RNI: DELENG/2005/15153
Publication: 15th of every month
Posting: 19th /20th of every month at NDPSO

No: DL(E)-01/5079/08-10
Licensed to post without pre-payment U(E) 28/2008-10
Rs.100

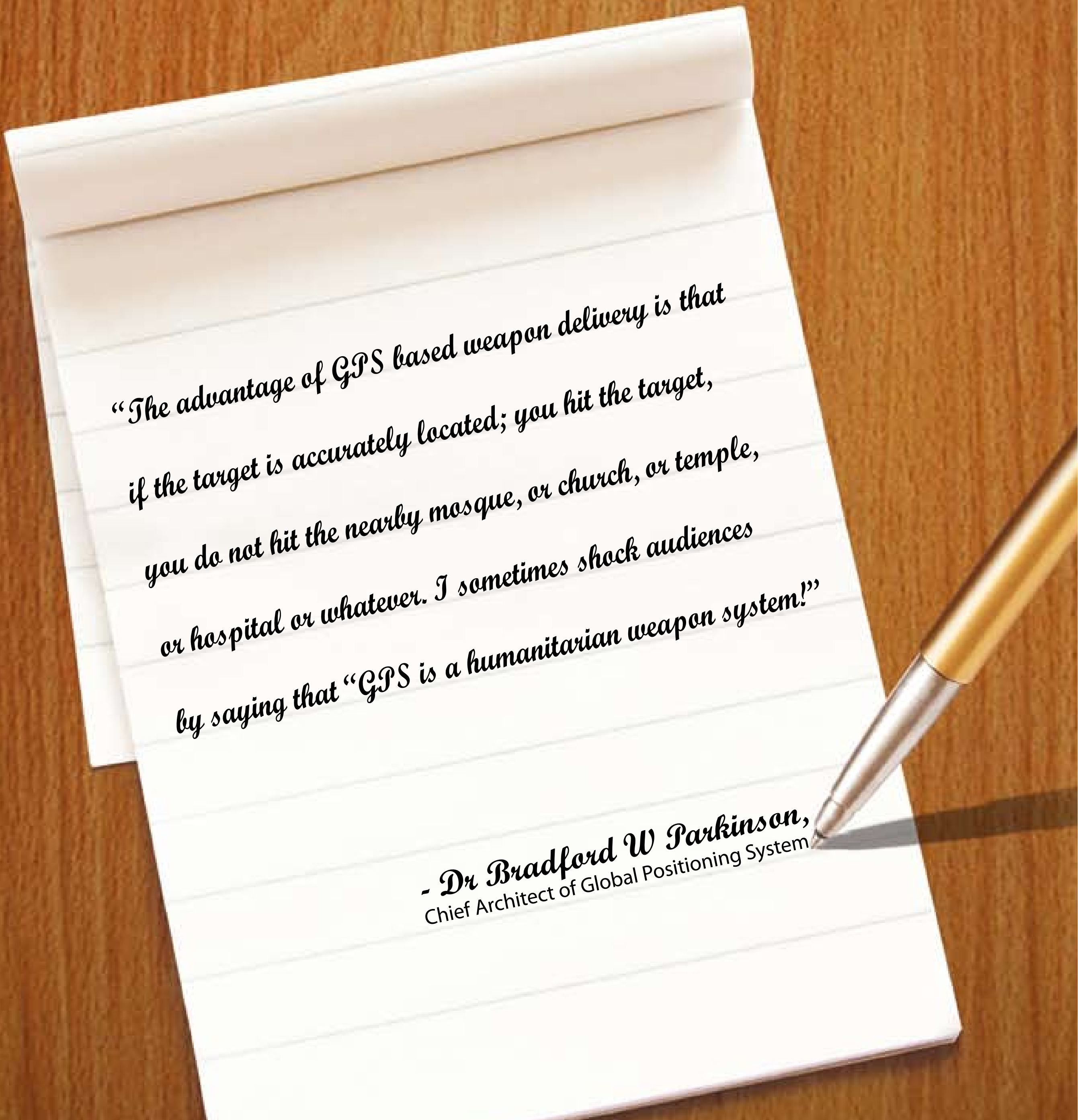
ISSN 0973-2136

www.mycoordinates.org

Coordinates

Volume VI, Issue 1, January 2010

THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND



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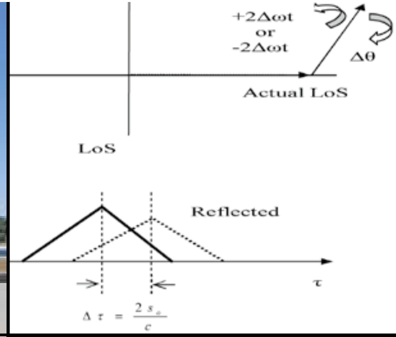

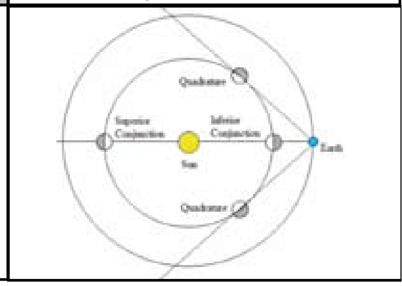

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Columns

This issue has been made possible by the support and good wishes of the following individuals and companies Bertacin R, Budnik F, Bradford W Parkinson, Dinesh Manandhar, Graziani A, Koichi Chino, Mercolino M, P Misra, Ryosuke Shibasaki, Slobodan Nedic, Tortora P, and and Digital Globe, Foif, GMV, Hemisphere GPS, Hi Target, Javad, Navcom, NovAtel, NRSC, Leica, South, Trimble; and many others

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Web www.mycoordinates.org

Annual subscription (12 issues) [India] Rs.1,200
[Overseas] US$80

Printed and published by Sanjay Malaviya on behalf of Centre for Geoinformation Technologies at A221 Mangal Apartments, Vasundhara Enclave, Delhi 110096, India.

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Owner Centre for Geoinformation Technologies

Designed at Thomson Press India Ltd.

Printer Thomson Press India Ltd., B 315, Okhla Phase I, New Delhi-110020, India

This issue of Coordinates is of 44 pages, including cover

Where does the buck stop?

Decade of Innovations - 2010 – 2020

The Government of India has declared so.

Indian Science needs money.

It also needs a change in mindset.

The country needs to develop an innovation eco-system.

Where innovators can produce newer solutions.

To meet the needs of society.

However, the need is to liberate Indian science.

From the shackles and deadweight of bureaucracy and in-house favouritism.

The red-tapism, political interference and lack of proper recognition of good work

All resulted in "regression" in Indian science.

So said the Prime Minister of India, Dr Manmohan Singh.

At the 97th annual session of the Indian Science
Congress (The Hindu, January 3, 2010).

Mr Prime Minister, you said it right.

But who will set it right.

Bal Krishna, Editor
bal@mycoordinates.org

"GPS is a humanitarian weapon system"

says Dr Bradford W Parkinson, Chief Architect of Global Positioning System

Given the enormous impact that GPS has on our lives today, how does it feel to be referred to as the 'Father of GPS'?

I am glad that you are asking this question, because it is my belief that there is no inventor of GPS. I certainly was the person that led the development of GPS, but if one goes back into history, there are two things that were really the foundation of what we did. In many cases the people involved, and what they did, has been totally forgotten.

The first was that, in 1964 to 1966 there was a study done by the Air Force's 621B program. In it, under Jim Woodford, all the alternatives to achieving a new satellite navigation system were explored. We drew on that study and, of the alternatives he looked at, we picked the one that was most challenging but at the same time had the greatest benefit to users. This selected alternative was the four-satellite, passive-signal, solution that eliminated the need for a user to have an Atomic Clock.

Secondly there was a lot of controversy on what type of signal we should use. Fortunately, by the time I advocated the GPS you know today, the Air Force had already run a series of tests using the PRN/CDMA signal and actually demonstrated that signal with aircraft at the White Sands Missile Range flying over transmitters of such codes. An alternative signal structure, known as Side-Tone Ranging, was deliberately rejected.

The Woodford study was originally classified Secret, and not generally known outside the GPS program. The study and the White Sands tests were the most fundamental basis for GPS. The resulting system is quite different from a proposed alternative that was patented in 1974; some 8 years after the Woodford study had been completed.

I had all the Secret Study and the test results when I decided what the architecture of GPS would be. Therefore, I was perhaps the chief architect and program manager, a leader and advocate, but inventor is not a word I like at all - I would like to set the record straight and credit the prior studies and developments.

GPS took time to evolve and there must have been many disappointments and hurdles in your journey, would you like to share some of those challenges with us?

The challenges came in a variety of ways. There were a number of technical challenges, and I will focus on one - making clocks. We all recognised that we needed to eventually put atomic clocks into space, but the radiation environment was quite intense. The Naval Research Laboratory had been working on space-borne clock technology. Based on their progress, I decided we could prudently design GPS with atomic clocks on orbit. Both NRL and the original 1966 Woodford study had recommended this. I tasked NRL to provide the clocks but they could not provide one that was robust enough in time for the first launch, and that was a disappointment.

As it turned out, it was an alternative clock that I had asked my satellite builder – Rockwell International (Dick Schwartz and Hugo Fruehof) – to develop, that actually flew first. There were several of these clocks on the first three satellites. On the fourth GPS satellite, a Cesium atomic clock developed by Bob Kern (a marvellous inventor and engineer) was included. This had been developed under the sponsorship of NRL.

Another aspect was the political challenge in keeping the GPS train on the track and keeping it supplied with fuel in the form of money. It was not an enormous amount of money: the first phase of the program was less than 200 million dollars - but the political challenge was in keeping that money flowing, in particular overcoming the lack of support by the Air Force.

The Air Force preferred to buy airplanes. Though some people did understand the value of the GPS system, by and large the leadership

Dr Parkinson oversaw the Global Positing System (GPS) program from conception through development and verification as the first GPS Program director and is best known as the 'father of GPS'.

He received his BS in general engineering at the US Naval Academy in 1957, and his MS in aeronautics from Massachusetts Institute of Technology (MIT) in 1961. In 1966, he received his PhD from Stanford University in aeronautics and astronautics. He became the manager of the NAVSTAR GPS development program in 1972, finally retiring from the Air Force in 1978. As a Professor at Stanford he pioneered a number of first-of-a-kind demonstrations of GPS applications including Robotic Farming and Aircraft Blind Landing.

Dr Parkinson is the recipient of several awards, including the 2003 Charles Stark Draper Prize, the IEEE Sperry Award, NASA's Distinguished Public Service Medal, and has been inducted into the NASA Hall of Fame.

did not understand the payoff of precision weapon delivery so that was a very serious challenge.

Incidentally from the start we had always designated GPS as a military-civilian system. Some people think that the civilian access came along later; it did not- from day one it was a military-civilian system.

You have faced resistance and lack of cooperation in this journey, how did you keep yourself motivated to achieve what you have?

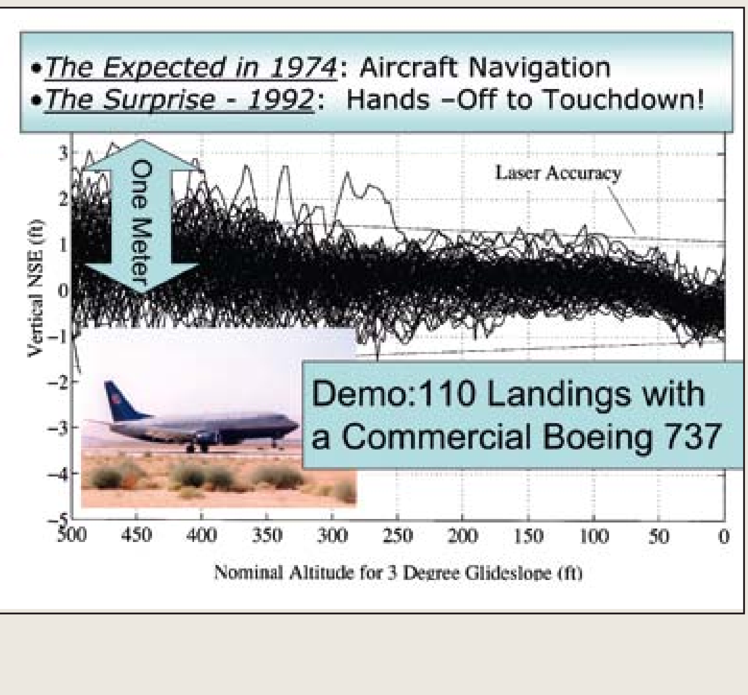
Actually that was never a problem. I had been allowed to handpick the officers that were working for me. There is a tendency in our country to think of military officers as not very smart, but the officers in my team were brilliant. There were three or four with PhD's and all the rest of them had Masters Degrees from MIT or Michigan or Stanford or places like that. We had an outstanding Aerospace Corporation support Team, and excellent contractors.

As a result, in terms of motivation, we fed on each other. They looked on me a leader, but at the same time it was almost like a football team and the mark of a really good team is that nobody wants to let the rest of the team members down. As a result, the long hours, the intellectual content, the motivation was always there. This team composition enabled us to take on each challenge as it came and solve it.

You had 'predicted' some of the uses that GPS is put to today, are there any uses/applications that even you had not envisaged ?

This is an excellent question. We could see the uses in general terms. Though there were many we missed, let me just point out three things that we did not envision.

