for the two-phased audit in 2010. This was revealed in the Three-Year Macro-Economic Policy and Budget Framework for 2010-2012. *http://allafrica.com*

ERDAS extends CAD and GIS support, launches APOLLO 2010

IMAGINE Feature Interoperability is a new product extending ERDAS IMAGINE's native vector support by adding support for additional CAD and GIS formats and tools.

ERDAS APOLLO 2010 is equipped to understand, manage and serve large volumes of vector, raster and terrain data. It implements a Service Oriented Architecture (SOA), that provides a publish, find and bind workflow for any data type. *www.erdas.com*

EPA strict on Eco-Crimes

U.S. Environmental Protection Agency (EPA) has developed a new Web-based tool and interactive map that allows the public to get detailed information by location about the enforcement actions taken at approximately 4,600 facilities. The maps show facilities where civil enforcement actions were taken for environmental laws for air, water, and land pollution. *www.epa.gov*

EVC IRAQ Large-Scale Dataset

EVC offers GIS-ready vector data of Iraq at 1:50,000 scale. This includes all major cities, most populated and high-traffic areas, and all of the northern Kurdish areas. *www.cartographic.com*

China launches Yaogan VIII, Hope One

China successfully launched two of its satellites from the Tai-yuan Satellite Launch Centre in Shanxi Province. "Yaogan VIII" remote-sensing satellite and science researching mini-satellite, "Hope One" were put into the orbit by a Long March 4C carrier rocket. *www.brahmand.com*

DigitalGlobe WorldView-2 operational

WorldView-2, Digital Globe has achieved full operational capability. It offers eight multispectral bands, which provide more spectral information and allow for greater analysis capabilities, including improved feature identification and change detection. *http://media.digitalglobe.com*

ISRO to launch Cartosat-2B

According to ISRO Chairman K Radhakrishnan, "ISRO is planning to launch Cartosat series 'Cartosat-2B' remote sensing satellite in March this year." He added that the testing of cryogenic engine system for GSLV will be held soon. He added, "Cartosat-2B, offers -meter-resolution images – second in the world only to the Quickbird, which offers an incredibly close 60-centimeter resolution – all of them from a distance of 800 to 900 kilometres in space." According to ISRO, Cartosat-2B will fulfil the military needs of accurate mapping of borders and Mountains in Kashmir Valley and help to monitor the terrorist infiltrations. *www.ptinews.com*

Sri Lanka initiates own Space Agency

The Sri Lankan government will soon establish a space agency. Although the prime motivation is to improve the nation's telecommunication technology, it will also have a profound effect on ICT in general, and remote sensing and positioning in particular. Surrey Satellite Technology, UK has been contracted for the project. *www.slbc.lk*

U.S. to monitor monsoon trend

The U.S. has agreed to provide India with imagery from its satellites on weather patterns over the Indian Ocean and the subcontinent that will allow scientists to predict rainfall 15 days in advance. At present, Indian scientists can predict the monsoons only one-and-a-half days in advance. It will also supply India a supercomputer that can analyse and interpret the satellite images.

Unpredictable monsoons can cause losses of 1-1.5 per cent of Indian GDP. In absolute terms, this ranges between Rs 40,000 crore and Rs 75,000 crore. The fine print of the data sharing agreement was worked out recently at a meeting of a joint committee of scientists from the two countries. *http://epaper.hindustantimes.com*

ScanEx publishes maps of Haiti

ScanEx published detailed EROS-B image (0.7 m) of the Haiti capital area, damaged as a result of the destructive earthquakes, for free access using the GeoMixer API software interface. *www.scanex.ru*

Expanded support of the DiMAC Ultralight+ camera

Optech has expanded support of the DiMAC Ultralight+ 60 megapixel medium-format digital mapping camera. The new cameras will be fully supported by Optech Services, the 24/7 software and hardware support team. *www.optech.ca*

FEMA's flood maps put additional burden on house owners

Many homeowners in Southern California in USA are being forced to buy costly flood insurance because new maps issued by FEMA say that they live in a high-risk flood area. The new maps are part of a nationwide effort that FEMA began in 2003 to better identify properties that could flood in a so-called 100-year storm. *www.latimes.com*

Survey Camp at Nainital, India

Survey Camp, Nainital was held from 28th November – 7th December, 2008 as part of the academic curriculum at IIT Kanpur. The site chosen for the camp was Nainital which is set in a valley containing a pear-shaped lake and is bounded by a great snowy range which forms the central axis of the Himalayas at an altitude of 1,938 metres above sea level. In this camp a batch of 80 students conducted survey operations covering Nainital and its adjoining areas using hand-held GPS, Total Station and Geodetic GPS. In addition, the students were introduced to some of the latest surveying techniques like LiDAR. The camp was coordinated by Dr. Bharat Lohani a faculty with IIT Kanpur.

