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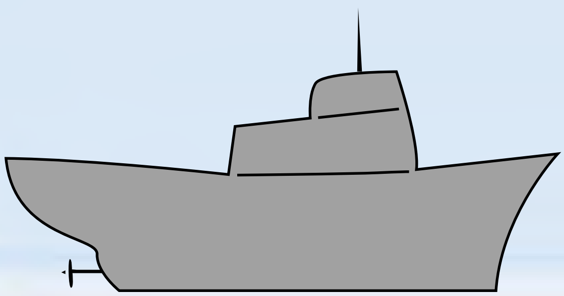
POSITIONING, NAVIGATION AND BEYOND

SEA SURVEYING

Dealing with disasters
... not by technology alone

Not by technology alone ARVIND SIVARAMAKRISHNAN **7** GPS surveyed time-invariant sea floor depths for safe navigation MUNEENDRA KUMAR AND GEORGE A MAUL **12** Reconfigurable software GNSS receiver in multipath environment FABIO DOVIS, MASSIMILIANO SPELAT, PAOLO MULASSANO, MARCO PINI **24** Indoor positioning in wireless LAN JAYWON CHEY, JANG GYU LEE, GYU-IN JEE **30** JAMFEST, A cost effective solution to GPS vulnerability testing LT COL ERIC LAGIER, CAPT DESIREE CRAIG, PAUL BENSHOOF **34**



A GIT publication

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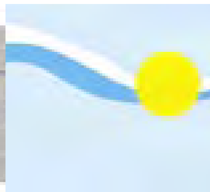


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The casualty

October 8, 2005.

The earth quaked again. This time more than 70,000 died.

Not a small number but still not enough to nudge our consciousness.

Strangely nothing happened.

But did anything really happen after Bhuj, Bam or Sumatra…?

Ironically, in this case the focus was on 'relief politics' instead of reaching out to victims. Relief is yet to reach many. Even after a month.

Such events are not merely a reminder of recurring disasters but also raise questions on human apathy.

Recently, when a series of bomb blasts hit Delhi on the eve of a festival (Diwali) with more than 60 dead and many injured, Delhi went ahead and celebrated the festival in the name of fighting terrorism.

We are a busy species totally occupied in the pursuit of something great. And in this race, who has time?

It seems that the real casualty is nothing but the human consciousness itself.

And in such a scenario, technology has hardly any role to play.

Bal Krishna, Editor
bal@mycoordinates.org

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India needs a 21st century Indian Geodetic System

I had the pleasure of reading Mr Muneendra Kumar's article that described about publishing two series of maps by Survey of India (SoI). Some more developments are necessary in SoI to keep up with technological developments and the needs of the country.

SOI was the first in the world to design the Everest Spheroid. It met the requirement of that period as the region of interest was limited. Now the country has capability for launching satellites, it uses GPS systems, has long range missile capability etc. Hence it is appropriate that the country switches over to International Spheroid/ ellipsoid. A considerable effort will be required to be put in before the switch over to the new proposed spheroid. It will take considerable time as well. Hence all the more essential that it is taken up without further delay.

VS Dave
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We ex-SOI geodesy and mapping professionals strongly believe that the time is here that India defines and establishes a new 21st century Indian Geodetic System (IGS) to replace 19th century Indian Datum. Modernization of IGS will eliminate the current huge handicap and position India's vast Geospatial Information Technology community at the competitive advantage in delivering and using reliable high quality geomatics and mapping services far more cost efficiently and rapidly than is now possible. The new IGS should have been established years before to enable scientific, professional, and user community to take full advantage of all new and current technological developments and position Indian community among the leaders in the field. Establishment of a new IGS should no longer be delayed.

Y P Singh
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Everest: The mounting dilemma

I have been browsing some of the pages of the new journal Coordinates issue no. 4. The only piece that I have printed off is that about the Height of Mount Everest. Could I just make a plea to the Editor - that to print white on black in the way it was done here makes it very difficult to read (as well as wasteful in black ink for those who print it off).

From time to time we see printed journals over here where the contents are superimposed on to a multi-colour photograph. Often part of the text is illegible because of the choice of colour for printing.

With reference to the Everest article, the question about snow/ice thickness at the surface is a never ending one. Is there no gadget available that can be placed on the surface of the snow/ice to determine the depth to rock surface by a form of sounding? Surely in this technological age that must be possible.

One other small point you might like to comment on is the use of "meter" instead of "metre". The unit of measurement was derived in France and from the beginning referred to as the "metre". So why accept the US corruption of "meter" which to us means "a box on the wall that records how much electricity has been used". When I wrote my elementary Geodesy book I had a running battle with the US publishers over the spelling. I used metre which they changed to meter without even asking me. I then changed them all to metre at proof stage only for them to be turned back (without my knowledge) to meter before publication.

Jim Smith
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I would like to give a summary of height of Mount Everest estimated at various times

1) 1846-52	Survey of India	29002 feet = 8839.9 meters
2) 1952-54	Survey of India	29028 feet = 8847.7 meters
3) 1975	Chinese National Bureau of Surveying and Mapping	8848.13 meters
4) 1992	EV-K2-CNR Committee of Italy and China's NBSM	8846.10 meters
5) 1998-99	NGS	8850 meters

It is seen from the above that 1952-54, 1975, 1992, and 1998-99 heights are in very close agreement. Technique, quality and accuracy of measurements are widely different, yet results are very close. Hence it has to be investigated if in modern determinations there was any bias to bring them quite close to 1952-54,value.

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Not by technology alone

Natural disasters happen all over the world, but the extent of damage and loss of life has far more to do with the preparedness and responsiveness of the relevant human systems, not only where the disaster happens but also often half-way across the world

ARVIND SIVARAMAKRISHNAN

The damage caused by Hurricane Katrina to the southern United States has exploded the myth that natural disasters happen only to poor countries. Yet there is a grain of truth in the myth. Natural disasters happen all over the world, but the extent of damage and loss of life has far more to do with the preparedness and responsiveness of the relevant human systems, not only where the disaster happens but also often half-way across the world.

This does not have to be a matter of great technological sophistication. The astonishing loss of only two lives in the Californian earthquake of 1989 was correctly attributed to the inclusion of all the right design features in roads, bridges, buildings, and so on. That might have been expected in an industrial country, but far less attention has been given to the fact that similar features were included in the requirements for buildings in, for example, the Indian city of Hyderabad, where the earthquake of September 1993 caused no damage. Yet the earthquake killed about 10,000 in the rural district of Latur, where poor peoples' homes were built without foundations, and presumably also without the prior approval of designs by the relevant officials of the Maharashtra state government. After the disaster, substantial proportions of relief money allocated by the Government of India and the World Bank flowed into the wrong pockets, and those worst affected by the disaster got the least help, though in some villages active women's NGOs helped women train in masonry so that they could help in and supervise the reconstruction.

In many cases too, the use of relatively everyday technology is more than enough to save lives. A man in Singapore saw television news of the tsunami in December 2004, used his mobile phone to call his village on the Tamil Nadu coast, and saved thousands of lives, as the villagers warned neighbouring villages too. Similarly, Hurricane Wilma in October 2005 has caused nothing like the devastation wrought by its predecessor Katrina, for the simple reason that early warnings have been issued and public services have been properly prepared in advance.