We thought GPS would be extensively used for aircraft navigation. We did not realise it could be used for full category III aircraft blind landings using GPS alone. That was demonstrated by some of my Stanford students (Clark Cohen, Stu Cobb, Dave Lawrence et. al.) sometime back in 1992, so that was a surprise. The second total surprise was robotic farming. Right now GPS Agriculture is a business worth more than 400 million dollars a year worldwide and growing. Again, with some of my Stanford students – Michael OConner, Tom Bell and others, we put together the first robotic farm tractor that was able to pull an implement on a rough field with an accuracy of about 4-5 cm. The John Deere Company helped us do this and it was more accurate than the best driver that they had.



We had thought we could do survey to perhaps a meter. The third big surprise was that the GPS industry has shown accuracies, in three dimensions, to better than a millimetre. Key developers included Charlie Trimble who founded Trimble Navigation, and Phil Ward of Texas Instruments.

All three of these applications were enabled with the signal structure: with the carrier tracking receivers that relied on the PRN/CDMA signal that had been demonstrated by 621B at the White Sands Missile Range back in 1971; but we did not realize such accuracy was achievable. This has enabled the very accurate tracking of tectonic plates and earth movement.

GPS has already achieved so much, what could be the next thing that may happen in the near future?

I think that, with the additional satellite signals (Galileo, GLONASS etc.) we are going to have much better service, more robust, better accuracy, more wide-laning; and I can visualise robotic automobiles.

In my opinion, robotic automobiles are first going to come up simply as warning and guidance systems to the users. But then, we may have automobiles on the freeways that are measuring the distance between vehicles that are cooperating in fog or reduced visibility, to avoid collisions. Eventually, this could lead to automobiles that are actually being steered robotically by GPS. The farm tractor is a predecessor of that, and I understand, even today, Mercedes is actually doing this, where the autos go round and round, on their test tracks, completely under GPS control.

Do you think the apprehensions about GPS 'failure' are justified?

First of all, I think the notion that GPS would suddenly not work is fairly far-fetched. I have dug into that a great deal. What is more apt to happen is that for some reason or another we may have premature failure of the satellites and hence we may not have as dense a population of them.

We would call that a brown out. I do have some concerns about that, but I don't think under any circumstances it is going to disappear. I am very anxious to see the first IIF be launched and I am anxious to see USAF JPO make progress on GPS III. I will be visiting the manufacturer here to get an assessment of that. I still serve on an Independent Review Team for the Department of Defence on GPS, and we help evaluate risks.

I think the probability is that we are not going to have as many satellites as we currently enjoy. The US commitment is for only 24 (there are currently about 30) – I believe that commitment can be met, but there is some risk. The current GPS Program Director, Col. Dave Madden is outstanding.

Please share your views on the eLoran program, which was seen as a valid 'backup' for GPS, but has been terminated now?

I was the chairman of a study by the Department of Transportation

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CE

to review the need for enhanced Loran (eLoran). We were initially very sceptical, but we dug into what eLoran could do. It was not the Loran of old: it was quite an improved system and we concluded that in areas where the coverage was available it could do 30 to 50 meters or better. (Aircraft would need to use a barometric altimeter for the third dimension.)

Although eLoran would not be quite as accurate as GPS, if it was done right, one could take the eLoran plus your altimeter, feed them into your instruments and have a smooth transition in the event something happened to the GPS signal- particularly local jamming.

The possibility of local jamming is certainly there and occasionally it has happened. So, if people were to want to do that maliciously or deliberately, having eLoran as a backup would deter such action. The point being that if they jammed GPS, it would make little difference for most applications, and they would not see a payoff for such an illegal activity.

> **Just before the first Iraq war, the US had turned on the GPS Selective Availability feature. But as soon as the war started, they decided to turn it off since many of the soldiers had civilian GPS sets. It was hurting themselves.**

I think eLoran is an excellent backup though it does not cover the world, but it covers many of the areas where you have intense dependence on GPS for safety of life applications. The investment is small, the yearly cost of running an eLoran system is somewhere around 30 million dollars and relative to everything else we are doing it is absolute peanuts. Cancelling the eLoran program is a very, very bad decision.

What is your opinion about the upcoming GNSS systems around the world?

First, I am an advocate for all of those systems and am very enthusiastic about them. I think it will be a great benefit to users to have these other systems deployed. I have gone on public record advocating Galileo. Candidly, when they first proposed Galileo, thinking they were going to do it in 4-5 years; I said No way! Do not underestimate the complexity of what you are doing; having said that, I still wanted them to do it.

Now, my guess is that the political support to do these things is going to waver as people discover it is not so easy, it takes a lot of effort. But, I would not characterise it as a race in the ordinary sense. I think what is important is that these other systems are all made to work seamlessly with GPS so that the user on the ground can benefit from a much larger constellation and allay any fear of brown outs.

What do think has driven so many countries to develop their own GNSS systems?

Well first of all there is the issue of robustness and putting all your eggs in one basket – that is one aspect and a major legitimate concern.

The other, is a matter of national pride. In Europe there is a feeling that GPS dominates things. The national pride also relates to perceived economic benefits.

Last, GPS has a signal that is used for our military and allies. I think in some cases other countries would like to have such a signal. The military aspect and having control of a GPS-based precision weapon delivery system is just part of the way the world operates. I think the reason the Chinese are developing Compass, more than anything else, is to support their military, though I am certain they are going to make a portion of their system available for civil use as well.

The advantage of GPS based weapon delivery is that if the target is accurately located; you hit the target, you do not hit the nearby mosque, or church, or temple, or hospital or whatever. I sometimes shock audiences by saying that "GPS is a humanitarian weapon system!" By that I mean you do not hit things you do not want to hit.

I think all those are reasons to develop additional, GPS-like, systems. Though it is ultimately a political decision made by you in India, the Japanese etc, but I will forecast that it is more expensive than most people think.

Can GPS be selectively switched on and off by the US?

Of all the countries in the world we are the most dependent on GPS, and as a matter of fact the new satellites do not even have such a capability. Disrupting the signal would be very dangerous to our own citizens. Earlier, the US used a technique called Selective Availability (S/A) to deny use - by simply wiggling the timing on the signal. The use of WAAS, the use of EGNOS and the use of the other differential overlay systems like the one the Indians are building all completely remove the effect of any such 'wiggle'.

Just before the first Iraq war, the US had turned on the GPS Selective Availability feature. But the irony was that, as soon as the war started, they decided to turn it off since many of the soldiers had civilian GPS sets. It was hurting themselves. We never should have done it in the first place.

Incidentally, I was very instrumental in getting that turned off; my argument always was that wiggling the signal with selective availability was only going to speed up the introduction of differential systems and that is exactly what happened. By 1978 we had already demonstrated differential GPS that could reduce errors to about 2 meters, so I said why on earth would you try and put something in place that is so trivially defeated.

Then, the great irony in the United States was that the United States Coast Guard put together a system of marine beacons that was taking that error out, even before WAAS. So you had one group in the government putting the error in and another group of the government taking it right back out.

Is there any application of GPS which you think has had a negative impact for the users?

Let me mention two things here. First of all I love GPS, but the total dependency on GPS, particularly for safety critical applications, to me is a mistake. That is the reason I like eLoran as a backup. We could have other backups too, but eLoran is virtually unjammable. So I think a generalised negative is that too much dependency leads you down a somewhat risky path.

Second, is this Big brother system of tracking people or vehicles without their knowledge. I can understand law enforcement doing that. I can perhaps also understand a parent tracking his teenaged daughter. I do not endorse it, but I can understand why they might want to do that. This aspect of tracking people is problematic and sort of uncomfortable for us in this country and I suspect it would be in other countries as well.

With everything going digital, do you think hardcopy paper maps still have a relevance in our lives today?

I am a map freak and I love maps – that is my emotional response. There are certain situations where GPS cannot help, for example as I sit up here in the mountains and gaze out at other mountains on the distant horizon, I need a map to know which peak I am really looking at.

I always get back to this total dependence on GPS, I think the map is a logical backup for many users. In particular, you hear about people accepting car routes, that take them into the wilderness and the next thing you know they are isolated; that was because they did not look at a map. GPS can tell them where they are but it is a different technology that tells them where they should go. Certainly map technology can be stored electronically, but on the other hand having a crosscheck with a paper map and using your common sense is pretty important too. So I hope there is always going to be a place for paper maps.

Could you please tell us about the NASA-funded Gravity Probe B program at Stanford University.

I am a Co-Principle Investigator on the program. Started back in 1961, Gravity Probe B is the longest running program at NASA and Stanford University. It went through enormous political and technical difficulties, but we finally launched the satellite in April 2004, putting into orbit four gyroscopes.

The spin axis of a perfect gyroscope, if one considers Newton's Theories, would stay pointing the same way forever. Einstein said something different. His theory implies that as the gyro orbits a body, such as the earth, the space-time fabric is distorted and it is distorted in such a way that every time it orbits the earth the spin and axis of this perfect gyroscope will actually be seen to move. This change in direction is predicted by Einstein's General Relativity theory, but the effect had never been seen before. We launched four gyroscopes in space and have seen the effect - verifying this predicted effect - to about 0.3 percent or better. I believe this is the most accurate test of Einstein's theory ever.

There is a second effect that is much more subtle. The rotating earth actually drags space and time with it almost like it was a viscous fluid. This effect is incredibly tiny, being on the order of 70 milliarcseconds per year. A milliarcsecond is the width of a human hair at 10 miles. We have now also measured this second effect to better than 15%. The final results are due out sometime in 2010, but the interim results have already generally been available (http://einstein.stanford.edu/highlights/status1.html).

The purpose is that all of the fundamental theories, including General Relativity or Newton's Gravity, are subject to modifications. You can test them to a certain point and then you run into a discrepancy. An example is the Michelson-Morley experiment, where the speed of light seemed wrong. It was Einstein who proposed the answer to that in Special Relativity.

The same is true of General Relativity and physicists know that General Relativity is going to have to be modified because it does not fit in with the other laws of the universe – the strong and weak nuclear forces, and electromagnetism.

Therefore the point was to try to ascertain if there is some weakness in this particular area of the theory that would act as a pointer to the theoretical physicists as to new modifications to the General Relativity Theory.

Gravity Probe-B has been a very long, very arduous journey. I was program manager for 8 or 9 years facing some of the most difficult technical challenges and I will say the Program is a tribute to the perseverance of the Stanford physicist Francis Everitt. He is the one who kept rescuing the program when it was threatened with cancellation. But, today we now have results with marvellous precision to calibrate how well we understand Einstein's theory.

A word of advice for the nations working towards their own GNSS systems?

Let me think about that. Well, the most important thing is tenacity. Along the way other developers are going to run into all kinds of obstacles - political, technical, the market will push back at them, one thing and another - if they are going to succeed they have to have tenacity.

GPS: Myth and facts

- There is no 'inventor' of GPS; it is the culmination of the efforts of many people.
- The GPS system design was fundamentally based on an extensive, classified, Program 621B study from 1964-1966, and a signal structure verified with 621B tests at the White Sands Missile range in the early 1970s.
- From the start GPS was a military-civilian system.
- Many applications that GPS is used for today had not been envisioned.
- Under no circumstance is GPS going to 'disappear'.
- Cancelling the eLoran program as a backup for GPS is a bad decision.
- The civilian signal of GPS is just as accurate as the military signal.
- The GNSS systems cost much more than people expect.
- GPS cannot be selectively switched on or off.
- GPS cannot replace common sense!

Tracking system for goods

The paper proposes basic concepts how to realize the Secure and Safety Tracking System (special for food, food material) between different countries

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Prof Ryosuke Shibasaki
Director
Center for Spatial Information Science
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Fig-2 current products of "μ-Chip Hibiki"

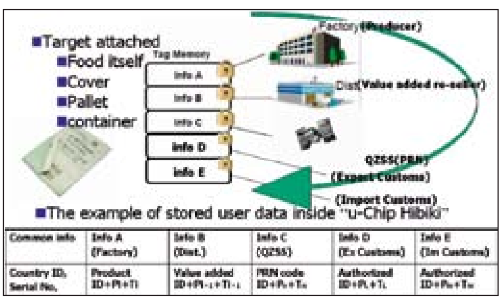

Fig-3 Database Image

As the world becomes a smaller place, countries are becoming more dependent on each other in many fields. Goods like industrial products, food and other materials are easily exported and imported by every country. A Secure and Safety Tracking System is indispensable from the viewpoint of defense of country especially in the field of food security and safety. Also when international accidents happen, for inter-police investigation between countries, we need some objective criteria for the problem between different countries.

Current situation

There are many commercial logistics tracking systems between countries, however, each commercial logistics tracking system is standalone, and there is no interoperability between the systems in various countries.

Actually, these commercial logistics tracking systems are operating well for tracking of products within their internal central control system. Customers can trace their baggage on the Internet by using a bar code or certain tracking number. We will show two examples.

First example: FedEx has many variations of the tracking system (1) like, shipping, tracking, website management, and business solutions, however, the elements of FedEx commodities are limited to Package/Envelope or office / Printing service. The users can trace their commodities both from surface to air and from domestic to international. More over, the commodities are displayed on a map by GPS tracking information. If FedEx deals in commodities such as modified materials (i.e. food materials) they are not part of the FedEx order system.

Second example: Hitachi Information & Control Solutions, Ltd. has Supply Chain Management Implementation System. (2) The Hitachi system is a good implementation example for a major Transportation Company and a Fuel Distribution Company. The Supply Chain Management Implementation System for major Transportation Company consists of four subsystems (3)

- Order Taking subsystem :OTS
- Transportation Management subsystem: TMS
- Geographic's Information subsystem; GIS
- External System interface subsystem: EXS

The purpose of this Supply Chain Management Implementation System is expansion of output and reduction of lead-time. The tracking of customers' products is traced either by purchase order number or customized unique number; however, these numbers are not fixed for covered packages. A universal criteria like both timestamp and position stamp would be needed.