Task Description

Mapping of Ashram using Total Station :-

Students were divided into groups of 7-8 and each group was allotted a Trimble 5600 DR200+ along with the accessories. This task involved mapping of the campsite, including all features at a scale of 1:500. The complexity of terrain required each group to establish controls using two closed traverses with each comprising of 6-7 stations. Free and known station techniques were used for determination of the next station's coordinates. The coordinates for the free station method were obtained using the Geodetic Differential GPS with reference station being at IIT Kanpur. More than a thousand points were observed for mapping of the campsite. Traverses were adjusted for horizontal and vertical closing errors. The corrected coordinates of features were imported into ArcGIS where using Northing, Easting, Elevation and ID of points detailed map of the area was made including contours with CI=50cm.

Road Profiling using Total Station :-

Using the same total station equipment, students were assigned road profiling of a 200 meter long road in which they had to generate data for increasing its width from 3 to 5 meters and also provide suggestions regarding soil removal and filling possibilities after inferring from the longitudinal and transverse profiles. Cross sections were taken every 20 meter along the road where Northing, Easting and Elevation at various points across cross-sections were recorded. Reflector-less method was employed for inaccessible points. As retaining walls and descending steep slopes are major factors in determining methodology for widening the road a number of points were observed on both sides besides normal features like manholes, trees, electric poles etc. The points were imported into ArcView and topographic map of road along with various profiles were prepared.

Mapping of road routes using hand-held GPS :-

The Leica GS-5 instrument was used to make maps of routes from campsite to city and back named G1 and G2. All important landmarks like hotels, schools, government buildings etc. enroute were plotted in ArcView after importing the shapefiles. Points were recorded only when more than three satellites were visible. WGS-84 and UTM were used as the ellipsoidal reference and projection system.

Computations, Corrections and plotting

For station establishement, two methods were used:

Free station method: Using points whose coordinates were known through Differential GPS.

Known station method: Used when coordinates of station point and reference object were known.

Free station method is more accurate as propagation of errors does not take place. After completion of work, traverse is closed and closing error is determined in horizontal and vertical. These errors are then adjusted and corrected coordinates are calculated satisfying the condition that coordinates of a point do not change when returned to the same point after traversing the loop. The corrected coordinates are imported to ArcView for detailed cartography and generation of profiles.

One of the groups at work on their Total Station during the mapping of the Campsite.

Outcome of Survey Camp: Tangible and Intangible

By the camp's end, students had prepared detailed maps of the Campsite, Road Profiling and road routes. The ArcView shapefiles were converted to the .kmz format which is readable in Google Earth and facilitated publishing the work over Google Earth, thereby making it available over internet. Apart from these files (.kmz and .shp), students were also required to submit a comprehensive report about the camp. Calculations and corrections were applied to various observations and were compared to have an idea about their level of accuracy and to have an understanding that which technique could be used in the field and under what conditions. *http://home.iitk.ac.in/~abhinavg/surveycamp/*

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3 prestigious contracts by NGA, USA

The National Geospatial-Intelligence Agency, U.S. has awarded three indefinite delivery indefinite quantity multiple award contracts for commercial satellite synthetic aperture radar imagery, data products and direct downlink services to MDA Geospatial Services, Inc, EADS and Lockheed Martin Space Systems Company.