Cuba better prepared than the US

Some states take certain types of preparation very seriously. In Cuba, the national leaders went on television and took charge before Hurricane Ivan, as powerful as Katrina, struck in September 2004. People had been told where their designated shelters were, and were evacuated together with their neighbourhood doctors, who knew the people they were accompanying and treating; all evacuees were allowed to take personal possessions with them so as to minimize looting of empty homes. They were even allowed to take animals, as veterinarians were also evacuated to the shelters. One and a half million people were evacuated. There was no curfew, no looting, and no violence. The hurricane, with winds of 160 miles an hour, destroyed 20,000 houses - but nobody died. Cuba has been cited as a model of hurricane preparedness by the United Nations International Secretariat for Disaster Reduction.

The important thing about Cuba is the recognition by state and society that the predicaments are shared by all. The contrast with what happened over Hurricane Katrina could not be greater. Scientists who had modelled a hurricane of Katrina's strength had told the US Federal Emergency Management Agency (FEMA) that 300,000 would be unlikely to leave New Orleans; in the event, the scientists knew the strength of Katrina in advance and told FEMA of it, but it turned out that 127,000 residents of New Orleans had no cars and that there was no transport to evacuate them. Despite the US federal government's declaration of an emergency, which gave FEMA the power to commandeer anything, nothing was done beyond a restatement of commitments to help. Even then, one FEMA official told a scientist at Louisiana State University's Hurricane Tracking Centre that evacuation was not considered because 'Americans don't live in tents.' FEMA put supplies for 15,000 into the refuge of last resort, the city's Superdome sports stadium, but 26,000 arrived there. As to the national leaders, President Bush carried on playing golf in the middle of his summer vacation. He made no TV announcement for three days, and did not visit the scene until five days after the hurricane had stuck. Even then, he started by flying over the area in his official jet, and then when he eventually made a personal visit he kept well away from the worst-hit areas; a New York Times leader said the President showed no understanding of the depth of the crisis. Not for President Bush the ordinary compassion shown by Senator Edward Kennedy, who in 1971 tramped knee-deep in mud through the refugee camps on the

Indian side of the Indo-Bangladesh border. And among the President's senior officials, Vice-President Dick Cheney remained on holiday in Wyoming for several days, and Secretary of State Condoleezza Rice went shopping in Manhattan for shoes at seven thousand dollars a pair.

Among the FEMA professionals, several found themselves bewildered by and very angry with their director Michael Brown, who – unlike previous FEMA directors – had no experience of disaster management and was an ideologically-motivated appointment made by President Bush. FEMA staff got water trucks ready on the Texas-Louisiana border, but were then ordered by Brown to hold them there. The trucks were not released for three more days. Brown's reason, that the aid could not be provided until the state government had asked the federal government for help, was a fiction; the state government had made the request four days earlier.

As to official agencies based in New Orleans, they were not trained for disaster relief. The police concentrated on law and order first and human needs later; when the US army arrived they, under the command of Lt Gen Russel Honoré, made sure people were attended to first. They also restored communications and water and power supplies, which the police simply may not have been equipped to do. It also caused great anger among tens of millions of Americans that some 10,000 of the Louisiana State Guard were in Iraq, helping to conduct a war which both violates international law and is now being questioned deeply across the United States.

New Orleans before and after Hurricane Katrina [credit: Space Imaging]

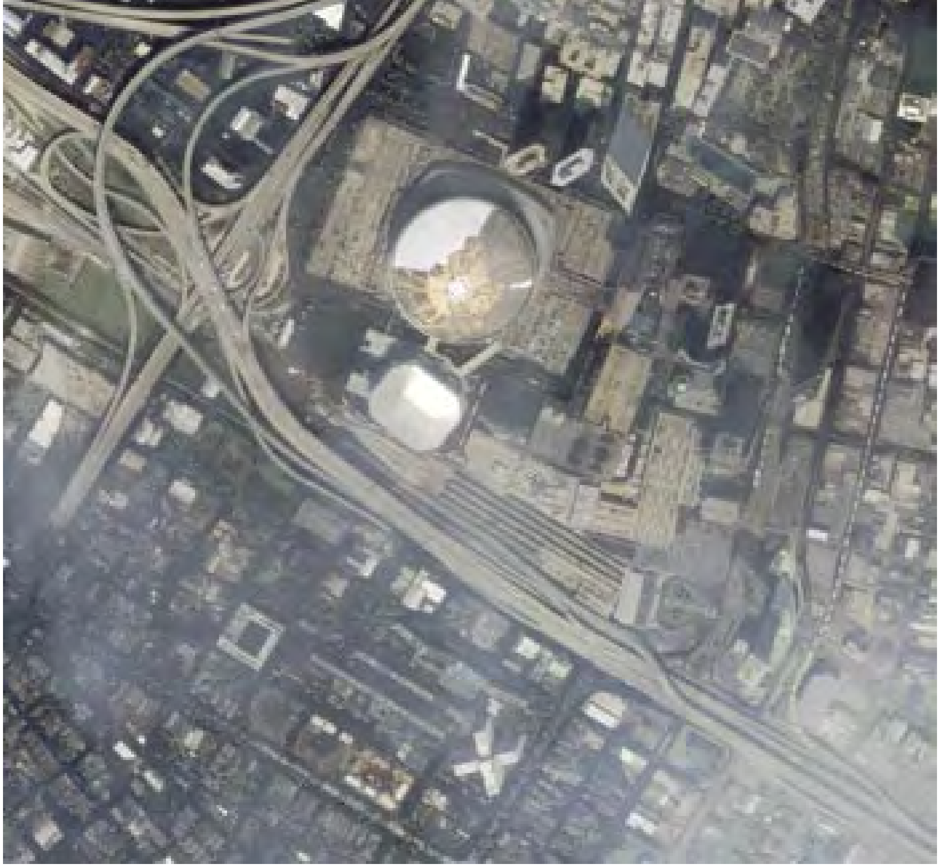
Turning crisis into catastrophe

If the US government's handling of the matter showed, as one scientist has said, 'complete ineptitude', the crisis was turned into catastrophe by the collapse of the levées or dykes which protect New Orleans from the waters of Lake Pontchartrain. These had indeed been reinforced in 1965 after Hurricane Betsy, but had been designed for a Category 3 hurricane, not one of Category 5 like Katrina. As it happened the fourteen-and-a-half foot high levées kept the waves out, but the concrete blocks comprising the dykes had been butt-jointed, not interlocked, and were held together only by mortar, which failed under the pressure of the storm. Maintenance money amounting to some $70 million had been cut from the budget of the responsible body, the US Army Corps of Engineers. That kind of money is small change to a country which has already spent $170 billion on the invasion and occupation of Iraq. Even the President's grandiose announcement of $200 billion in post-Katrina relief has infuriated his own supporters in the US Congress, many of whom have been elected on promises of huge tax cuts. There are reservations too, about who will benefit from the federal largesse, as several big construction companies are lining up for the rebuilding contracts.