In this research, we considered the application of Global Navigation Satellite System (GNSS) on a Secure and Safety Tracking System.

GNSS is global and is useful on a worldwide scale. However, in a localized area a local navigation satellite system (e.g. The Japanese Quazi-Zenith Satellite System (QZSS)) (4) is sometimes more useful.

The combination of QZSS and RF-ID is much more suitable for the Secure and Safety Tracking System.

RF-ID (i.e. µ-Chip Hibiki) (5) is attached to the target industrial product, food, or material, and so on.

The benefit of RF-ID is that the information is stored inside. The RF-ID reader can read this information. If the RF-ID is re-writable new information can be added to this RF-ID again and again. The point of combining of the QZSS and µ-Chip Hibiki is to trace logging information by position and time stamp. The monitoring of the position and time stamp is achieved with QZSS receiver. This QZSS receiver consists of a RF-ID reader and writer with GNSS receiver (including QZSS receiver).

Problems

To realize the Secure and Safety Tracking System between different countries, Bible methodology will be important. All major countries should accept the methodology. The problems to be solved will be as follows:

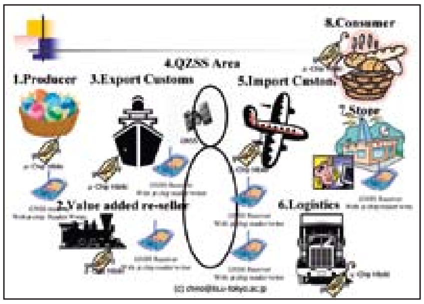

Figure-4 System Image

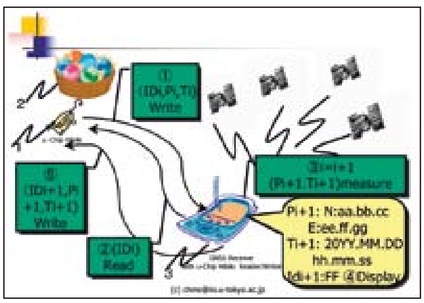
Fig-5 Tracking data update methods

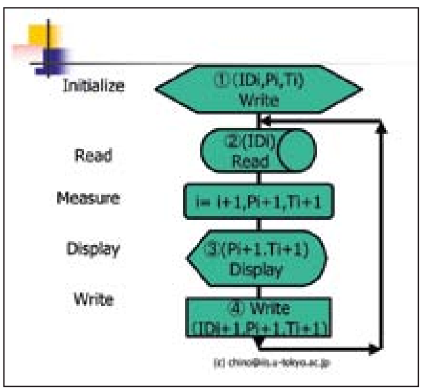

Fig-6 Tracking data update Flowchart

- The uncertainty of tracking routes from producer to consumer through logistic and Value added re-seller from country to country.
- The uncleanness of tracking route from export country to import country and checkpoints like immigration, customs, means of transportation.
- The un-certification of tracking route and the lack of authorized agency certification.
- The un-clearness of inter-police investigation, the lack of methodology and absence of international rules.

Basic elements

To solve the above problems, we propose basic elements of the technology and system solutions. We propose ISO standard activities for the Political and methodology points of view; however, this is still under consideration. Therefore this point will be discussed in another paper.

Basic elements of the technology

We will discuss Satellite, RF-ID, Receiver, Database and Display.

(1) Satellite: we are approaching the multi GNSS age. Outside of Japan, both GPS in the United States (under modernization) and Galileo project in Europe (now under demonstration stage) would result in the creation of an international network of satellite positioning systems. That would enable a high rate of utilization of real-time spatiotemporal information on a global scale. On the other hand, inside Japan, the satellite positioning technology derived from the Quasi-Zenith Satellite System has been incorporated into the Basic Program for Science and Technology, and has been further strengthened by its recognition as a national critical technology. By 2012 we will have over 60 satellites on the earth.

(2) (2) RF-ID: There are many types of RF-ID all over the world, However, we will focus on Hitachi's RF-ID, µ-Chip Hibiki, because the µ-Chip-Hibiki has unique features and is suitable to the application of a Secure and Safety Tracking System. We have shown the features of a "µ-Chip Hibiki" in Figure-1

- UHF band RFID
  - ➢ Frequency ; 952~954MHz
- Secure RFID protocol (Air Protocol
  - ➢ Privacy & User data Perotection
- Standar d
  - ➢ ISO/IEC 18000- 6Type-C compliance
- Large Re-writable Memory
  - ➢ 1.5K bits User area
  - ➢ The largest User area sized RFID tag
- Target cost
  - ➢ 0.05$/chip at 500 million Qty

Fig-1 Features of "µ-Chip Hibiki"

Secure RFID protocol (Air Protocol) is the most important and suitable feature for the application of a Secure and Safety Tracking System. Secure RFID protocol (Air protocol) of a "µ-Chip Hibiki" has three features. These are privacy protection, user data protection and apply to standard.

- **Privacy Protection** Communication distance between reader and tag is minimized by special command.

- **User Data Protection** User memory area can be protected by password to read lock and write lock. User memory area is divided into 5 areas (max) and each area can have its own password (max 5).

- **Standard** This Air Protocol is compliant with ISO/IEC 18000-6 Type C.

(3) Receiver: RF-ID reader/writer with GNSS receiver (including QZSS receiver) is under consideration. For reference, we have shown current products of "µ-Chip Hibiki" in Figure-2

The semiconductor process has rapidly progressed, and on commercial basis, GPS chipset is sold from many semiconductor venders at less than 10$ for volume quantities. We find that the size and cost of GNSS Receiver with μ-Chip Hibiki Reader/Writer is almost same as current products.

(4) Database: Trace data of a Secure and Safety Tracking System is stored inside "μ-Chip Hibiki". As we explained at 4.1 (2), user memory area is divided into 5 areas (max.) and these user memory areas can be protected by password (Read lock and write lock) and addition to that, each password (max. 5) can provide protection for each area (max. 5). The size of user area inside "μ-Chip Hibiki" is 1.5Kbits and can be re-writable. According to the tracking system, "μ-Chip Hibiki" is attached to the target Goods (itself, cover, pallet, container). We have shown these images in Figure-3

(5) Display: When food/ food materials are displayed in the show case, the manager of the Retail (store) can read the "μ-Chip Hibiki" tracking time stamp data by POS, to check if the tracking data is false or true. The example of stored user tracking time stamp data is shown at Figure-3. The country ID, Serial Number is common information. According to the Tacking stage, each information A, B, C, D and E are added inside "μ-Chip Hibiki" with position and Time stamp data (Pi +Ti).

System Solutions

We will now discuss System Solutions. System Solutions consist of three major points; QZSS implementation, RF-ID roistered by authorized institution and Total cost vs. Security cost.

(6) QZSS implementation:
Japanese local Navigation Satellite System QZSS is suitable for the measurement of position and timestamp. QZSS is fully compatible with GPS in USA. The accuracy of positioning with QZSS is almost the same as that with GPS. In high-speed transportation vehicles like airplanes, the accuracy is near to 10 or 20 m. In static positioning, the accuracy is near to cm-level. This accuracy is enough for this tracking application, because the accuracy of positioning is not as important as tracking the trace of position.

(7) RF-ID registered by authorized institution:
There are two major RF- ID institutes in the world the EPCglobal and the Auto-ID center. A "μ-Chip Hibiki" is compliant with EPCglobal. There are several advantages of "μ-Chip Hibiki" in authorization. In production phase, EPCglobal authorizes country code and Serial number when a vender issues the "μ-Chip Hibiki" to customers. A pair of Country code and serial number is unique. A Vender can identify the customer that the "μ-Chip Hibiki" is sold to.

In operation phase, when "μ-Chip Hibiki" goes thorough Export/ Import Customs at an Airport or Ship port, each country has their own authorized ID for Customs. By reading the authorized ID inside the user data of "μ-Chip Hibiki", it is easily recognized which country the Goods are exported from and which country the Goods are imported to.

(8) Total cost vs. Security cost ;
For the marketing points of view, the key points for expanding this type of a Secure and Safety Tracking System is up to system construction cost + system operation cost. If the logistic private company decides to use a Secure and Safety Tracking System, a consideration would be that the total cost (construction cost and operation cost) must be minimized and optimized. However, a security cost is enough reason to pay additional charge for a Secure and Safety Tracking System.

For the political points of view, the safety and security of Food and Food materials would be first priority in operation of agriculture politics. In public sector, some regulation to protect the safety and security of foods would be considered in the near future. Once the food import regulations are established, the security cost would be an indispensable cost for a Secure and Safety Tracking System.

We have shown total system image of "Concept of Secure and Safety Tracking System using QZSS and RF-ID" in Figure-4 System Image in Section 5.

Operation

System Image and system flow

We will explain the process of how the food materials are transferred from 1. producer to 8. consumer in Figure-4 The point is that Position + Time stamp by GNSS receiver (including QZSS receiver) is linkage to a μ-Chip Hibiki ID code and the Position+time stamp is stored with new ID at different memory area (refer to Figure-3).

Producer

- μ-Chip Hibiki is attached to Goods like food/food materials/food cover.

- The country ID, Serial Number is common information and is assigned by Authorized agency. Using GNSS receiver with μ-Chip Hibiki reader/ writer, Producer writes (product ID+Position+Time) to Information A field of μ-Chip Hibiki user data (refer to Figure-3). At the same time Producer reads μ-Chip Hibiki (the country ID, Serial Number) of common field of μ-Chip Hibiki user data (refer to Figure-3).

Value added re-seller (including warehouse)

- According to the Logistics layer, μ-Chip Hibiki is attached to food itself, food cover, food box, food container

2010 FOIF NEW PRODUCT

A20 GNSS Receiver

- 3G Satellites tracking (GPS, Glonass, Galileo)
- All-in-one Flexibility
- Voice messages
- OLED display with super brightness & weatherability
- Advanced GNSS tracking performance
- Advanced multipath mitigation
- Advanced rugged design

TS650/680 can work together with data collector by bluetooth

Total Station

- RTS/OTS650 series
  OLED display with super brightness & weatherability
  Arctic option for a wide range of applications
  Bluetooth cable-free connection
- RTS/OTS680 series
  RTOS & GUI platform
  3D road design and stake out
  SD card and internal memory
  Bluetooth cable-free connection
- RTS/OTS810 series
  Windows CE 5.0 Operating system
  Large full color graphic display
  Touch screen
  Guide light system
  Professional onboard software:
  FOIF Survey_TS or FOIF FieldGenius
- FOIF Geomatics CAD desktop software
  FOIF FieldGenius field software

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It's professional
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www.foif.com.cn
or email to: ***internationalsales@foif.com.cn***

Suzhou FOIF Co.,Ltd.

- Value added re-seller marks (authorized ID+ position + time) in Information B field of μ-Chip Hibiki user data (refer to Figure-3) by GNSS receiver with μ-Chip Hibiki reader/writer

Expert customs

- Export Customs read tracking data inside μ-Chip Hibiki

- Export Customs mark (authorized ID+ position + time) in Information D field of μ-Chip Hibiki user data (refer to Figure-3) by GNSS receiver with μ-Chip Hibiki reader/writer

QZSS area

- Transportation tool (Ship or airplane) come into the QZSS Area

- If GNSS receiver reads PRN code of QZSS, (PRN code+Position+Time) it is stored to Information C field of μ-Chip Hibiki user data.

- GNSS receiver will update new (position + time) after certain interval (i.e. 30 minutes)

- Update procedure will automatically repeat.

Import customs

- Import Customs read current data (ID + Time + position and its history) by μ-Chip Hibiki reader

- Import Customs marked (authorized ID+ position + time) to Information E field of μ-Chip Hibiki user data (refer to Fig-3) by GNSS receiver with μ-Chip Hibiki reader/writer

Domestic logistics

- According to the Logistics layer, μ-Chip Hibiki is attached to food itself, food cover, food box, food container and marked by related (ID+Time+position)

- At the same time, GNSS receiver with μ-Chip Hibiki reader/writer read ID and write time and position

Store

- When food/ food materials are displayed to show case, the store read the μ-Chip Hibiki tracking time stamp data by POS, if the tracking data is false or true.

- If the data is vaguer, omit the applied food / food materials

Consumer

- After checking the food property, they buy food / food materials, if they agree with the data.

- At purchasing, the tracking data will be printed out from POS and they buy Secure and Safety products.

Tracking data update methods

We will discuss tracking data update methods as shown in Figure-5. If products are packed again and again with cover, box, container, and so on, a pare of (IDi ,Pi,Ti) and next pare of (ID i+1 ,Pi+1 ,Ti+1) is the time domain relationship of the same product. This update idea is unique for ID+ position +timing criteria and these three elements (ID, Position, Time) will be key measurements to find out: What is it? Where is it? When is it?

One of the traditional RF-ID applications was Factory Automation like production line control system. (6) In this production line control system, RF-ID was active tag and read/ Write tag, so on going forward. RF-ID active tag read instruction from reader connected line Programmable Ladder controller, on the contrary, RF-ID active tag wrote its status information to RF writer. But there was no time-stamp function at all. In production line, the important information was ID information and position.

Tracking data update flowchart

I t is important for position +time stamp function to realize the Secure and Safety Tracking System between different countries. Especially the update of Tracking data (ID, Position, Time) is essential for this system. We have shown Tracking data update flowchart in Figure-6.In this flowchart, GNSS receiver measures new position data, and the measured new position data is stored to μ-Chip Hibiki user memory area linked to ID.

Conclusion

We have proposed basic concepts of how to realize the Secure and Safety Tracking System (especially for food, food material) between different countries. The problems to be solved are cleared as follows:

- The certainty of tracking route from producer to consumer through logistic and Value added re-seller over country to country.
- The cleanness of tracking route from export country to import country and the checkpoints as immigration, customs, means of transportation.
- The certification of tracking route and the satisfaction of authorized agency certification.