GMV awarded contract for GAGAN

GMV has been awarded a contract with Raytheon Company to develop a prototype algorithm for the detection of ionospheric depletions in the magnetic equatorial region that may be utilized in the user receiver data processing for the space-based augmentation system for the GAGAN (Global Positioning Satellite-Aided Geosynchronous Augmented Navigation System) program operated by the Indian Space Research Organization (ISRO). *www.gmv.com*

ProMark 500 V4.0 GNSS receiver

Ashtech® released ProMark™ 500 V4.0 GNSS receiver for high-performance RTK surveying. It has faster signal acquisition and improved tracking capability; auto dial to RTK networks, USB key plug and play, RTC bridge to relay GSM/GPRS RTK network corrections to multiple rovers via license-free radios, U-Link™ TRx radio repeater support, Virtual antenna, L2C signal support, 20 Hz RTK and data output option. *www.ashtech.com*

VIAJEO for efficient transport planning

The newly launched EU-funded VIAJEO project will design, demonstrate and implement an IT-based open platform to collect and process data for travel information and transport planning in cities in Europe, China and Brazil. *www.viajeo.eu*

TCAT's new multimedia GPS navigator

TC AUTO TOOLING Sdn Bhd (TCAT) multimedia GPS navigator provides easy-to-understand 3D junctions and 2.5D building views for clearer and detailed directions. The device includes a high-resolution rear view monitor with reverse camera that provides a wide angle view with guidelines for accurate estimation of distance between the rear bumper and objects. *http://tcat.com.my*

Spirent introduces A-GLONASS testing for Mobile Devices

Spirent Communications plc introduced a testing capability for assisted GLONASS (A-GLONASS) on UMTS mobile devices and chipsets. It gives early adopters of A-GLONASS a competitive edge by enabling the delivery of better-performing devices and improved user experiences. *www.spirent.com*

FME 2010 addresses common data interoperability

Safe Software FME 2010 is a complete solution for data conversion and distribution. It includes new releases of FME Desktop and FME Server, and aims to address common data interoperability challenges faced by customers and the geospatial market. *www.safe.com*

RIEGL USA releases airborne laser scanner LMS-Q680i

RIEGL Laser Measurement Systems GmbH released its airborne laser scanner LMS-Q680i, for the USA. With 400 KHz laser pulse repetition rate, LMS-Q680i provides effective measurement rate of up to 266,000 coordinates per second. *www.riegl.com*

Hemisphere's new G100 GPS

Hemisphere GPS launched G100, all-in-one steering and guidance system for auto-steer ready agricultural vehicles. It comes with a custom software application that is developed specifically for compatibility with ISOBUS components to automatically sense the machine. The first version of the G100 software is compatible with the AGCO(R) Auto-

Amity International School-Saket Wins 2009-2010 Future Cities India 2020

The Ministry of Science & Technology, Government of India, and Bentley Systems have announced that the project designed by the student team from Amity International School-Saket won top honours in the Future Cities India 2020 design competition. Launched by the Ministry of Science & Technology and Bentley Systems in 2006, the program is a partnership among government, universities, and the business community to promote and inspire young students to consider careers in the infrastructure design and engineering professions. Future Cities India 2020 actively engages students from the Delhi and National Capital Region (NCR) schools to develop solutions to real-world infrastructure challenges and issues. It encourages students to use their design skills, along with Bentley software, to help prepare India's cities for the year 2020. This year's projects focused on the redevelopment of Chandni Chowk, one of the oldest and busiest markets in central north Delhi. Each of the 15 student teams submitted 3D conceptual design models and presented ideas for a redeveloped Chandni Chowk district.

Shri. Kapil Sibal, the Honourable Union Minister for Ministry of Human Resource Development, in his congratulatory message to the students, said, "The young people participating in this year's competition met the challenge of this difficult endeavour directly. Their vision and brilliant ideas for a revitalized and better functioning Chandni Chowk district were outstanding and thought provoking." Dr. R. Siva Kumar, CEO of National Spatial Data Infrastructure and Head of Natural Resources Data Management System, Department of Science & Technology, said, "These projects express a unique vision for an environmentally and user-friendly market area." Scott Lofgren, Bentley global director, Be Careers Network, said, "The ultimate purpose of Future Cities India 2020 is, of course, to inspire India's youth to choose an educational path that leads to a career in one of the architectural, engineering, and construction disciplines."