Incompetence, avarice, and collusion

The companies concerned will, presumably, add to the existing construction on the wetlands around New Orleans – which provide vital protection against flooding and tidal surges but whose protective effect has been substantially reduced by drainage for construction; further, the federal government has tied all environmental funding to the promotion of interstate commerce. (A similar problem has occurred in southern England, where in some areas planning regulations were abolished in pursuit of the free-market ideology, despite municipal engineers' warnings. Building contractors made huge profits on the deregulated floodplains, and the new residents were inevitably the victims of severe winter flooding. Now the owners of the houses cannot get insurance for their properties and cannot find buyers when they seek to sell.)

This kind of wretched tale of incompetence, avarice, and collusion between big money, politicians, and – possibly – sections of the mass media is only too familiar. After the tsunami of December 2004, the US Geological Survey staff and the US military were cited as saying they did not know whom to contact, and no



official spokespeople seem to have been challenged over the failure even to telephone international media organisations or the Washington embassies of the states affected. The US National Oceanic and Atmospheric Administration (NOAA) did, however, contact the US military base in the British colony of Diego Garcia to notify them of an approaching deadly wave. In fact Diego Garcia is on the western edge of the Chagos Trench, which is more than 15,000 feet deep and absorbed much of the tsunami's energy; the coral reef to the east of the island may also have helped break up the tsunami, and the service personnel on the island reported only a minor increase in wave activity.

As to post-tsunami responses, letters from private citizens to the UK press castigated the Diego Garcia base for making no attempt to warn the states of the Indian Ocean littoral about the approaching danger. It also emerged in public that an NOAA official emailed Indonesian officials but made no further attempt at contact. One commentator said it was 'beyond belief that the officials at the NOAA could not find any method to directly and immediately contact civilian authorities in the area'. The NOAA's slogan is 'Working together to save lives.'

US-South Asia parallels

It would seem then, that irrespective of the existence and availability of technology and techniques, the crucial factors have to do with the preparedness and willingness of people and institutions both to maintain physical and systemic infrastructure at all times and to act quickly when disaster does strike. Those features have been manifestly lacking, but – even worse – are still lacking. While ordinary people's post-tsunami donations have been channelled into relief efforts by international NGOs, much of the hundreds of millions promised by states has simply not been paid. The recent and terrible earthquake in South Asia is yet another example of the fact that the powerful simply do not want to learn or act unless they themselves suffer political damage. It has taken India and Pakistan weeks to agree to open the Line of Control for relief efforts, and as to transport, the United States, which documentedly has fleets of helicopters lying idle in Iraq, has offered a bare handful from its matériel in Afghanistan. The Government of India was among those states which refused funding for undersea seismic recording systems which would have foretold the tsunami-causing earthquake of December 2004. In effect, India, the so-called emerging superpower, apparently has no disaster-management policy.

The parallels between the South Asian and the American responses to the recent disasters are striking. As always it is the poor who are hit hardest. They are the most exposed, have the least chance of escape, and usually get the least help afterwards. Neither are officials in South Asia any less culpable than those in the United States. In South Asia, official attitudes are familiar enough, but in the United States some very old truths have resurfaced. The overwhelming bulk of Katrina's victims are poor and black. For centuries, African-Americans have had next to no voice in the politics of the United States, and it has even been said that, since the start of the Reagan presidency in 1980, significant Supreme Court rulings and federal tax cuts (such as the impending abolition of death duties on estates) have been intended to harm them and to favour the rich, who are overwhelmingly white. Even African-Americans' access to the most formal elements of the political system has been severely restricted. Byzantine voter-registration procedures, many of which in the southern states were designed to make it as hard as possible for black voters to register, mean that African-Americans are hugely underrepresented on the states' electoral rolls. They are people whom, it seems, America does not want to think about. They are the single poorest group in the US, large proportions of them are not on the voting lists, and even if they are and even if they vote, they certainly do not vote Republican. Indeed it is not even clear if President Bush and his Republican cohorts regard them as Americans at all.

Accountability and the price of neglect

It is, further, worth noting that while we can criticize states for their failures over natural and other disasters, the private sector – which so dominates the rhetoric of contemporary political economy and is so quick to exploit technology in the service of profit – is deafeningly silent after every disaster. Moreover, it has been noted in other contexts that criminal law cannot cope with culpability on a very large scale. The nature of its concepts of individual intention and possibly also of causation, even in questions of gross negligence such as those which arise in our responses to natural disasters, render it at best an awkward instrument with which to enforce accountability in respect of large-scale failures in the public or private sectors. Yet the fact remains that states, being publicly-constituted entities, at least have to answer in some way, even if their answers are often grossly inadequate.

We might feel powerless to alter the conduct of states, but unless we attempt serious engagement with institutions and processes of state we too shall be complicit in the failures of maintenance, supervision, and organization which so often precede catastrophic disaster and exacerbate its effects so greatly. This will mean recognizing that systems and organization are as important as technological developments, and it will mean recognizing something that goes totally against the managerial rhetoric and public-relations babble that constitute the contemporary Zeitgeist. Serious maintenance and preparedness are unglamorous, expensive, and often unseen; they have to be carried out by people who know their work and have to be paid properly to do it, and they have to be carried out because we all share the risks of failure. The price of neglecting maintenance and preparedness, however, is colossally, unimaginably, worse.

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This article is based on a wide range of sources, including the author's articles in The Hindu on 13 January 2005 and 7 September 2005 respectively. We are most grateful to The Hindu for permission to use material from those two articles.

GPS surveyed time-invariant sea floor depths for safe navigation

This article describes the surveying mode to establish time-invariant ellipsoidal depths or heights of the sea floor in the open ocean

MUNEENDRA KUMAR, PHD AND GEORGE A MAUL, PHD

For safe sailing, two most important requirements are to be able to determine clearances between the sea floor and the keel of the ship, and between the mainmast and overhead structures, such as cables and bridges. For these clearances, the mariner has to know correctly and accurately the following:

1. Location of the sea floor or ocean depth,
2. Height of the overhead structure,
3. Locations of the ship's keel and mainmast.

For centuries and even in the present practice, the above four surveyed positions are referenced to more than one datum. Further more, these datums are time-dependent and time-variant.

We propose that the two clearances or the four positions are measured with respect to one time-invariant ellipsoidal surface as zero reference. Then, the mariners would have them correctly and accurately in one datum, whenever required. In shallow waters and inside harbors, the captain of a ship would be able to measure the clearances accurately and with confidence to avoid grounding or striking overhead obstructions, such as bridges and cables.

Combining GPS surveys and acoustic soundings, highly accurate ellipsoidal depths of the sea floor can be established in new areas or by filling gaps independent of the stage of the tide and any tidal datum. In separate GPS surveys, the ellipsoidal heights for overhead structures can be determined. The time-invariant sea floor depths and heights of the overhead structures can then be stored in the Marine Information System (MIS) database for future use. While underway in shallow waters, in berthing, in approaching channels, and inside harbor, using a mainmast-mounted GPS antenna and the ship's general arrangement drawings, the shipboard computer will determine the positions of the ship's keel, mainmast, and Plimsoll marks. Then, recovering the already established sea floor depths and overhead heights, it can compute the two clearances for safe navigation without any reference to the time-variant tides, tidal datum(s), and ship's draft.