Acknowledgments

We thank Mr. Shigeru MATSUOKA, of SPAC for his support and comments on our research.

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Do we fail on delivery of geospatial projects?

Projects don't fail, people do

Prof P Misra
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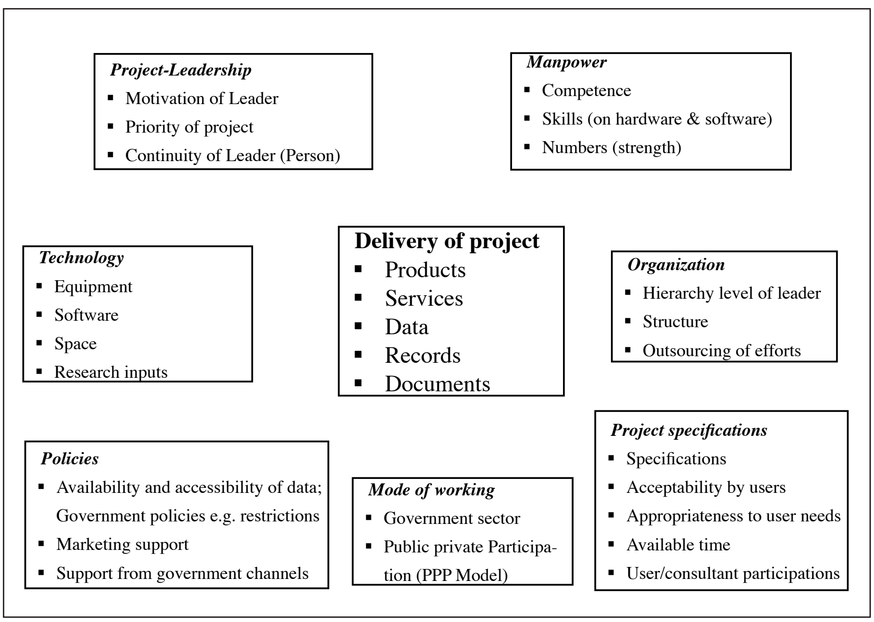
Present situation

It appears that big talk and promises about the technologies (GIS et al) have still not carried weight and conviction with the user – organizations, the ultimate beneficiary of the productivity of the modern technologies. The spatial solutions have still not reached these organizations like urban development authorities. Land Information Technologies (LIT) have not delivered spatial solutions as a matter of routine or policy.

Many well known organizations in the government sector working in LIT field have devoted more time and resources on research as compared to the practical applications. This is, perhaps, due to an impression, may be erroneous, that the career graphs of the technical persons depend more on research and less on projects and still less on solving real and current geo-spatial problems of the nation. For example, cadastral surveys of villages and base maps of towns still remain big challenges to LIT and GIS.



Guiding model to explain the linkages between the various factors

Scope of this paper

This paper encompasses some collected thoughts and experiences of the author on this subject of delivery of geo-spatial solutions. Why don't we see many success stories? The answer to this question lies in many factors which have been highlighted in the 'model'.

The readers are requested to validate them and add some more from their experience.

Major managerial factors of the model explained further

Most of the factors facilitating 'delivery' have been listed in the model. Absence of any one of those will certainly act as an obstacle – to – delivery. To maintain brevity, only the important ones have been amplified and analyzed further.

Leadership and its continuity

According to the definition, a Project is a well defined task. This definition is to be provided and manifested by the leader. A competent leader, both as a technologist and as a human-resource manager is the most important motivator for the delivery. He also needs support from all the sub-organizational 'heads'. He should, therefore, have a hierarchical status which is commensurate with the functional requirements of the project. This will minimize the maze of sanctions, approvals and allocation of resources. It follows from above that the status of the leader should be functionally right and not merely in designation. The higher in the functional status, the better will be the chance for success.

Continuity of the leader is the least talked about subject. The leader is already imbibed with the details of the project. Therefore his 'continuity' for the project is essential for the momentum and team-work of the project. Many projects could not survive because continuity became a casualty.

Manpower: Competence and adequacy of numbers

Many projects fail because the technical manpower is not thoughtfully trained on the operational / practical aspects of the technology. Mere exposure to the theoretical concepts may not deliver the results. The number of persons deployed on the project is also very significant for timely completion. It is here that private organizations score over government set-ups as they can easily recruit and enhance the number of persons working on the project.

Working mode of the project

The success of a project also depends on the mode in which it is visualized to be implemented. There are several modes of working but one which is most successful has been the PPP (Public-Private Participation) model. In this model of working, a project is said to have the strength of Government office and flexibility of procedures of a private firm. Both the partners are supposed to work in a synergistic manner. Unfortunately, the reverse is also true and litigation is the result! A well thought out working model earmarking the various functions between the parties has been found very effective. For example, maps can be produced by the Survey of India employing photogrammetry etc while their revision, derived maps can be entrusted to private firms. A private firm may have the manpower but not the software or the equipment.

Technology, data from various sources

A quick look at the website of NSDI will show the various organizations who are in the charter of producing land information, namely Forest Survey of India, Survey of India, National Bureau of Soil Survey and Land Use Planning, etc. Each department produces data/ map etc only according to its charter. On the other hand GIS by definition and by application is a spatial solution based on the multi-disciplinary data.

Therefore it becomes a great time taking exercise to collect data from different sources located all over India. In addition, one has to know where, what, in what form, the data is available / accessible. This phase of the project is extremely tedious. Only the most patient survive this ordeal!

As an example, take the case of Meerut, a city in Uttar Pradesh in India. If you have a GIS project, the topographies available is of 1973 edition. The need for GIS is for larger scales e.g. 1:5000 / 1:10,000 or larger. This implies that fresh topographical surveys will have to be undertaken. That adds one more year to the project and a lot of headache. So the time for a GIS project becomes: 12 months+2minutes. Topographic layer is an important layer of GIS as all the other spatial information is hooked on to it.

The modern technology of photogrammetry is helpful in such situation. But be aware of restriction policy.

The cardinal experience regarding data is that:

Data is not given, it is always obtained.

In such a scenario, one can easily imagine the pitfalls: various out-of-station journeys, e-mails etc. A ray of hope can, however, be found in my suggestion for augmentation of charter for NSDI, described further.

NSDI-A plea for augmentation of objectives – structure (Please refer to portal)

The author has suggested (in another paper) that the charter of NSDI should be augmented to a level where NSDI not only gets the desired data from its constituents but should organizationally take them in its administrative network. This could be done in a phased manner. NSDI may need a very major reorganization. It should be a part of a freshly constituted ministry of geo-surveys.

It is visualized that only then the GIS will be turned into a successful tool which will deliver results. Meanwhile, NSDI should collect and collate all necessary, non-restricted data and publish them on its portal.

Project specifications

The specifications should be deliberately made simple, especially if the project is a first time or proof-of –technology project. It is a better strategy for success. It is seen that in many cases BEST becomes the enemy of GOOD. The specifications could be improved in subsequent projects. It will be a good idea if the 'users' or consultant to the user organization could be involved while making specifications.

Policies of government

Many policies of the government e.g. restriction policy have proved counter productive to the introduction of aerial photography etc. A re-look is necessary.

Conclusion

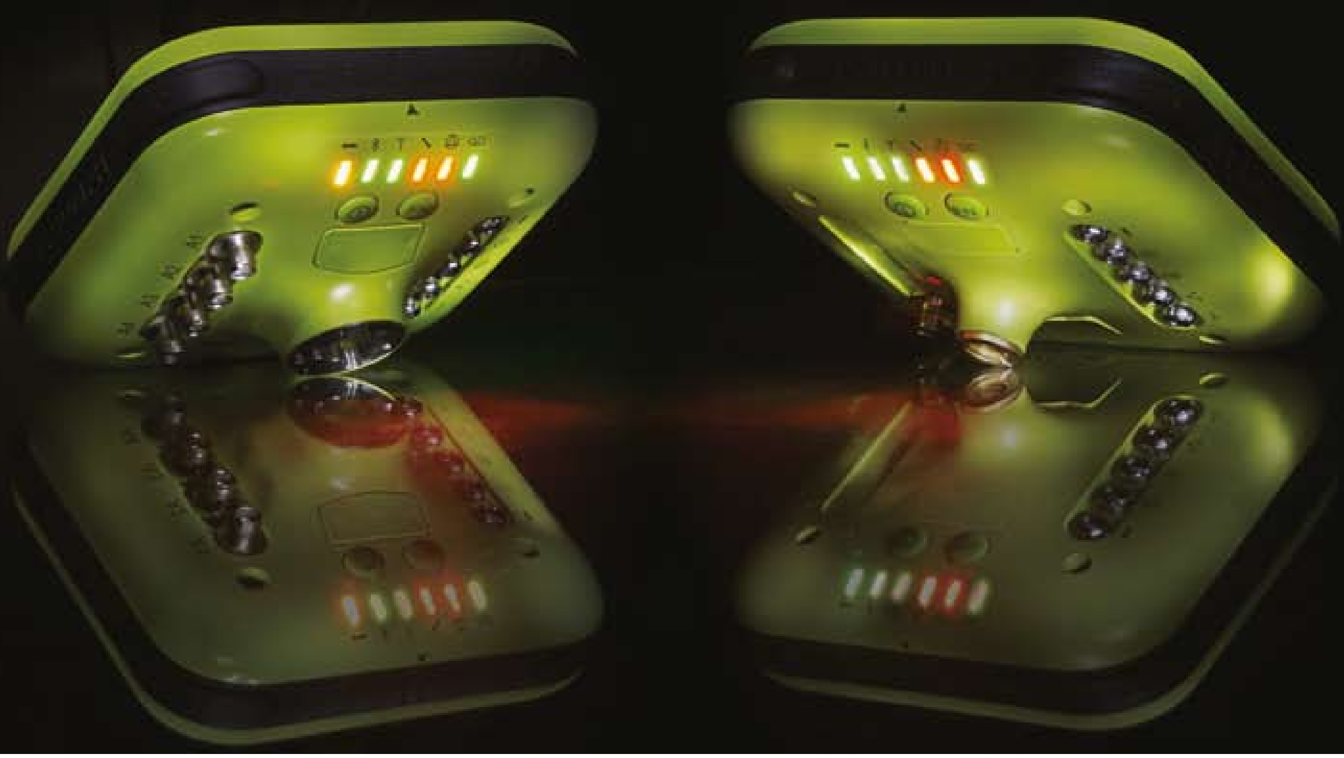
The paper draws attention to some of the major difficulties in bringing a geo-spatial project to a successful end. The difficulties (call them as challenges) will be quite formidable as they emanate from areas which can be called:

Multidisciplinary

Multi-organizational

Multi-locational

These will always be a part of a geo-spatial project. A judicious use of project – management techniques, as mentioned above may be useful.



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

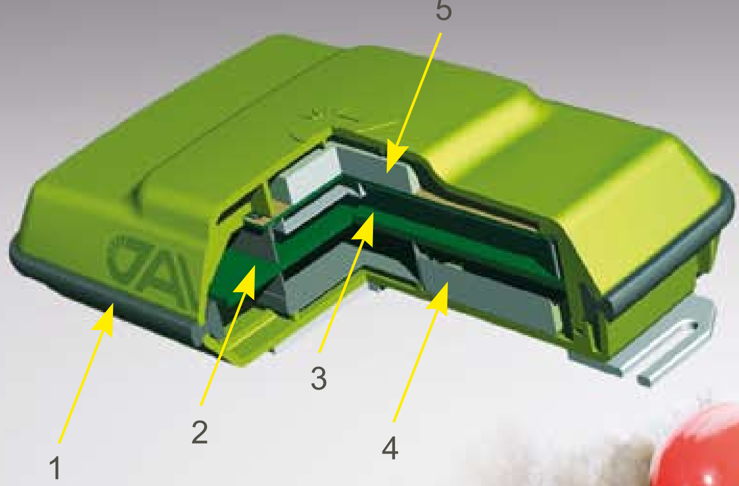
1. Guard Bumper

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

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.

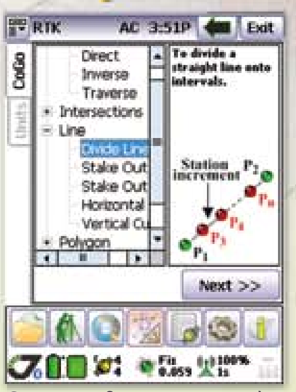
Victor

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.

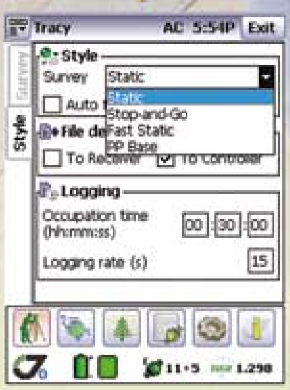
- **Lightweight (17 ounces; 482 grams) magnesium case with easy-to-grip over-molding**
- **Operating temperature -22°F to 122°F (-30°C to 50°C)**
- **Connectivity via built in Bluetooth, USB Host and Client, plus 9-pin RS-232 and optional WiFi and Modems**
- **Rechargeable, field replaceable, Li-Ion 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

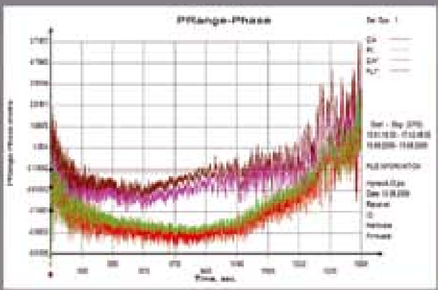
Software for Windows Mobile OS to control receivers, automated GNSS post processing surveying tasks (Static, Fast Static, Stop&Go, Data Acquisition), and to perform RTK survey and stakeout tasks.