Members of the winning team were Shruti Sahrawat, Neha Ahooja, Agrim Singh and Arjun Hans. Second place honours in the competition went to Manava Bharati India International School.*www.futurecitiesindia2020.co.in.*

Guide Ready(TM) tractors including AGCO DT-b and RT-a, Challenger(R) MT600C and Massey(R) 6400, 7400 and 8600 series. *www.hemispheregps.com*

Sokkia GRX1 versatile GNSS System

SOKKIA BV announced the new GRX1 GNSS receiver that includes the new SHC250 data collector, as well as a new controller and post-processing software. It has an integrated antenna, digital UHF radio, GSM module, Bluetooth® module and detachable battery in a compact, rugged, magnesium-alloy body. *www.sokkia.eu*

PB unveils Enterprise Routing Module

Pitney Bowes Business Insight (PBBI) released Enterprise Routing Module for the Pitney Bowes Spectrum™ Technology Platform. It offers integrated enterprise location intelligence functionality, enabling organizations to better understand their customers and assets in terms of location. Individuals responsible for logistics, marketing and network performance can now integrate in-house data and run route optimization analysis in batch or real-time mode. *www.pbinsight.com*

Raveon upgrades RavTrack PC

Raveon Technologies upgraded RavTrack PC - a GPS tracking program for Automatic Vehicle Location (AVL), asset tracking, and personal location. It works with Raveon's line of real-time GPS transponders. Version 3.0 can be used for tracking much larger fleets of vehicles. *www.raveontech.com*

Topcon SurveyMaster Lite

Topcon Europe Positioning B.V. has released SurveyMaster Lite. It is loaded with survey specific functionality as well as surface modelling and contouring tools. It provides tools required to produce final plats and survey calculations for property surveys, topographic maps and ALTA surveys. *www.topcon.eu*

Spot Image and Infoterra sign agreement with Google

Spot Image and Infoterra Ltd, both part of EADS Astrium, has signed agreement with Google to be a partner for Google Earth Enterprise. Both have been a Google Earth content partner for a number of years, providing ready to use imagery to Google as well as to Google Earth Enterprise users. Professional customers will be able to access their own internal geospatial data in 2D and 3D as well as new geospatial imagery and services provided by them

Siano's MDTV receiver chip

Siano Mobile Silicon of Israel announced that Garmin, Mio, Navigon, and others have integrated its mobile digital TV (MDTV) receiver chips into their latest consumer GPS products. *www.siano-ms.com.*

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March 2010

ILMF 2010
3 - 5 March
Denver, CO, USA
http://www.lidarmap.org

GEOFORM+'2010
30 March –2 April
Moscow, Russia
www.geoexpo.ru

CARIS 2010
22-25 March
Miami, Florida, USA
www.caris.com/caris2010

April 2010

XXIV FIG International Congress 2010
11 - 16 April 2010
Sydney, Australia
www.fig2010.com

Geo-Siberia 2010
27-29 April
Novosibirsk, Russia
www.geosiberia.sibfair.ru

ASPRS 2010
26-30 April
San Diego, CA, USA
www.asprs.org/SanDiego2010

May 2010

TIDES 2010
20-21 May
Taipei, Taiwan, R.O.C.
derc@mail.pccu.edu.tw

International Conference on Integrated Navigation Systems
31 May - 02 June 2010
Saint Petersburg, Russia
http://www.elektropribor.spb.ru

June 2010

Toulouse Space Show 2010
8 - 11 June
Toulouse, France
contact@toulousespaceshow.eu
www.toulousespaceshow.eu

GEA'2010
22 -24th June
Cracow, Poland
jacek@gea.com.pl
http://gea.com.pl/targieng.php

July 2010

ISPRS Centenary celebrations
4 July
Vienna, Austria
www.isprs100vienna.org

ESRI International User Conference
12–16 July
San Diego, USA
www.esri.com

September 2010

IPIN 2010
September 15-17, 2010
ETH Zurich, Campus Science City
(Hoenggerberg), Switzerland
www.geometh.ethz.ch/ipin/

ION GNSS 2010
21-24 September
Portland, Oregon, USA
www.ion.org

October 2010

INTERGEO
5 - 7 October
Cologne, Germany
www.intergeo.de

GSDI-12 World Conference
19-22 October
Singapore
www.gsdi.org

GEOINT 2010
25-28 Oct
Nashville, Tennessee, USA
http://geoint2010.com

November 2010

Trimble Dimensions 2010
8 - 10 November
Las Vegas, USA
www.trimble-events.com

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