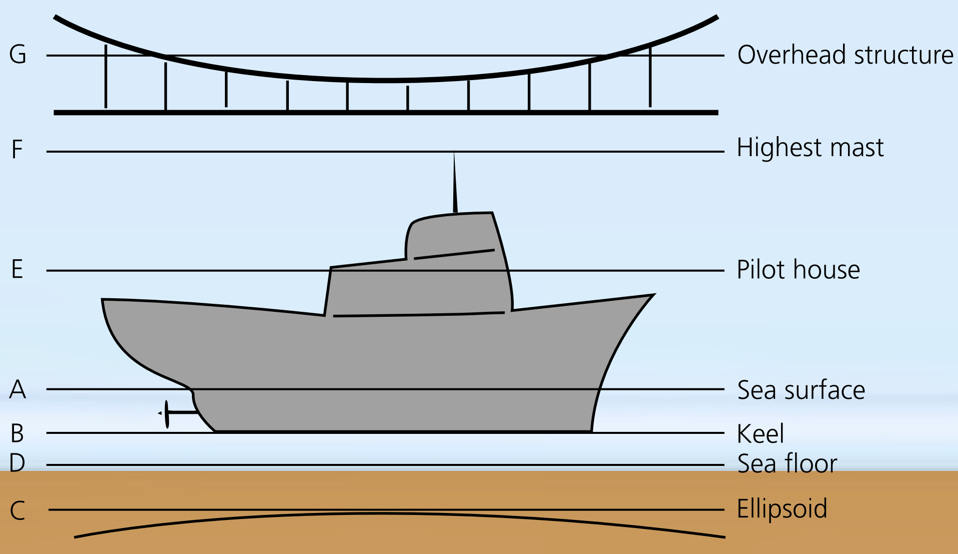
This article describes the surveying mode to establish time-invariant ellipsoidal depths or heights of the sea floor in the open ocean. A few additional survey procedures have been specified to achieve higher accuracy for shallow waters and inside harbors. A step by step algorithm is also included to compute the ship's two vertical clearances.

Surveying the sea floor and overhead structures

In the marine scenario, the Ellipsoid of the World Geodetic System (WGS) 1984, the coordinate system used within GPS, is both below and above the sea surface, which can result in the surveyed ellipsoidal depths or heights to be plus or minus respectively. In the following figures, ellipsoidal depths or heights are positive upwards with respect to the ellipsoidal surface.

A. When the WGS 84 Ellipsoid is below the sea surface - Figure 1 shows schematic locations for the overhead structure, ship's

Figure 1. Ellipsoidal heights when ellipsoid is below the sea surface



mainmast, pilothouse deck, and keel, sea surface, sea floor, and ellipsoidal zero reference surface.

DC = Ellipsoidal Height of sea floor (+h)

AC = Ellipsoidal Height of sea surface (+h)

BC = Ellipsoid Height of ship's Keel (+h)

CE = Ellipsoidal Height of the Pilothouse (+h)

CF = Ellipsoid Height of Ship's Mainmast (+h)

CG = Ellipsoid Height of the Overhead Structure (+h)

BD = Depth of Sea Floor from keel as measured by acoustic sounding.

During the GPS surveying, the distance BD between the ship's keel and sea floor will be measured with presently used acoustic sounding techniques. Then, the ellipsoid height (h) of the sea floor DC will be

DC = BC - BD = [CF - BF] - BD

In this configuration, the distances CF, BF, and BD are measured during GPS surveys without any reference to the stage of the tide and/or tidal surface. This is the decided advantage over the depths determined with respect to time-variant tidal datums.

In many cases, especially in deep water, the sea floor will be below the ellipsoid and have a negative height (-h). Here, the accuracy of the distance BD is accepted as achievable by acoustic techniques.

B. When the WGS 84 Ellipsoid is above the sea surface - Figure 2 shows schematic locations when the ellipsoid is above the sea surface.

DC = Ellipsoidal Height of sea floor (- h)

AC = Ellipsoidal Height of sea surface (-h)

BC = Ellipsoid Height of ship's Keel (-h)

CE = Ellipsoidal Height of the Pilothouse (-h)

CF = Ellipsoid Height of Ship's Mainmast (-h)

CG = Ellipsoid Height of Overhead Structure (+h)

BD = Depth of Sea Floor from keel as measured by acoustic sounding.

In this case, the ellipsoid depth of sea floor DC will be

DC = - BC - BD = - [CF + BF] - BD.

It may be pointed out that near Sri Lanka, the ellipsoid height of the sea surface AC has a maximum "low" of about -100 meters and this particular type of geometry is mostly not known to many users, particularly mariners.

Computing ship's two clearances while underway

A. Clearance for ship's keel - When the keel clearance (BD) is required, the mariner first surveys the geodetic position (φ, λ, h) of the ship's mainmast using GPS. Then, using the general arrangement drawings for the particular vessel, and combining with the ellipsoidal depth or height of the sea floor, the clearance can be computed (when ellipsoid is below sea floor) as

BD = BC - DC = [BF - CF] - DC

where BC is surveyed while underway and DC is taken from the database. Similarly the freeboard distance to the Plimsoll marks can be readily known.

B. Clearance for ship's mainmast - The clearance for the mainmast GF can be computed as

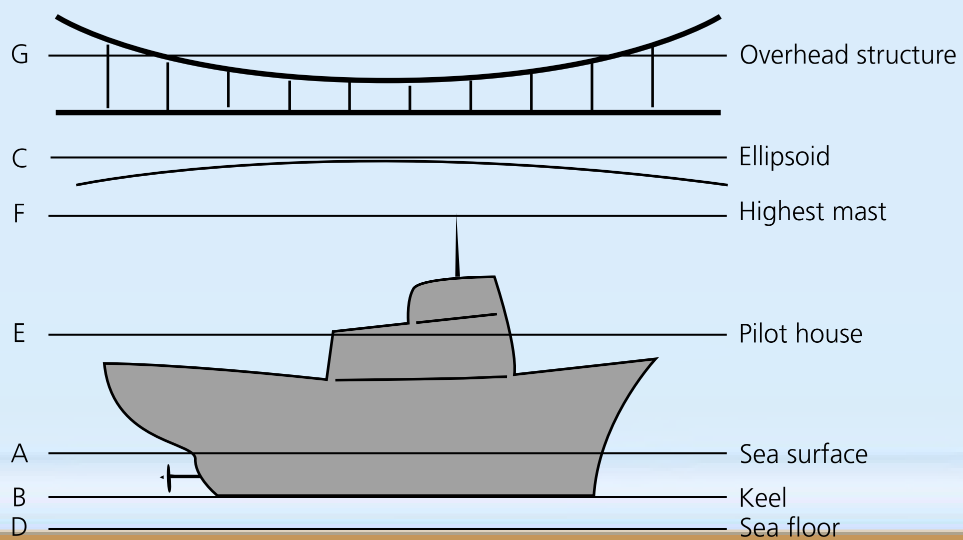
GF = CG - CF

where CF is surveyed with GPS while underway and CG is taken from the database.