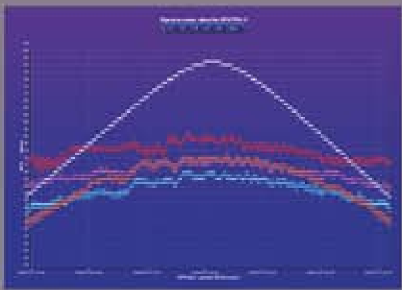
Javad eliminates GPS SVN 49 anomalies

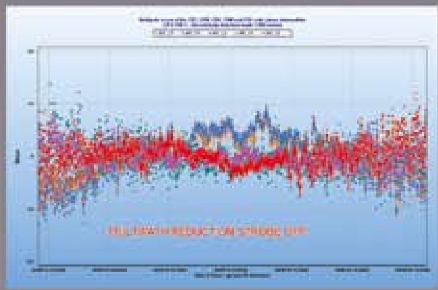
The anomalies in the recently launched SVN49(PRN1) was a chance to demonstrate the advanced multipath reduction capabilities of JAVAD GNSS Triumph technologies.

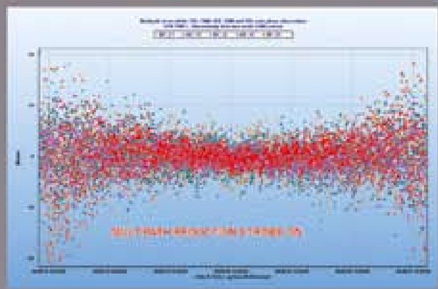
Figure below shows SNV49 (PRN1) code-minus-phase plot for usual correlator (magenta - C/A code, brown - P/L1 code) and for "mpnew" (red - C/A code, green - P/L1 code), which shows almost all anomalies and satellite multipath are removed.

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.



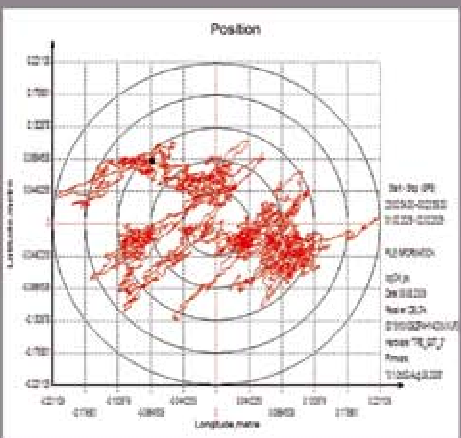






The optimized multipath mitigation technique implemented in our Triumph technology allows nearly complete compensation for the satellite-induced multipath anomalies that would otherwise badly affect GPS SVN49 measurements. The same multipath reduction capabilities which removed the SVN49 multipath anomalies 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	T_C/A	T_P1	T_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	27	--	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	88	4986	0xA153	-------	-------	Y(0)
Gal	78	18	--	50	0	0	81	4892	0xA153	-------	-------	Y(0)
Gal	79	30	--	49	0	0	85	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

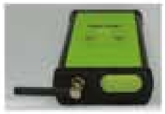
ALPHA

- 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

Earth troposphere calibration system

Purpose of this work is to demonstrate the potential improvement of troposphere calibration using GPS measurements for an ESA deep space probe orbit determination

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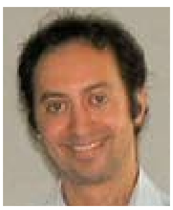

Mattia Mercolino
European Space Operations Centre, European Space Agency

Frank Budnik
Spacecraft navigator, Interplanetary Mission Support Section, Flight Dynamics Division, ESOC

For interplanetary missions, the determination of S/C state vector (position and velocity) is required both for navigation purposes and science operations. The main error sources affecting S/C tracking data are the solar corona and the interplanetary plasma, which could be removed by using the multifrequency link technique between the probe and the ground station [1]. Once solar plasma noise has been removed, the Earth troposphere remains one of the major noise sources in radiometric tracking data. At present, Earth media calibration systems are performed at NASA's Deep Space Network (DSN) stations with different techniques, in order to reach different levels of precision due to the specific purpose of the tracking activity [2].

In particular, for S/C navigation, the troposphere calibration technique is based upon a combination of weather data and multidirectional, dual-frequency GPS measurements acquired at each DSN complex.

At present, ESA's Deep Space Antennas (DSA) are equipped with meteo stations, capable of measuring the atmospheric parameters and to retrieve the hydrostatic and the wet components of the Earth troposphere. With this technique a residual uncalibrated wet component is not accounted for, in an error of about 1-2% of the total tropospheric delay [2][3].

In order to avoid this, the short time-scale variations of the wet component of the Earth troposphere should be calibrated by means of water vapour radiometers or GPS measurements. A future ESA ground station media calibration systems should be at least capable to calibrate both the zenith hydrostatic path delay (ZHD) and the zenith wet path delay (ZWD) at centimeter level. The natural choice is the use of the high performance GPS receivers already installed at all ESA ground station complexes for station location purposes.

Unibo software overview

A GPS data processing S/W has been developed in MATLAB® code at the Radio Science Laboratory of the University of Bologna. The main purposes of the S/W code is the estimation of the ZWD, using dual-frequency GPS observables. At present, the S/W is still just demonstration breadboard and needs accurate setup procedures in order to estimate the troposphere delay. The software has been designed using the Kalman filtering technique in order to estimate the time-varying state vector unknowns (including the ZWD). GPS observables residuals are obtained with the single and double difference techniques. The S/W architectural design is divided in four steps: Input phase, Pre-processing phase, Processing phase and Post-processing phase. Once all data are collected from the database, the Input phase starts, consisting in the translation of all input parameters which will be used in the following phases for the data analysis. The main input parameters are the GPS observables, acquired from the RINEX files and the satellite position acquired from the precise IGS database. In order to model as much as possible the errors affecting the raw GPS observables, other parameters have been included: IONEX data,, Earth Rotation Parameters, station antenna phase center and satellite antenna phase center. In the preprocessing phase the stations coordinates are computed. The nominal GPS observables are combined in the so called "ionosphere-free" combination and used as the sole observable for the following phases. A preliminary estimation of the ionosphere and the dry troposphere model have been computed and combined. Finally the single and double differences for observables, ionospheric delay and dry tropospheric delay are computed. The processing phase is split in two steps. The first stage is related to the computation of the double difference of the geometric distance, starting from the already computed corrected satellite position and station coordinates. The second stage of the processing phase corresponds to the Kalman filtering process through which the unknown parameters are estimated.: the rover station positioning, the rover station ZWD and the integer phase ambiguity. Finally, once the wet delay has been obtained via the processing phase described above, the whole troposphere delay can be computed. A detailed description of the last version of the S/W code is reported in [4] where a test campaign for the validation of the results is presented too.

Layout of venus express navigation test

Starting from the first results obtained in [4], the S/W code developed at University of Bologna was used for a more complex test involving also the ESA-ESOC FD team. The experiment described was carried out to demonstrate the potential improvement of troposphere calibration using GPS measurements for an ESA deep space probe orbit determination test. Thanks to the non dispersive nature of the troposphere delay, the GPS-based estimation of the ZWD was used to calibrate the Doppler tracking observables of the ESA probe Venus Express (VEX), a mission launched on November 9th, 2005, currently orbiting Venus [5] and daily tracked by the ESA Deep Space Antenna (DSA) in Cebreros, Spain [6]. Among all the equipments installed in Cebreros, there is also a dual frequency GPS receiver, mainly used for station location purposes, named CEBR. The CEBR antenna and its receiver are installed about 80 m North of the DSA Figure 1.

In the estimation process, the new S/W used GPS data acquired at 3 GPS reference station of the EUREF Permanent Network (EPN). These stations were considered as master stations, while CEBR was used as the rover station. The corresponding baselines between each master station and the rover station are:

– ACOR-CEBR 468 km
– TERU-CEBR 270 km
– LAGO-CEBR 530 km

Standard ESA estimation of the ZWD is obtained using surface measured temperature and relative humidity. The model used is:

$$ZWD = 0.0022768\left(\frac{1255}{273.15 + T} + 0.05\right)e \quad (2)$$

Where T is the temperature in Celsius degrees and e is the water vapour pressure in millibars.

As far as the GPS S/W is concerned, the estimation of the ZWD is obtained as the output of the whole S/W process.

Figure 2 shows the comparison between the estimation of the ZWD obtained with the ESA standard technique and with the GPS-based S/W. Although some points present a difference larger than 5 cm, the difference is on average within 3 cm, as expected. The troposphere estimation test was carried out using data acquired on July 4th, 2009. During that day the VEX S/C was close to "quadrature" with the Earth and the Sun. As shown in Figure 3, this means that the Sun-Probe-Earth (SPE) angle was about 90 deg. In particular, the SPE angle during the test was approximately 75 deg , meaning that the quadrature point had been reached a few days before, and that VEX was farther away from the Earth than in quadrature.

The geometry shown in Figure 3 is unfortunately not the optimal one, in order to minimize plasma noise in Doppler data. For S/C inner solar system mission, the minimum plasma noise is reached when the SPE angle is 180 deg (inferior conjunction). For this reason, VEX data acquired on July 4th, 2009, may very well be dominated by residual plasma noise. The possible presence of significant plasma noise in the range-rate observables residuals may invalidate the troposphere calibration test, as a precise troposphere calibration would be appreciable only when plasma noise is reduced below the level of tropospheric scintillation.

Data analysis

The routine orbit determination of VEX is done by using coherent 2-way Doppler tracking data acquired at X-band frequencies during daily passes at CEB. The Doppler raw data are recorded with a sampling of 1 Hz but in the pre-processing to the orbit determination they are compressed to 60 seconds count time and converted to range-rate.

	Mean [mm/s]	Rms [mm/s]
ESA standard	0.000	0.056
GPS measurements	-0.003	0.055

Table 1 Mean value and rms of the two compared range-rate pass-through

Figure 1 Overview of the GPS antenna of CEBR with CEB DSA in background

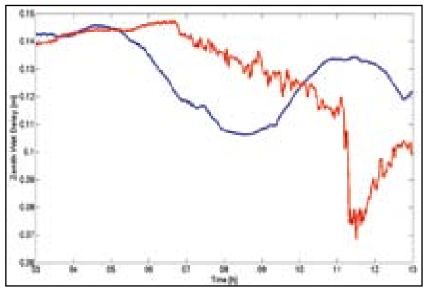

Figure 2 Comparison of the ZWD estimation between the standard ESA (red curve) and the GPS S/W (blue curve)

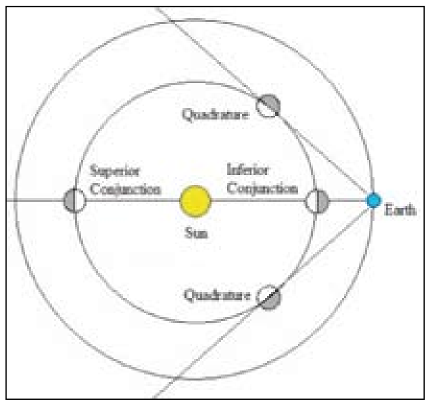

Figure 3: Orbital geometry of Venus, Earth and Sun around the troposphere calibration test of July 4th, 2009

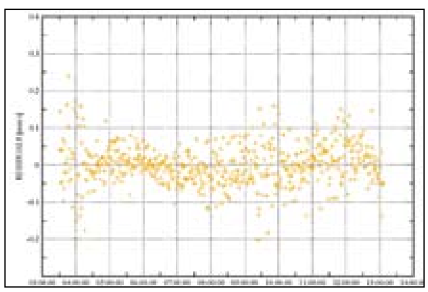

Figure 4 Doppler residuals obtained with a pass-through using standard ESA estimation for both ZHD and ZWD

Within the orbit determination the range-rate data are computed based on the best estimate of the orbit and the residuals with the pre-processed range-rate observations are formed. The computed range-rate observables are thereby calibrated for the effects of the Earth troposphere and ionosphere. As far as the ionosphere is concerned the calibrations are provided by JPL. On the other hand the troposphere is modeled by using measured local weather data at CEB that are acquired over the full tracking pass duration as briefly mentioned.

Moreover all Doppler data at elevations below 15 deg are discarded from the orbit determination process. The reconstructed orbit derived from the routine VEX orbit determinations has been used for the analysis by performing pass-through. In each pass-through the modeling of the range-rate has been kept identical but just the troposphere calibration has been changed. Figure 4 shows the residuals where the aforementioned ESA standard troposphere model has been used. The residuals are basically identical to the post-fit residuals that had been obtained in the routine orbit determination apart from that the range-rate data below 15 deg elevation are also computed. Figure 5 shows a pass-through in which the ZWD polynomial has been replaced by the one derived from the UniBO GPS-based S/W. The computation of the ZHD has been kept unaltered because this is performed exactly the same way in the GPS-based S/W.

The rage-rate residuals shown in Figure 4 and Figure 5 seem very similar although, at a closer look, there is a marginal improvement in the residuals rms of Figure 5. Table 1 shows the mean value and the rms of the two sequences of range-rate residuals obtained with the two techniques. As expected, for the ESA standard calibration pass-through the mean value is zero, as the VEX orbital solution is based on the same residuals. On the other hand, a non-zero value of the mean of the range-rate residuals obtained using GPS-based tropospheric calibrations can be ascribed to the choice of non updating VEX orbit solution but just performing a pass-through.