Ellipsoid depths and soundings accuracy

In open ocean areas, the accuracy of an ellipsoidal height (h) with GPS will be about ± 5 meters and thus the sea floor location with this

Figure 2. Ellipsoidal heights when ellipsoid is above the sea surface



order of accuracy will be sufficient for most practical purposes. In shallow waters, along coastlines, and inside harbors, specially designed Differential GPS (DGPS) surveys can measure ellipsoidal heights in the range of ± 5-10 cm. The accuracy for keel clearance BD will be as per presently used acoustic soundings. To match the DGPS accuracy, it will be worthwhile that acoustic sounding techniques, procedures, and algorithms are examined again and updated as necessary.

Special surveying for high accuracy

In congested areas, the accuracy of ellipsoidal heights and depths can be increased by surveying in DGPS mode. The following additional surveying procedures will help to improve the collected data for safer navigation, particularly to the traditional mariner:

1. In harbors, buoys with small DGPS receivers can monitor AC as it fluctuates with the tide, to provide real-time data to the ship's captain. Similarly the ship's draft AD can be monitored with a keel-placed pressure sensor.
2. In cases where the sea floor heights vary significantly from one time to another, it will require regular DGPS surveys to keep the mariner informed of shoaling and other shifts in the channels.
3. In case of small ships, DGPS surveys for roll, pitch, and yaw will improve the accuracy of the ellipsoidal heights of the keel and its clearance with the sea floor.

Conclusions

GPS and DGPS surveys provide the accuracy necessary for the ellipsoidal depths and ship operations, whereby all measurements are referenced to the WGS 84 Ellipsoid. Thus, an invariant zero reference surface (or a vertical datum) will eliminate the necessity of measuring tides and ship's draft, settlement(s), and squat during bathymetric surveying. In addition, this approach will replace any the time-variant tidal surfaces. The ellipsoid as the zero reference surface also allows the mariner, while underway, to determine keel and overhead obstruction clearance independent of the stage of the tide, and the draft of the ship and freeboard. As is traditional however, the prudent seaman will seek independent verification of all the available nautical information.

Innovations 1983 and 1996

Tidal Modeling for GPS Positioning –

In 1983, International Association of Geodesy (IAG) took a step into the future to adopt its Resolution 16:

"The International Association of Geodesy (IAG), recognizing the need for the uniform treatment of tidal corrections to various geodetic quantities such as gravity and station positions, and considering the reports of the Standard Earth Tide Committee and S.S.G. 2.55, recommends that:

- the rigid Earth model be the Cartwright – Taylor - Edden model with additional constants specified by the International Centre for Earth Tides,
- the elastic Earth model be that described by Wahr using the 1066 A model Earth of Gilbert and Dziewonski,
- the indirect effect due the permanent yielding of the Earth be not removed, and
- ocean loading effects be calculated using the tidal charts and data produced by Schwiderski as working standards".

In 1996, International Earth Rotation Service (IERS) in its Tech Notes No. 21 stated:

"To account for the effect of the permanent tide, terrestrial reference frames may be defined as **Zero-tide** Permanent or 'zero frequency tide' is retained. The crust corresponds to the realistic time average, which varies with the luni-solar tides. **Tide-free** All effects of permanent tide are removed. This is not realistic since the crust cannot be observed. **Mean-tide** This a "tide-free" system except the geoid is modeled with permanent tide effects.

From 2001 to 2003, I contacted Professors W. Torge, E.Groten, G. Seeber, and M. Vermeer on the IAG Resolution 16. They all agree that the present computational approach, which recommends the "Zero-tide" modeling, is still to be followed. To this view point, if we bring in the IERS definitions as above, it seems completely impractical and non-scientific to overlook IAG and IERS and follow any other practice. The most surprising aspect is that nobody knows who is that Authority in tidal modeling, who formulated the present practice of computing in the "Tide-free" non-realistic and not-observable environment.

Muneendra Kumar, Ph.D., Research Consultant.

Muneendra Kumar Ph.D. is Chief Geodesist (Retired), U S National Geospatial-Intelligence Agency **munismk@yahoo.com**

George A Maul Professor of Oceanography and HOD of Marine and Environmental Systems at the Florida Institute of Technology. **gmaul@fit.edu**

Products

Applanix launches the DSS 322

Applanix has announced the launch of its next generation Digital Sensor System, the DSS 322. The new system incorporates a 22 megapixel CCD array, Aerolens™ custom-manufactured optics, and TruSpectrum ™ technology engineered to maximize the system's capability in generating high-quality color and CIR (color infrared) digital geospatial imaging products. Applanix has also announced the release of its new POSTrack system designed for streamlined airborne direct georeferencing and in-flight task automation. The new system combines the latest integrated Inertial/GPS technology from Applanix with the Flight Management System (FMS) expertise of Track'air B.V. in The Netherlands. *airborne@applanix.com*

Trimble introduces new surveying products

Trimble has introduced five surveying products as part of its new Connected Survey Site model—the Trimble® GX™ 3D Laser Scanner; the Trimble R8 system with Global Navigation Satellite System (GNSS) capabilities; the Trimble M3 Total Station; the Trimble R3 GPS System; and the Trimble S6 Total Station with GPS Search. The new positioning products add greater flexibility and versatility to provide seamless and streamlined workflow for all of the critical phases of surveying. The announcement was made at INTERGEO 2005. Also, Trimble recently announced that it has developed a software-based technology supporting GNSS to maximize flexibility and minimize cost in end-user positioning products that will use a variety of existing and planned satellite-based systems. Trimble's future-ready GNSS technology will accommodate signals broadcast by GPS as well as signals broadcast by Galileo and the GLONASS satellite systems. *www.trimble.com*

Leica GNSS QC quality control and data analysis software

Leica Geosystems introduces GNSS QC V1.0, a stand-alone software that can perform automatic quality checking and reporting of RINEX data logged by a GPS reference station network. Leica GNSS QC is a multipurpose data analysis tool suitable for single stations or networks of stations.

Topcon introduces New Long Prismless Total Station

Topcon/Japan released new "Power PULSE" prismless total station model GPT-7000L series. 1.2km prismless distance measurement function is newly employed. AAA (Anything, Anywhere, Anytime) feature provides stable 350m prismless measurement at any condition, even to low reflection object such as dark colored concrete etc, which would solve a traditional problem of prismless total station "impossible to measure, depending on type of object". GPT-7000L comes with built-in windows CE data collector with color graphic display and alphanumeric keyboard, as well as in-field solution program for survey/civil/roading and data management PC software. Data export to CAD/GIS/XML etc are supported. *marketing@topcon.com.sg*

Spectra Precision targets the survey market

Spectra Precision has introduced a cost-effective suite of surveying products for the conventional survey market. The new line of Spectra Precision® products are intended to bring more affordable, professional-grade survey instruments to a broader range of surveyors worldwide. The Spectra Precision survey product line will include GPS, optical total stations, and data collection hardware, as well as field and office software *www.spectraprecision.com*

Second Asia Pacific Users Conference held at Bhubaneshwar by Surpac

Surpac Software India Limited, the wholly owned subsidiary of Surpac Minex Group, Australia organized its second Asia Pacific Users Conference and Training during 13th to 16th September 2005 at Bhubaneswar. The event was inaugurated by Mr.Sanjeev Chopra, IAS, Managing Director, Orissa Mining Corporation was attended by over 100 dignitaries from the Indian mining and exploration industry. During the conference SMG show cased their new version of Surpac Vision and Minex Suites of Softwares besides SiroVision the new photogrametric tool developed by SCIRO division of Government of Australia and marketed and supported world over by SMG.

DVP Vectorization 6 is launched

DVP-GS has announced the launch of DVP Vectorization 6.0, designed as an efficient 3D Data Extraction tool within a new user-friendly interface. The included orientation tool provides a rigorous mathematical solution to create oriented models in monoscopic and stereoscopic modes. The improved views and display possibilities provides a flexible environment developed to increase productivity. It also includes enhancement capabilities and channel combination functionalities for multi-spectral imagery and new capturing functionalities. The Feature Editor lets you create categories settings that will favour workflow structuring. Also included for a limited time DVP Image Batch Processing enables to export and convert efficiently images within optimal formats (image pyramid, tiled images). *www.dvp-gs.com*

Planar Introduces StereoMirror™

Planar Systems, Inc, is introducing the latest in stereoscopic 3D technology to address imaging applications in geospatial intelligence and photogrammetry where customers need 3D viewing to discern depth and interpret spatial details. Planar's SD1710 provides a new dimension of digital image quality and user comfort to geoscientists, cartographers, engineers, image analysts and environmental planners who need to accurately map terrain, monitor erosion, design mass transit systems, identify boundaries, plan missions and investigate habitats. *www.planar.com/stereomirror*

Business

Change of Leadership at Leica Geosystems

As announced in June, Hans Hess has stepped last month after 10 years as CEO of Leica Geosystems. Following the takeover by Hexagon, the Board appointed Ola Rollén, CEO of Hexagon, as President of Leica Geosystems as per 1 November 2005. The current Board of Directors will step down at a specially scheduled Extraordinary General Meeting on 18 November 2005, when Hexagon will appoint its own representatives to the Board of Directors.

Intermap announces US $3.7 million mapping contract

Intermap Technologies Corp. has recently announced that its subsidiary Intermap Federal Services Inc. has been awarded a new data acquisition contract in the amount of US$3.7 million. The contract is for delivery of Intermap's high-resolution digital elevation data and radar imagery. Intermap has two aircraft deployed onsite and data collection for the project is already underway. The majority of the revenues from this contract will be recognized in the third and fourth quarters of 2005. *www.intermap.com*

Fleming College chooses MAPublisher

Avenza Systems Inc., producers of MAPublisher cartographic software, announces that the Geomatics Institute at Fleming College in Lindsay, Ontario, Canada has expanded their MAPublisher installation with 70 floating licenses of MAPublisher 6.2 software. This implementation extends the existing usage of MAPublisher in Fleming's Geomatics programs and puts it within reach of every student in geomatics programs at Fleming. *www.avenza.com*

Alliances

Sensor Systems joins Overwatch Systems Group

Sensor Systems, has joined the Overwatch Systems group of companies. Effective October 1, Sensor Systems changed its name to Overwatch Geospatial Operations and remains headquartered in Sterling, Va. Overwatch Systems, based in Morristown, N.J., combines the resources of four companies – Sensor Systems, Austin IT Systems, ITSpatial and Federal IT – to provide a suite of integrated geospatial and fusion software tools for the defense/intelligence community called the Overwatch Intelligence Center (OIC). The OIC focuses on providing situational awareness by enabling analysts to generate relevant, actionable intelligence faster and more effectively for the warfighter, first responder and decision maker. *www.overwatch.com.*

No 8 Ventures to invest $2 million in Surveylab

Surveylab Ltd and No 8 Ventures announced that No 8 Ventures has committed to invest $2million in Surveylab. This investment will enable Surveylab to capitalise on significant interest in its product from the United States. Surveylab's Chairman, Rex Nicholls, commented, "No 8 Ventures' equity enables us to pursue key customers in the United States. The funding will also enable us to complete development of the next generation of "ike" product."

Solo around the world with OmniSTAR-AM Tracking services

Earlier this year OmniSTAR BV had sponsored a non-stop/ solo sailing trip around the world by Mark Slats under the name of Oceanstocross. In return for sponsoring Mark with our OmniSTAR-AM Tracking service Mark gave us a 'taste' of what it was like to sail across the oceans by letting us experience a day on the North Sea. We were blessed with wonderful weather: sunny, light winds. At the end of the day our Tracking device was returned to us. Mark expressed his gratitude for having been given the use of our Tracking service that performed flawlessly. It gave all interested parties that had been left at home, instant insight in exact location, speed, direction as well as a historical trail of where he had been. *www.omnistar.nl*

All roads lead to GIS…

…The Rural Road Development Project

The Rural Road Development Project, Pradhan Mantri Gram Sadak Yojna (PMGSY) is using GIS for planning and decision making. An Online management tool OMMAS is being developed to populate the attribute data for GIS and provide access to the citizens to view status of various rural roads and other related information. Public Works Department Rajasthan is playing leading role in creating GIS data base and implementing the PMGSY Scheme. A customized standalone GIS software GRIMMS to run various queries related with planning of roads is being developed. Web GIS module is also being developed to make the complete system transparent and will allow citizens to access the information in spatial format related with PMGSY. C-DAC Pune is providing the technical assistance. *Submitted by K.K.Mishra, mishra09720@itc.nl*

…Online road information of Delhi

The Municipal Corporation Delhi, through a new project worth Rs 3 crore, aims to put all information about roads online in the form of a digital map, linked with a GIS. Once this is done, one will be able to log on and avail information on any MCD road in the Capital - when it was built, when it was repaired and how much it was tendered out for. The GIS mapping will start soon. The GIS mapping will help curb corruption, as it would make all information available to everyone on a transparent system. All roads will be marked on the map that will also carry basic information pertaining to their length, breadth and the degree. This map, according to the MCD officials, will enable one to see when a particular road was repaired, and how much it cost, and provide information about the tenders and the contractors involved. *http://cities.expressindia.com*

ASI to draw up monument map

The Archaeological Survey of India (ASI) is planning a heritage map for the country, logging in unprotected monuments and antiquities to curb trafficking and ensure they are not neglected. The Rs 90-crore project, National Mission on Monuments and Antiquities, proposes a locational analysis that would include not only the protected monuments but thousands of others which according to the project document are "unprotected or in utter state of neglect". As of now, only 3,659 built heritage sites are protected by the ASI; about 3,500 are conserved by the states. *www.indianexpress.com*

Food inspection in Sharjah to use electronic maps

Armed with the new PDA advanced system, Sharjah Municipality inspectors are all set to conduct their examinations of various outlets selling food including supermarkets, restaurants and groceries to safeguard the health of consumers. The equipment has entailed an estimated cost of half a million dirham. The main objective of using the device is to ensure the safety of the food items offered for sale in the emirate of Sharjah. The PDA device will ensure the quality and the safety of various food items offered in the market. The device features electronic maps that will facilitate the job of the inspectors in determining the locations of the food outlets. *www.khaleejtimes.com*