Although the rms improvement obtained using GPS-based tropospheric calibration is marginal and statistically not very significant, two important preliminary conclusions can be drawn: (1) the GPS-based S/W produces an estimated ZWD which is at least *consistent* with the one computed using standard, much simpler, methods; (2) the slight improvement shows that the GPS-based tropospheric calibrations obtained by the newly developed S/W might be more precise than those obtained using only standard meteorological data. In order to understand whether the lack of a major improvement can be ascribed to the presence of a significant plasma noise on Doppler data, the range-rate residuals where analyzed with statistical methods, searching for possible unambiguous traces of solar plasma noise.

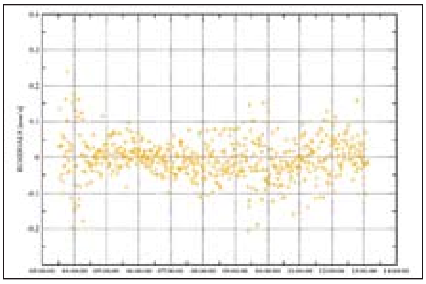

Figure 5 Doppler residuals obtained with a pass-through using the ZWD estimated by GPS measurements while the ZHD has been obtained via the standard ESA method

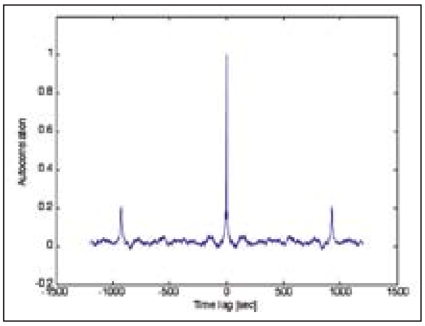

Figure 6 Normalized autocorrelation function of the VEX range-rate residuals, sampled at 1Hz

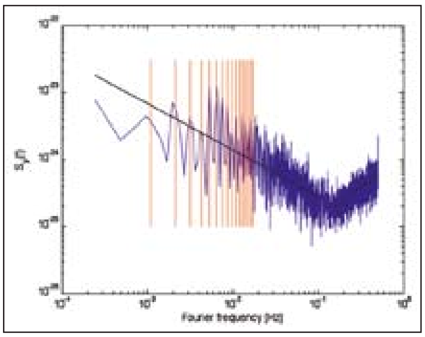

Figure 7 Power Spectral Density of the VEX range-rate residuals, sampled at 1Hz

Range-rate residuals autocorrelation and spectral analysis

In order to perform a statistical analysis on the range-rate residuals, a new pass-through on VEX Doppler data was performed at a sampling rate of 1Hz, which allows having more data and then a more statistically significant estimation of both the autocorrelation function and power spectral density. The normalized autocorrelation function of the range-rate residuals in shown in Figure 6.

In addition to the peak at zero time lag, a statistically significant peak shows up at exactly the average two-way-light-time (TWLT) during the pass, ~925 s. This means that the range rate residuals are dominated by noises concentrated at the Earth. On the other hand, the autocorrelation function is quite noisy all over the time-lags between zero and the TWLT, pointing to a diffuse noise source. This could easily be solar plasma which, at the Sun-Earth-Probe angle of 43 degrees of July 4th, 2009, impacted all along the RF beam.

To test this hypothesis, we computed the power spectrum of two-way range-rate residuals converted to Hz. The Power Spectral Density (PSD) is shown in Figure 7. There are clearly two "zones" in the PSD plot: the one between 10^{-4} Hz and 10^{-1} Hz where the power spectrum of the frequency residuals follows a power law with a spectral index, computed by a least square fit of the power spectrum and a straight line, equal to $p=-0.69$, thus very close to $p=-2/3$ (associated to a Kolmogorov spectrum of a fully developed turbulence, compatible with solar plasma noise). The superimposed solid line is the fitting function $f^{-0.69}$. In the second zone, between 10^{-1} Hz and 5×10^{-1} Hz, the spectral line is dominated by thermal noise in the receiver and random processes which are consistent with antenna mechanical noise The superimposed black dashed line, obtained, again, with a least square fit, is $f^{0.93}$. The red vertical lines represent multiple frequencies of the TWLT, explaining the periodic modulation of the spectrum due to residual noise at the Earth due to troposphere and antenna mechanical noise.

Conclusions

For both VEX range-rate data processing, the residuals were formed, by using, the current best orbit determination solution available. The mean value and the rms of the two sets of range-rate residuals were compared, searching for an improvement: a reduction of the rms value of the range-rate residuals.

The improvement was indeed present, although very marginal and not statistically significant. This may be caused, in addition to a poor tuning of the GPS-based tropospheric calibration S/W, by the presence of other noise sources in the range-rate data at hand, which might render ineffective the better Earth tropospheric calibrations. This has been shown to be the case, by performing a statistical analysis on the range-rate data and in particular by computing the normalized autocorrelation function and the power spectral density (PSD). VEX range-rate data acquired on July 4th, 2009 (a few days after VEX quadrature with the Sun and the Earth), seem to be quite affected by solar plasma noise which is clearly visible in the frequency range 10^{-4} Hz - 10^{-1}Hz of the residuals PSD, where the power spectrum follows a power law with a spectral index ≈−2/3, associated to a Kolmogorov spectrum of a fully developed turbulence, compatible with solar plasma noise. Another possibility which will be investigated in the future is to use tracking data from the ESA's Herschel and/or Planck S/C for tropospheric analysis purpose and the VEX mission during the inferior conjunction phase.

Aknowledgments

The authors wish to thank Pedro Alfaro and Carlos Garcia-Martinez of ESA-ESOC for the CEBR RINEX data provided for the test. The work of A. Graziani, R. Bertacin and P. Tortora was funded in part by the Italian Space Agency (ASI).

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On GPS/GNSS signals multipath modeling

The article discusses the apparent deficiency of traditional modeling in dynamical situations, and consequently the utilization of LoS-like path modeling for all relevant reflections is advocated

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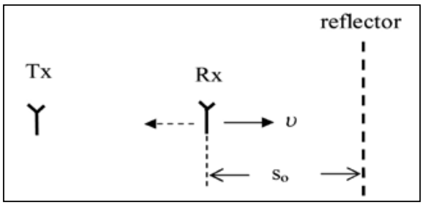

Fig 1 – Mobility scenario I – fixed reflector and transmitter.

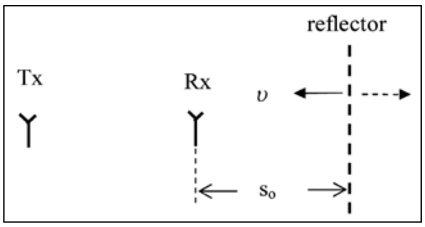

Fig 2–Mobility scenario II – fixed receiver and transmitter, and moving reflector.

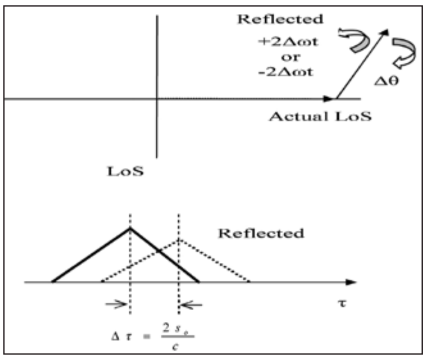

Fig 3a – A situation where LoS component is tracked.

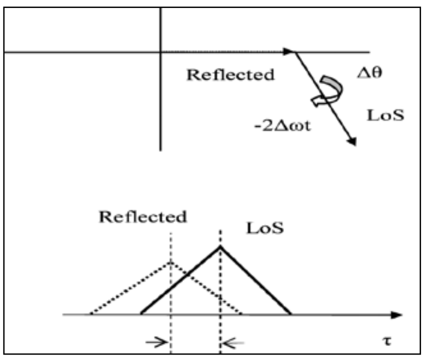

Fig 3b – A situation with reflected component tracked.

GPS ranging is based on the reception of the LoS component of the signals transmitted from the constellation of GPS satellite vehicles (SV), and on measuring the time elapsed in the propagation of appropriately time-marked signal signatures. Even in the absence of any reflected (multipath) signal components, the determination of physical separations between SVs and receiver is tied to a subtlety arising from the relative motion between the two –Doppler effect. The Doppler effect can be approximately represented by a shift of the transmitted signal spectrum toward higher or lower frequencies along with an increase or decrease in the modulation (code) signal bandwidth, respectively for the cases when transmitter and receiver are approaching or receding from each other.

By the process of demodulation routinely performed in GPS receivers, the motion-induced spectral shifting is essentially compensated for, and the (remaining uncompensated) correlation peak positions tracked by Delay-Lock Loop (DLL) can be directly related to physical distance(s). The latter is done by multiplying the pertaining time delay by the speed of light, c, apart from correcting for ionosphere & troposphere propagation effects, clock corrections, and along with accounting for the navigation solution related SVs ephemeredes, earth rotation, etc.

Without such Doppler correction/tracking, the measured propagation delay would differ from the actual physical separation (say, at the time of transmission) by the group delay accumulated during the pertaining signal (energy) transition time. This in turn suggests that at every time instant the total measured delay based on Doppler shift uncompensated signal correlation peaks, or on the ranging signal markers, equals the algebraic sum of the physical delay (always positive), and the group delay accumulated up to the time of reception, which can be positive or negative, depending on the sense of relative motion.

This can be described implicitly by the so-called 'code ranging formula'

$$R = R_0\left(1+\frac{\upsilon_r}{c}\right) = c\left(T_0+\frac{\upsilon_r}{c}T_0\right), \quad (1)$$

where R_0 is the physical delay at the moment of sending, υ_r- the relative speed, and T_0 the signal transition time; Explicitly, it may be expressed by the two delay terms summation as

$$\tau_{total}(t) = \tau_{physical}(t) + \tau(t), \quad (2)$$

with the group delay term defined by $\tau(t) = \frac{\upsilon_r}{c}t$, and taking negative υ_r values for lowering separation distances.

The presence of the time-varying group delay term of this form in (2), the so-called code Doppler, can be proven by first representing the carrier modulating base-band (code) signal $g(t)$ in the transmit signal $s(t) = g(t)\sin(\omega_c t)$ by its inverse Fourier transform components, shifting all the resulting frequency components by Doppler factor $1+\xi_0 (=1+\upsilon_r/c)$, and converting back to time-domain to get the received signal $s^0(t) = g(t-\tau(t))\sin(\omega_c^o t)$, with $\omega_c^o = \omega_c(1+\xi_0)$ being the Doppler shifted carrier (angular) frequency.

Based on this, the Doppler uncompensated LoS signal model has the form

$$s^0(t) = \alpha_0\begin{Bmatrix} g[(1+\xi_0(t))t-\gamma(t)-\Delta\tau_0(t)]\cdot \\ \exp\left(j[\omega_c+\omega_0^D(t)]t+\phi'+\beta\right)\end{Bmatrix}, \quad (3)$$

where α_0 is the level scaling (normalized $\alpha_0 = 1$,), the relative delay $\Delta\tau_0 = 0$, γ is the time-varying (physical) delay of the originally sent signal (LoS component), ω_0^D- the LoS carrier Doppler shift, and $\phi' = -(\omega_c + \omega_0^D)\gamma + \phi$ (with ϕ the initial phase of the originally transmitted signal). The term ξ_0 represents the LoS component Doppler shift to carrier frequency ratio, $\xi_0(t) = \omega_0^D/\omega_c$, or in terms of previously used relative speed, $\xi_0(t) = \upsilon_r(t)/c$.

In the Doppler compensated case, $s^0(t) = \alpha_0 \cdot g(t-\gamma(t)) . \exp(j\Delta\theta_0)$ with $\Delta\theta_o$ a phase shift.

Even with the LoS component undisturbed by multipath reflections, a 'poor' GPS receiver design can ensue, either because the pertinent signal propagation model is not correctly interpreted (this applies to the SV constellation signals modeling as well), or because the code tracking loop is too 'heavy-driven' by the carrier tracking loop control signal.

As the traditional multipath modeling having been in use since the very GPS inception totally ignores the LoS relative multipath code Doppler resulting from the multipath components themselves having carrier Doppler shifts differing from the LoS one, the question is what all could be the repercussions in situations involving receiver and/or reflectors mobility?! The chance that the vehicle moving in an urban-canyon area gets directed and even ends-up 'into a ditch', or that the aircraft shows unable to autonomously perform the Category II/III landing may be substantially increased, if one strictly follows the 'conventional wisdom', or de-facto 'GPS Dogma' that the first detectable correlation peak has to be the LoS one, or that all measured multipath delays have to be positive 'by definition'.

Multipath modeling – static versus dynamic

Actually, in GPS/GNSS there is no such thing as an entirely static scenario. Even in the static receiver case (non-moving vehicle), in the ubiquitous presence of nearby reflectors, there is a slight (mostly sub-Hz) difference between the Doppler shifts on LoS and the reflected multipath components due to SVs motion and resulting time varying reflection angles. Still, for almost all practical purposes, except perhaps for the sub-cm accuracies, this can be considered as a static case. With low and moderate vehicle speeds of some tens of mi/h, depending on the time duration of reflection presence or its existence before the receiver is exposed to it, the generally un-modeled code Doppler effects can be of great importance. This is the more so since the resulting (LoS-relative) multipath carrier Doppler shifts (up to a few 100Hz) may remain insufficiently attenuated by coherent correlations, which due to practical implementation constraints may not be much longer than 20ms.