Digital maps foil suicide bombing attempts in Israel

The Israel Security Agency has developed an intelligence processing system designed to quickly detect insurgency plots and relay real-time alerts to field commanders. The system developed by ISA's computer branch, collates data and intelligence from a range of sources and processes them into digital maps and other situational awareness graphics. The system then relays the information to everyone from senior officials and analysts to field commanders and police patrols. The system has foiled scores of suicide bombing attempts over the last year. The system is being examined by a range of countries for use in counter-insurgency and homeland security missions. *www.menewsline.comes*

Population and socio-economic atlas of Nepal

Recently the Population and Socio-economic Atlas of Nepal was published. With 210 maps on 10 different themes related to social, economic and demographic indicators, the atlas offers graphic versions of data from the 2001 census, dissecting Nepal into cross-sections viewed through a host of parameters. The atlas will be a very useful tool for geographers, development planners, policy makers and researchers. Jointly conceived and produced by the Survey Department and Central Bureau of Statistics (CBS) with support from the EU, the main objective was to present demographic socio-economic indicators based on the last census. *www.nepalitimes.com*

Maps identify graves in abandoned cemetery

Eastern Kentucky University geography professor Dr Dan Weir has developed a project for mapping and identifying the 200-plus burial plots in the Old Soldier's Cemetery as part of a renovation effort. Weir, along with EKU geography students, Boys and Girls club members and Richmond Rotary club members, used GPS units to map the site and determine the position of the tombs. The Old Soldier's Cemetery has housed tombs of black soldiers and war veterans for more than 130 years. Nearly two-thirds of the headstones are missing, and the number of people buried at the site, as well as the identity of many, is unknown. Weir is hoping that, by determining the latitude and longitude of each existing headstone and plotting it into a map of the cemetery. *www.kentucky.com*

OS seeks partners for GPS correction service

Ordnance Survey is offering Licensed Partners and other interested parties the chance to develop positioning services based on a revolutionary national framework for correcting signals from orbiting satellites. OS Net is a network of more than 80 GPS base stations designed to enable different levels of improved real-time accuracy from the Global Positioning System (GPS) anywhere in Great Britain. OS Net is already delivering efficiencies for Ordnance Survey field staff where it is enabling centimetre-level positioning for their data-collection operations. Now, Ordnance Survey is planning to make the service publicly available through a tier of partner organisations. *www.ordnancesurvey.co.uk/business/technical/osnet.html*

Technology mission on railway safety

Railway Board has reviewed the progress of 14 on-going projects initiated by the Research, Design and Standards Organisation (RDSO) of the Ministry of Railways under the 'Technology Mission on Railway Safety and Re-designing of Wagons'. The Board has expressed satisfaction with the progress. These projects have been initiated to develop cost effective technological solutions indigenously for Indian Railways to bring about improvement in safety standard and increase in productivity. Most of these projects under the Technology Mission on Railway Safety have been taken on by RDSO in coordination with IIT, Kanpur.

GPS-Guided 155mm Artillery Projectile

The Raytheon Missile Systems-Bofors' Excalibur team fired a global positioning system (GPS)-guided 155mm artillery projectile, successfully engaging a representative target with devastating effects. "The end-to-end test of the Excalibur system demonstrates that we have a weapon system ready for fielding," said Raytheon's Excalibur program director John Halvey. "The Excalibur team has made a tremendous step forward toward meeting the objective of fielding by March 2006," said Lt. Col. Bill Cole, the U.S. Army's product manager for Excalibur at Picatinny Arsenal, N.J. "Excalibur has proven at the system level that it can meet its precision and lethality objectives." The program is a cooperative effort between the United States and Sweden. *www.spacewar.com*

2-Track Global announces launch of Personal GPS Tracker

2-Track Global has announced that it had commenced the commercial launch of its Condor 505 Personal GPS Tracker. This product has been specifically designed for the safety and security of People in the hazardous areas, elders as well as children. It is a portable GPS tracking device that allows the user to be monitored from a control centre. The product incorporates the latest technology of GPS, GSM and GPRS as means of communication. The operation of the product is simple and provides for three sets of telephone numbers to be pre-configured into the device for fast dialling and to restrict and limit phone bills that could otherwise be incurred by children. The product is also compatible with normal SMS text messaging and enables parties to receive and read any SMS messages from anybody throughout the world.*www.spacedaily.com*

Garmin is Tier-One Supplier for Honda Motorcycle GPS

Garmin International announced that it is now serving as a tier-one automotive OEM supplier with its newly-developed modular GPS navigation system on the 2006 Honda Gold Wing motorcycle. Tier-one suppliers provide parts and systems directly to vehicle manufacturers and must meet the demanding performance specifications and quality requirements provided by the manufacturer. Known as the Honda Satellite Linked Navigation System, it provides complete North American mapping with nearly six million points of interest -- places like hotels, restaurants, tourist attractions, and Honda Motorcycle dealerships and service centers -- displayed on a large seven-inch integrated display. *www.spacedaily.com*

Dangerous-materials transport vehicles to have GPS

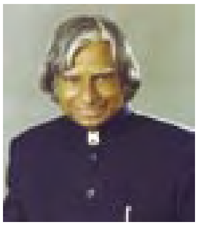
The city government of Shanghai, the largest economic hub of eastern China, has recently required all vehicles transporting dangerous and toxic materials to be equipped with GPS devices, in its latest bid to intensify control over such chemicals. Official statistics show that there are now in Shanghai more than 6,000 businesses handling dangerous chemicals. Over 43 million tons of dangerous chemicals in 3,000-odd varieties enter and depart Shanghai annually. *http://news.xinhuanet.com*

GPS remeasures height of Mount Everest

Mt Everest is 3.7 metres shorter than in 1975 when it was measured last according to a recent announcement by the Chinese government. The elevation of Mt Everest's summit rock is 8844.43 metres, with a precision of 10.21 metres as announced by the Director General of the Chinese State Bureau of Surveying and Mapping. The elevation data of Mt Qomolangma (Chinese name for Mt Everest) published in 1975 will cease to be used within China. Chinese surveyors, armed with latest GPS and radar measuring equipment, spent 40 minutes at the summit to take the measurements. The Chinese surveyors found that the thickness of the ice and snow layer covering the summit rock is 3.5 metres now, using ice and snow detector. This latest figure was much higher than that of 1975 when surveyors estimated the figure at 0.90 metres by thrusting a steel rod into the ice to calculate its depth. *http://in.rediff.com*

The Google furore

President expresses concerns



President Kalam expressed concern over a free mapping programme from Google that he said could help terrorists by providing aerial photos of potential targets. "... some of the developing countries, which are already in danger of terrorist attacks, have been singularily chosen to provide such high resolution," Dr Kalam told a meeting of top police officials. South Korea, Netherlands and Thailand have similar concerns. Google has said it takes India's concerns seriously and is willing to have a dialogue on the issue. Responding to President Kalam's concerns, Google spokeswoman Debbie Frost said: "Google takes governmental concerns about Google Earth and Google Maps very seriously. Google welcomes dialogue with governments, and will be happy to talk to Indian authorities about any concerns they may have." *The Hindu and the Economic Times*

Google's Taiwan map earns China's wrath

Google's deletion of the words 'Taiwan, a province of the People's Republic of China' from a map of Taiwan on Google Earth ired Beijing. The words have been deleted at the top left corner of the page. Instead, arrows and some other graphics have been placed through which the map can be moved or enlarged. Peng Keyu, consul general of the Chinese consulate in San Francisco, voiced objection to the Google decision and urged it to follow the American government's allegiance to the one-China principle. Google spokesman Debbie Frost claimed the alteration was just a "regular update" rather than a deliberate effort to specially update the Taiwan page. *http://epaperdaily.timesofindia.com*

India to launch radar imaging satellite

India will soon join a select club of nations by launching its own radar imaging satellite (RISAT) with an all-weather capability for disaster management, as said by a top space agency official. The RISAT would be launched on board the polar satellite launch vehicle (PSLV) from the Satish Dhawan space centre at Sriharikota in Andhra Pradesh in 2007, Indian Space Research Organisation (ISRO) chairman G. Madhavan Nair told IANS.