Traditionally, even for dynamical situations, the multipath is modeled through just the modification of the signal's complex envelope in the (LoS Doppler corrected) form

$$s_r(t) = \sum_{m=0}^{M} \alpha_m \cdot g[t-\gamma(y)-\Delta\tau_m(t)] \cdot \exp(j\Delta\theta_m) \text{ , (4)}$$

where α_m is the multipath component scaling ($\alpha_0 = 1$), $\Delta\tau_m$ is the (time varying) physical delay of the *m*-th component with respect to the LoS ($\Delta\tau_0 = 0$), and $\Delta\theta_m$ is the phase shift term induced by the reflector and the combined effect of delay and carrier frequency. Consequently, only physical delays and mostly, with some exceptions, even same carrier frequencies (Dopplers) for the LoS and the reflected paths are assumed.

If, for example, the LoS component is fully attenuated, and there exists only one reflected component with the level sufficient to allow for signal acquisition and subsequent tracking, the signal would be 'regularly' demodulated by the reflected signal Doppler frequency, and consequently the measured code delay would correspond to the total (presumable LoS, plus relative reflection) physical delay. Apart from the wrong delay and Doppler measurements, there would essentially be no added delay from the code delay accumulation.

However, if the LoS is present with its nominal level, and the receiver keeps acquiring and tracking it, the remaining Doppler on the reflected components stays uncompensated, and the corresponding multipath correlation peaks exhibit additional group delay terms in addition to their relative physical delay terms, $\Delta\tau_m$, or the $\tau_{physical}$ term, as per (2) & (3).

Consequently, the multipath modeling in environments with a moving receiver and/or reflectors takes the form

$$s_r(t) = \sum_{m=0}^{M} \alpha_m \begin{Bmatrix} g\left[\left(1+\xi_m(t)\right)t-\gamma(t)-\Delta\tau_m(t)\right] \\ \exp\left(j\left[\omega_c+\omega_m^D(t)\right]t+\phi^{'}+\beta\right) \end{Bmatrix} \text{, (5)}$$

In addition to previously introduced variables in the above expression, ω_m^D is Doppler shift on the m-th signal component, $\phi' = -(\omega_c + \omega_0^D)\gamma + \phi$ (with ϕ the initial phase of the originally transmitted signal), and the term ξ_m represents the *m*-th component Doppler shift to carrier frequency ratio, $\xi_{m(t)} = \omega_m^D(t)/\omega_c$ Together with the *m*-th reflector LoS relative physical delay term $\Delta\tau_m$, the latter defines the total delay of the *m*-th received signal component as $\Delta\tau_m^{total}(t)\,\Delta\tau_m(t) - \xi_m(t).t$

This analysis suggests that the code-phase terms should be explicitly modeled in software and hardware simulators for each separate path (or delay-line tap) in accordance with the corresponding Doppler shift. The parameters' dynamics should be inferred from measurements carefully conducted to capture this effect in a number of typical scenarios.

Evaluation in simple two-path scenarios

For the sake of illustration, we evaluate the underlying Doppler to code-phase conversion using the total measured delay of the reflected component with respect to the LoS, a part of which is the group delay in equation 2. The simplified scenarios are shown in Fig. 1 and Fig. 2, with s_o the separation at $t = 0$. To relate these to the model in (3), here m=1, and transmitter is assumed to be fixed.

The received signal consists of a sum of LoS and the reflected component

$$r(t) = g(t)\sin(\omega_0 t) + g(t-\tau_{total}(t))\sin f(\omega_0^{'} t + \varphi$$

(6)

with $\omega_0 = \omega_c(1 - \frac{\upsilon}{c})$, $\omega'_0 = \omega_c(1 + \frac{\upsilon}{c})$, where $f = \omega c / 2\pi$ is nominal carrier frequency, and the total code phase shift is given by the sum of physical and group delays

$$\tau_{total}(t) = \tau_{physical}(t) + \tau(t), \quad (7)$$

with $$\tau_{physical}(t) = \frac{2s_0}{c}\left(1 \pm \frac{t}{T}\right), \quad (8)$$

and $\tau(t) = \frac{2\upsilon}{c} t$. (9)

φ in (6) is the relative phase shift, w.r.t. the presumably tracked LoS carrier component (ω_0 here), induced by the time delay component, and is irrelevant for code delay considerations.

At $t = 0$, when the receiver 'starts' moving towards reflector, the physical delay is $\tau_{physical}(0) = \frac{2s_0}{c} = \tau_0$, s_0 initial separation, and the group (code) delay is equal to zero.

On the other end, after $t = T = s_0 / \upsilon$, when the receiver reaches the reflector, the total (measured) code delay is given by

$$\tau_{total}(t) = \frac{2s_o}{c}(1 - \frac{T}{T}) - \frac{2s_o}{c} = -\tau_G, \quad (10)$$

and in the case of the receiver moving away from the reflector, it is given by

$$\tau_{total}(t) = \frac{2s_o}{c}(1 + \frac{T}{T}) + \frac{2s_o}{c} = 3\tau_G. \quad (11)$$

This suggests that the LoS 'barrier' gets 'broken-through', and consequently the reflected component comes ahead of the LoS one. In this simplified scenario the advancing of the reflected code correlation peak over the LoS one starts after the initial physical separation is halved, at t = $T / 2$, when the LoS and the reflected peak positions coincide. Essentially, this effect takes place at all relative vehicle speeds, so that it is in fact the product of relative Doppler shifts and the duration of the receiver exposure to the reflected, ie the 'deformed' field, that determines the actual departure of measured code phase with respect to the LoS component's code phase. Of course, this is by no means in violation of the currently valid physical principles – we are not talking here about the electromagnetic energy propagation, but rather its group propagation, and it is a well known fact of physics that the light group speed of propagation can be measured as either higher or lower, and even negative w.r.t the speed of light propagation constant c, depending on the dispersivity features of the transmission medium.

To provide some quantitative indications for the possibility that the reflected path correlation peak position itself can 'break-through' the LoS 'barrier', the following examples are given: For a medium dynamical situation take υ = 50km/h, S0 =15m, τ_0 = 0.1/us, and T=1.08s; these values produce 0.1/us of maximal code advance, i.e 0.4/us of maximal total code delay, respectively in cases when the receiver is moving toward reflector, and away from it. In the case of only a 10ms long coherent integration, the resulting constant Doppler shift (w.r.t. LoS) of 146 Hz results in only up to 13.3 dB of the sin(x)/x attenuation. For a low mobility scenario - υ = 6.5km/h, s_0=75m, τ_0 = 0.5/us, and T=40s produce the respective maximal code advances and retardations of 0.5/us 1.5/us, the related correlation peaks remaining essentially un-attenuated (1dB at 13.5Hz) even with the coherent integration interval time as long as 50ms.

In these scenarios the maximal negative delay happens at the instant when the vehicle 'hits' the reflector; while for an experimental set-up this could still be feasible, in a practical situation the reflector can actually be 'nearby-passed', or 'nearby-passing. Typical real-life situations of this kind would be reflections from vehicles moving in the opposite direction, and aircraft landing, for example.

Relative Doppler and code phase relationships between the LoS and the reflected signal components can similarly be evaluated in the case of a fixed receiver position and a moving reflector. Although the relative speed between LoS and reflected path is the same, a very important distinction here is that the accumulated code phase difference may be fully independent of the duration of the receiver's exposure to the reflected signal field, but may rather depend on the time interval over which at a particular location the (compressed or dilated) reflected electromagnetic field had been 'taking place', no matter how short the receiver exposure to the reflected signal electromagnetic field might be, provided it is long enough to reliably measure the pertinent code phase.

The corresponding scenario is shown in the figure 2.

The received signal again consists of a sum of LoS and reflected components in (6), with $\omega_o = \omega_c$, $\omega'_o = \omega_c(1 + \frac{2\upsilon}{c})$.

Repercussions on receiver operations

Following the acquisition of the LoS component in the figure 1 example, the tracking process can be described by the phasor diagram of Fig. 3a, with the reflected path's phasor moving by ($\pm 2\Delta\omega t$ ($\Delta\omega$ is the LoS relative Doppler shift) around the (ideally) zero-phase (in PLL case) actual LoS component. Half way to the reflector, the reflected component may take control over both tracking loops. When the reflector is reached by the receiver, the tracking situation is described by Fig. 3b – with LoS now rotating over the reflected signal's phasor.

In various situations involving accelerations and highly time-varying ratios of the LoS and reflected components' levels, the dynamics and stability of tracking loops may be affected in many diverse ways. The use of an enhanced multipath model of the kind proposed here is important for the acquisition and tracking strategies and designing effective multipath mitigation algorithms for operations in urban-canyon environments, pedestrian and jogging applications, avionics, guided weaponry, miniature autonomous systems, and other dynamical environments.

In summary

This article presented some considerations regarding a due extension and enhancement of the traditional modeling of multipath in Urban-Canyons and other dynamical environments containing Doppler shifts on reflected signal components that are generally different from the LoS Doppler. An extended model has been derived and some simple illustrative scenarios have been evaluated. The impact of the code group delays on GPS/GNSS receiver tracking loops has been discussed in qualitative terms.

An adaptation of the paper presented at the International Symposium on GPS/GNSS, November 11-14, 2008, Tokyo; and also can be found in the Proceedings of the IEEE Aerospace Conference, March 7-14, 2009, Big Sky, Montana, U.S.A.


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Galileo update

Galileo Satellite Platform tests under way

The engineering model of the first Galileo satellites has completed platform integration tests at the Thales Alenia Space facility in Rome, reports ESA. The platform is now undergoing functional testing. Delivery of the engineering model payload from Astrium UK is expected this month. These tests are an important step towards building and launching the first four Galileo satellites. Integration testing verifies the interfaces between units or subsystems and the larger integrated system, ESA said. Functional testing demonstrates that the integrated elements meet their design specifications.

Four IOV Satellites planned

The Galileo In-Orbit Validation (IOV) phase will validate the system design using a reduced constellation of four satellites - the minimum required to provide exact positioning and timing at the test locations - along with a small number of ground stations. The proto-flight and three flight model satellites will also be integrated and tested at Thales Alenia Space in Rome. They will be carried into orbit in pairs by Soyuz ST-B / Fregat MT launchers from Europe's Spaceport in French Guiana. The first launch is scheduled for late 2010 and the second for early in 2011. *www.esa.int*

Galileo Application Days supported by ESA

The European Space Agency's Technology Transfer Programme Office (TPP) will be the official partner of the first Galileo Application Days which will be held from 3 to 5 March 2010 in Brussels. The event aims at promoting added value of the European GNSS programmes and fostering collaboration especially between SMEs and larger enterprises. The event's unique 'Application Village' will showcase innovations in an outdoor theatre consisting of different settings, such as the countryside, the city, the harbour or the playground. The Application Village will be the venue for a wide range of cutting-edge GNSS application and services demonstrations throughout the three days of the event.*Source: European Space Agency*

Spain demonstrates the success of Galileo Applications in emergency situations

GMV has taken an active part in Spain's demonstration of the European MAGES project (Mature Applications of Galileo for Emergency Services). MAGES is a European Commission FP7 project driven by a partnership of research institutes and companies from nine European countries with a wealth of experience between them in emergency management and GNSS technology. The aim of MAGES is to analyze the use of Galileo for emergency situations and response; its activities include a series of demonstrations in diverse emergency scenarios. GMV, with its proven track record in satellite navigation applications, fleet management and emergency response systems, is bringing this experience to bear on three fronts, firstly in the Galileo added-value study for emergency services, secondly the study of new applications that will be made possible by breakthroughs in European navigation systems and thirdly the definition of technology demonstration scenarios. *http://mages-project.eu*

CEOs peg 2010 growth rate at 11%

According to market Research firm Daratech, GIS/Geospatial industry CEOs interviewed, were unanimous in their belief that growth consistent with the robust 11% compound annual growth rate of the past six years would return in 2010. It stated that 2009 was a tough year in the private sector GIS/Geospatial market, which is forecast to close at $1.4 billion, down 0.7% from 2008. This downturn echoes the general pull back of the private sector from major additional investments in new IT technologies. *www.daratech.com*

Mumbai selects ArcGIS Server

Municipal Corporation of Greater Mumbai in India has selected ESRI ArcGIS Server technology as its citywide GIS enterprise management solution. It will integrate images, detailed maps, and property-level maps and link them to a wide range of enterprise data used for various city functions. *www.esri.com*

ESA States open Sentinel data policy

ESA Member States have approved the new principles for the Sentinel Data Policy. The Sentinels comprise five new missions being developed by ESA specifically for the operational needs of the Global Monitoring for Environment and Security programme (GMES). The new data policy ensures free-of-charge access to all Sentinel data as well as the products generated via the Internet to anyone interested in using them, mainly for GMES data use but also for scientific and commercial use. *www.esa.int*

Monitoring rhinos geospatially

The Assam forest department in India has decided to prepare the database of every rhino found in the state's national parks for a better understanding of the prized animal. GIS and GPS will be used to monitor the rhinos at the parks on a day-to-day basis. The database will include details like date of birth, body structure, behaviour and its area of movement, among others. *www.telegraphindia.com*

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LORAN-C signal termination

LORAN-C was originally developed to provide radionavigation service for US coastal waters and was later expanded to include complete coverage of the continental US as well as most of Alaska. It was approved as an en route supplemental air navigation system for both Instrument Flight Rule (IFR) and Visual Flight Rule (VFR) operations. The LORAN-C system served the 48 continental states, their coastal areas, and parts of Alaska.

The Homeland Security Appropriations Act for Fiscal Year 2010 allows for termination of the LORAN-C signal on January 4, 2010, after certification from the Commandant of the Coast Guard that it is not needed for navigation and from the Secretary of DHS that it is not needed as a backup for GPS. *www.navcen.uscg.gov*

Earthquake monitoring in Myanmar

Myanmar is setting up a GPS to monitor earthquakes. The project is being implemented in the four cities of Kyaikto, Wal, Bago and Taikgyi lying on the country's main live fault diagonally with the help of the Earth Observatory of Singapore. The Japan International Cooperation Agency has also been helping Myanmar establish an early earthquake warning system by setting up seismographic network and record center in the country. *Xinhua Net*

Brazil to have GPS landing system

Brazilian airline will be equipping all its aircraft with sensors to allow the use of the GPS Landing System and Vertical Situational Display. The system allows the plotting of curved segments in a single procedure, with increased accuracy and safety, enabling continuous ascent or descent. Vertical Situation Display enables pilots to accurately identify information on ground relief and obstacles from the cockpit, by providing an additional tool for monitoring the position of the aircraft in relation to the ground. *www.tradingmarkets.com*

Qantas expands GPS use in flights

Qantas is expanding its use of the latest generation GPS-based navigation systems to some Melbourne flights. Called as 'RNP' - Required Navigational Performance, it uses GPS to map very precise flight paths to and from airport runways, which in turn delivers savings on virtually all fronts, from fuel, emissions, distance, time and even quieter landings. *www.smh.com.au*

Russia to equip railways with antiterrorist attack detectors

A group of Russian scientists has developed detectors to prevent terrorist attacks on Russian railways. The detectors will use Glonass or GPS, and are designed for both military and civilian use. Both systems allow users to determine an object's position to within a few meters. *RIA Novosti*

GLONASS reaches 22 Satellites

Russian Space Command has taken control of the three newly launched GLONASS satellites. All satellites are in their correct orbits and operating properly. This launch brings the total number of satellites in orbit to 22. *www.glonass-ianc.rsa.ru*

Online access of maps free-of-charge

Norwegian Mapping Authority has recently released a new map service accessible for everyone. The Authority is responsible for providing nationwide geographic information and services to private and public users. *www.egovmonitor.com*

China launches 'Yaogan VII' satellite

China has launched the remote-sensing satellite, 'Yaogan VII' from the Jiuquan Satellite Launch Centre in northwestern Gansu Province. The satellite will be mainly used for scientific experiment, land resources survey, crop yield estimates and disaster prevention and reduction. *www.chinaview.cn*

New Leica mojoMINI 3D

Growers looking for an entry point into precision guidance now have the Leica mojoMINI 3D lightbar guidance system, which also comes with standard street navigation for daily use in any on-road vehicle. It comes with the Leica SmartAg antenna and GLIDE technology for in-field accuracy. *www.mojoRTK.com*

UKHO unveils E-Navigator

The United Kingdom Hydrographic Office (UKHO) has launched Admiralty e-Navigator, the new integrated digital catalogue, product viewer and passage planning tool. It organises, updates, and brings together all of the paper and digital information needed to plan safe voyages and simplify essential tasks. On the bridge or in the office, it will give access to a wealth of information, it will organise, maintain, and display all of that data, so bridge and office-based teams have instant access to all the navigational information they need, whenever they need it and wherever they are in the world. *www.ukho.gov.uk*

Geoscape helps marketers in Europe

Geoscape Europe has launched Geoscape® Intelligence System (GIS) for European markets. The product is an online platform to support strategic and tactical decision making for marketing, media, distribution and strategic planning. It is a new suite of geographical analysis modules providing an array of market intelligence functions in a simple-to-use web browser interface. *www.geoscape.eu*

Samsung and deCarta smartphone location apps

deCarta announced its partnership with Samsung Electronics to provide developers with location geoservices on the new bada smartphone platform. It enables developers to create applications for the next generation of mobile devices from Samsung. Through the partnership with deCarta, developers will be able to add maps, location-based search and routing instructions to any application designed for bada-enabled mobile phones. *www.samsung.com*

Hyper-Accurate Tracking Technologies

IContain and InSeT Systems have paired to bring accurate and time-sensitive location data to emergency response personnel. Its Inertial Tracking Unit and IContain's device-agnostic tracking software allow location data to be gathered and displayed from subterranean mines and other - previously impossible - locales.*www.i-contain.com*

Device to track people without sensors

The new motion tracking platform from Organic Motion, OpenSTAGE, does not require participants to wear any attached devices, tags or sensors. The tracking platform enables multiple people to step into a virtual world with no prep time and be instantly tracked. The technology enhances the operations of a wide range of simulated training environments and is effective in tracking multiple people at the same time, without special backgrounds or controlled environments. *www.organicmotion.com*

New GIS on Blackberry®

Freeance™ Mobile software enables BlackBerry smartphones to access ESRI ArcGIS® Server software, and with the release of new BlackBerry smartphones running BlackBerry OS 5.0, will have even more GIS productivity tools. *www.Freeance.com*

AccuTerra Version 3.1 for iPhone

Intermap Technologies latest version of its AccuTerra application is for the iPhone. The upgraded base application is currently free and includes the first detailed map download from the AccuTerra map store. *www.intermap.com*

Addition to LiDAR technology

The European Space Agency (ESA) and Midaz Lasers Ltd. will work together on a development program to use alexandrite lasers to replace Nd:YAG lasers as the dominant source for LiDAR applications. LiDAR is currently dominated by YAG lasers as the laser source of choice but they can suffer from low efficiency and applications are restricted by lack of wavelength tunability which severely limits the scientific data they can acquire. *www.laserfocusworld.com*

Malaysia to task TerraSAR-X directly

Infoterra and its Malaysian partner IMS have now installed a TerraSAR-X Virtual Ground Station at the Malaysian Remote Sensing Agency (MRSA) in Kuala Lumpur: following the delivery and installation of all necessary technical equipment as well as thorough training on the planning and ordering tool. *www.infoterra-global.com*

GeoEye-1 ops in Saudi Arabia

GeoEye announced it's Regional Affiliate, King Abdulaziz City for Science and Technology (KACST) began directly downlinking high-resolution satellite imagery from the GeoEye-1 Earth-imaging satellite. It has the exclusive right to sell GeoEye-1 imagery in Saudi Arabia. *www.geoeye.com*

New set of Landsat imagery available

A new collection of selected Landsat earth images worldwide, Global Land Survey 2005 (GLS2005), is now available for free download to any user around the globe. Under a long-term partnership, the US Geological Survey and NASA periodically selected and processed thousands of the best-available Landsat satellite images, or "scenes," into a Global Land Survey, recording baseline conditions across the Earth's land surface. *www.usgs.gov*

'NSDI in India – through the years' book launched

The National Spatial Data Infrastructure (NSDI) initiative in India began in the year 2000. 'NSDI in India: Through the years' a comprehensive book charts the course of this decade long journey, which is still continuing.

For the first time in India, all events related to NSDI are now brought together in this story by the Coordinates team of Bal Krishna, Shubhra Kingdang, Sanjay Malaviya and Prof P Misra.

The book is organised as episodes, and the heading of each episode captures the mood prevailing in NSDI at a particular juncture. The book highlights the significance of individual events by short commentaries, notes and posers.

Being a one-stop reference for NSDI in India, the book was formally launched by Shri Prithviraj Chavan, Hon'ble Minister for Science, Technology, Government of India during the inaugural ceremony of the 9th NSDI workshop held in Pune on 22nd Dec 2009. *www.mycoordinates.org*

Leica Geosystems' digitizer for LIDAR

Leica Geosystems announced the introduction of a full-waveform digitizer, WDM65, designed specifically for use with its ALS-series airborne LIDAR Systems. *www.leica-geosystems.com*

GPSDifferential™ module for MobileMapper™

The GPSDifferential module for the MobileMapper 6 from Magellan is a software option that has been integrated into the new version of DigiTerra Explorer 6 to provide sub-meter performance for DigiTerra Explorer users working with a MobileMapper 6 device. *http://promagellangps.com*

Trimble's updated Software suite

Trimble has updated its entire portfolio of Mapping & GIS field and office software products. A key addition is Trimble® DeltaPhase™ technology, a new technique for improving the accuracy of GNSS code measurements. *www.trimble.com*

StreetMapper in China

3D Laser Mapping has delivered the first laser based mobile mapping system to China. StreetMapper 360, has been specifically designed for the rapid 3D mapping of highways, runways, railways, infrastructure and buildings. *www.streetmapper.com*

Avenza® releases MAPublisher®

Avenza Systems Inc. announced the latest release of MAPublisher version 8.2 that supports the direct import of GIS data to Adobe Illustrator from ESRI geodatabases. *www.avenza.com*

UltraMap 2.0 Photogrammetric software

Vexcel Imaging GmbH will release 2.0 of its UltraMap photogrammetric software. It includes features for managing data download, distributed processing using load balancing and resource management, aerial triangulation, and interactive data visualization for quality control. *www.microsoft.com*

Navilock introduces GPS USB Stick

u-blox UBX-G5010 single-chip GPS receiver is at the heart of Navilock's new USB GPS logger device designed for Windows XP and Vista. Navilock's NL-457DL EasyLogger gives plug-and-play GPS capability to Google Maps and Google Earth for PC users. *www.u-blox.com*

ERDAS releases IMAGINE, ER Mapper 2010 and LPS 2010

ERDAS released ERDAS IMAGINE® and ERDAS ER Mapper 2010 which also includes IMAGINE Feature Interoperability, a new module, and IMAGINE SAR Interferometry, a new collection of products in the IMAGINE Radar Mapping Suite.

LPS 2010 now includes ERDAS MosaicPro. This release also provides improved sensor support and increased performance. *www.erdas.com*

Cambridge cos win INSPIRE contract

RSW Geomatics has been awarded a contract by the European Commission's Joint Research Centre, Institute for Environment and Sustainability. This contract is to 'Develop Technical Guidance for the INSPIRE Transformation Service' – enabling on line access to geographically referenced datasets from different countries and different environmental themes. *www.rswgeomatics.com*

SSTL delivers GPS receivers

Surrey Satellite Technology Limited (SSTL) has delivered 18 SGR-10 GPS receivers to Sierra Nevada Corporation (SNC) of the USA to provide on-board orbit determination for the ORBCOMM Generation 2 (OG2) satellites. SSTL's SGR-10 is a spacecraft orbit determination sub-system designed for small and large Low Earth Orbit satellite applications. *www.sstl.co.uk*

PBBI joins Software Alliance

Pitney Bowes Business Insight (PBBI) has joined the Business Software Alliance in India. The Alliance is one of the largest groups of (mainly) US companies dedicated to promoting the protection of IP in Asia by attempting to ensure that government agencies and private organisations buy licences to the software they use. *www.bsa.org*

New CAD Software for surveying

Topcon Positioning Systems (TPS) has released SurveyMaster Lite - a new CAD-based desktop application for surveying and job site information editing and plotting. Survey calculations can be completed and uploaded to the field collector for stakeout and field verification. *www.topconpositioning.com*

LiDAR Data Management Software

The GeoSpatial Solutions division of Merrick & Company announced the online availability of the new version 6.0 Merrick Advanced Remote Sensing (MARS®) software suite. The software suite is a Windows® application designed to manage, visualize, process, and analyze LiDAR data. *www.merrick.com*

Optech to Include DiMAC Camera

Optech Inc has expanded support of the DiMAC Ultralight+ 60 megapixel medium-format digital mapping camera. It now supports the widest range of medium-format cameras of any lidar sensor manufacturer. Available for the entire suite of Optech ALTM™, the new DiMAC cameras will be fully supported by Optech Services, the 24/7 software and hardware support team.

Bentley PowerDraft for Mapping

Bentley PowerDraft for Mapping provides precise geospatial data creation, maintenance and analysis. Users can integrate data from a wide variety of geospatial data sources into engineering and mapping workflows. Multiple data types with varying coordinate systems are also transformed 'on-the-fly'. It is a standalone application and does not require MicroStation as a prerequisite. *www.bentley.com*

GMV supports 13 satellites launched

Thirteen satellites using GMV technology have launched in 2009, including LRO, Herschel-Plank, NSS-12 and Thor 6. Four other satellites currently in orbit will add GMV's monitoring and control systems to their operation. Finally, two additional launches incorporating GMV technology are scheduled before the end of the year. The latest satellite brought under complete control of GMV systems is the NSS-12 of SES World Skies (part of SES group), which launched in October of last year. The satellite features 40 C-band transponders and 48 Ku-band transponders as well as elaborate beam interconnectivity and C-/Ku-band cross-strapping.

Thin Multi-Positional GPS Antennas

Pulse announced the W4000 series of GPS active antennas. The thin, oval-shaped antenna can be positioned on the dashboard or window without concerns about orientation. Designed for in-vehicle mounting, Pulse GPS antennas combine a Pulse ceramic chip antenna with a low noise amplifier (LNA) resulting in an antenna profile that's more than 50% thinner than standard GPS antennas while still maintaining an excellent level of performance. *www.pulseeng.com*

SuperGeo supports research

SuperGeo Technologies supported a GIS workshop in historical research and cultural study in Taiwan. It offered numerous sets of SuperGIS software and CCTS Analyst to support the workshop. *www.supergeotek.com*

Tele Atlas and GPS Tuner agreement

Tele Atlas and GPS Tuner announced an agreement under which Tele Atlas supplies digital maps on GPS Tuner's off-road navigation software - GPS Tuner Atlas. The software uses satellite imagery from DigitalGlobe.

GLONASS/GPS Satellite Terminal

SkyWave Mobile Communications launched GLONASS navigation capability in its DMR-800L satellite data communication terminal. The DMR-800L with integrated GLONASS provides the capability to compute its exact location using either or both the GLONASS and GPS systems. *www.SkyWave.com*

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9-11 March
Munich, Germany
www.munich-satellite-navigation-summit.org

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

Digital Preservation of Archaeological Heritage
10 - 12 March, 2010.
IIT Kanpur, Kanpur, India
arch3d@iitk.ac.in
www.iitk.ac.in/arch3d

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

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
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