Antrix-Sierra sign MoU for cartosat data products

Antrix Corporation Limited signed a memorandum of understanding with Sierra Atlantic for developing an appropriate interface software and integrating the Cartosat-1 products with Sierra's COTS-IP&SP Software package,ENVI. The Cartosat-1 satellite, which was launched by Indian Space Research Organization (ISRO) on 5th May 2005 provides stereo data suitable for advanced and large scale mapping applications with its two panchromatic cameras having spatial resolution of 2.5 meter.

Space Research Institute established in China

The Chinese University of Hong Kong has launched its space and earth information research institute and and completed the first phase of its satellite remote sensing ground station. The ground station won the support of the Ministry of Science and Technology and the Hong Kong Special Administrative Region government. After the operation of the satellite remote sensing ground station, Hong Kong could strengthen its monitoring of weather, environment and natural disasters in Hong Kong, southern China and the surrounding areas. *http://news.xinhuanet.com*

Remote Sensing in Nature Conservation

ISRS Delhi Chapter, with WWF India organized its annual event coinciding with WWF's wildlife week celebration. The week started with Shiela Dikshit, Chief Minister of Delhi planting an amla (*Emblica officinalis*) tree in the presence of many school children who came to participate in a series of competition like debate, essay, quiz and painting. The end of the week was marked a two days regional symposium on "Remote Sensing in Nature Conservation" that was inaugurated by eminent environmentalist Chairperson Wasteland Development Board, Dr Kamla Chowdhary on 7th October. In his welcome address, Dr Srikanta K Panigrahi, Chairman, ISRS Delhi Chapter, highlighted the role of ISRS in catalyzing the use of remote sensing and space technology in nature conservation. Mr Parkshit Gautam, Director Freshwater Programme, WWF-India; Dr SS Prasad, Director, Defence Terrain Research Laboratory (DTRL) delivered a special lecture on the main theme of the symposium. Chairman, ISRS Delhi Chapter declared the citation of felicitation for great scholar and nature scientist Dr PS Roy, Deputy Director, National Remote Sensing Agency (NRSA), Hyderabad. The website of ISRS Delhi was was released on the occasion. On 8th October 2005 started with high level technical deliberations by the eminent space scientists. Many leading speakers Dr P S Roy, NRSA; Dr SN Das, All India Land Use and Soild Survey (AILUS); Dr Areendan, Project Director, WWF-India; Dr N Kalra, IARI, Dr K V Sundaram, Chairman, Bhoovigyan Vikas Foundation, Dr Ajai Pradhan, CMD DHI; Dr Rajesh Tamhare, ESRI-India, Dr Saumitra Mukherjee, JNU; Dr R N Sahoo, IARI, and Bal Krishna, Coordinates made interesting and thoughtful presentations.

Signal propagation through the troposphere

Space environmental effects on satellite communication can be considered as related to space segment, ground segment and on the signals propagating through the earth's lower and upper atmosphere. The atmospheric structure has significant influence on signal propagation. This has definite influence on the data processing methodologies. The specific applications with which are concerned here are essentially related to navigation and positioning. Troposphere and ionosphere are the two regions that have different properties of signal propagation. The structure of atmosphere can be described through concentric layers of atmospheric domains with different physical and chemical properties. The signal propagation results in ionospheric errors, tropospheric errors and multipath errors apart from the clock errors. In addition, the error in the signal can be significantly increased depending upon the geometry of the satellite used to determine a position. This can be estimated through the parameter PDOP – (Position dilution of precision). The Dilution of precision factors (DOP) explain how geometry effects to yield position accuracy and scale ranging accuracy. The optimum geometry accuracy for four GPS satellites is achieved when three satellites are equally spaced on the horizon and one directly at zenith point of observation station. The aspects related to GPS accuracies shall be discussed in subsequent Class Room Sessions.

The most significant error occurs when the satellites signal goes through the earth atmosphere. This is a blanket of electrically charged particles located between 130 and 195 km above the earth. These particles affect the speed of light and so affect the speed of the GPS radio signals. Specific features as given below characterize the broad categories of lower and upper atmosphere.

The troposphere is the lower part of the earth's atmosphere extending from the earth's surface to 40 km above the earth. The signal propagation depends mainly on the water vapor content and on the temperature of the atmospheric layers. The troposphere is the gaseous atmosphere and the temperature decreases with height by 6° to 7° C per km. The horizontal temperature gradients vary possibly at the rate of 1° to 5° C per 100 km depending upon the latitudes.

In the troposphere region air pressure, temperature, and water vapor pressure influence the index of refraction. The atmosphere can be thought of as mixture of two ideal gases, dry air and water vapor. The dry part contributes 90% of tropospheric refraction. The distribution of water vapor cannot be accurately predicted. Fortunately it comprises only 10% of the tropospheric refraction. The conditions are extremely dynamic in this zone. The index of refraction influences the propagation and it is greater than 1 and decreases to 1 (at upper limit of the troposphere) with increase in height. The delay caused by the troposphere (zenith delay) depends on the refractive index of the atmosphere. The troposphere is a non-dispersive medium for radio waves up to about 15 GHz. Tropospheric refraction is thus identical for both GPS carriers, L1 (1575.42 MHz) and L2 (1227.60 MHz). The troposphere delay reaches a value of about 2 meters in the zenith direction and varies inversely with the sine of the elevation angle of the signal up to about 27 meters at angles of 5 degrees. The lower the elevation angle of the signal, the more it is adversely effected because it must travel a longer path through the troposphere. There are several models to calculate the tropospheric delays. Prominent among them is the modified Hopefield model. The propagation delay caused by the troposphere is nearly identical for the total spectrum of visible light and for the radio frequency domain. Due to the wet component, the absorption is much greater for visible light. When high accuracy is required as in the case of geodynamic modeling, attempts can be made to measure the water vapor content directly along the signal propagation path with water vapor radiometer. An earlier example of this is the use of dual frequency microwave water vapor radiometer developed for geodetic applications at ETH- Zurich- The instrument operates at 23.8 and 31.5 Ghz and is capable of automatically tracking space targets like GPS satellites. The accuracy estimate for the determination of the signal path delay is 1 to 3 cm.

IV Murali Krishna

Director (R&D) Professor and Head, Centre for Spatial Information Technology, Jawaharlal Nehru Technological University, Hyderabad

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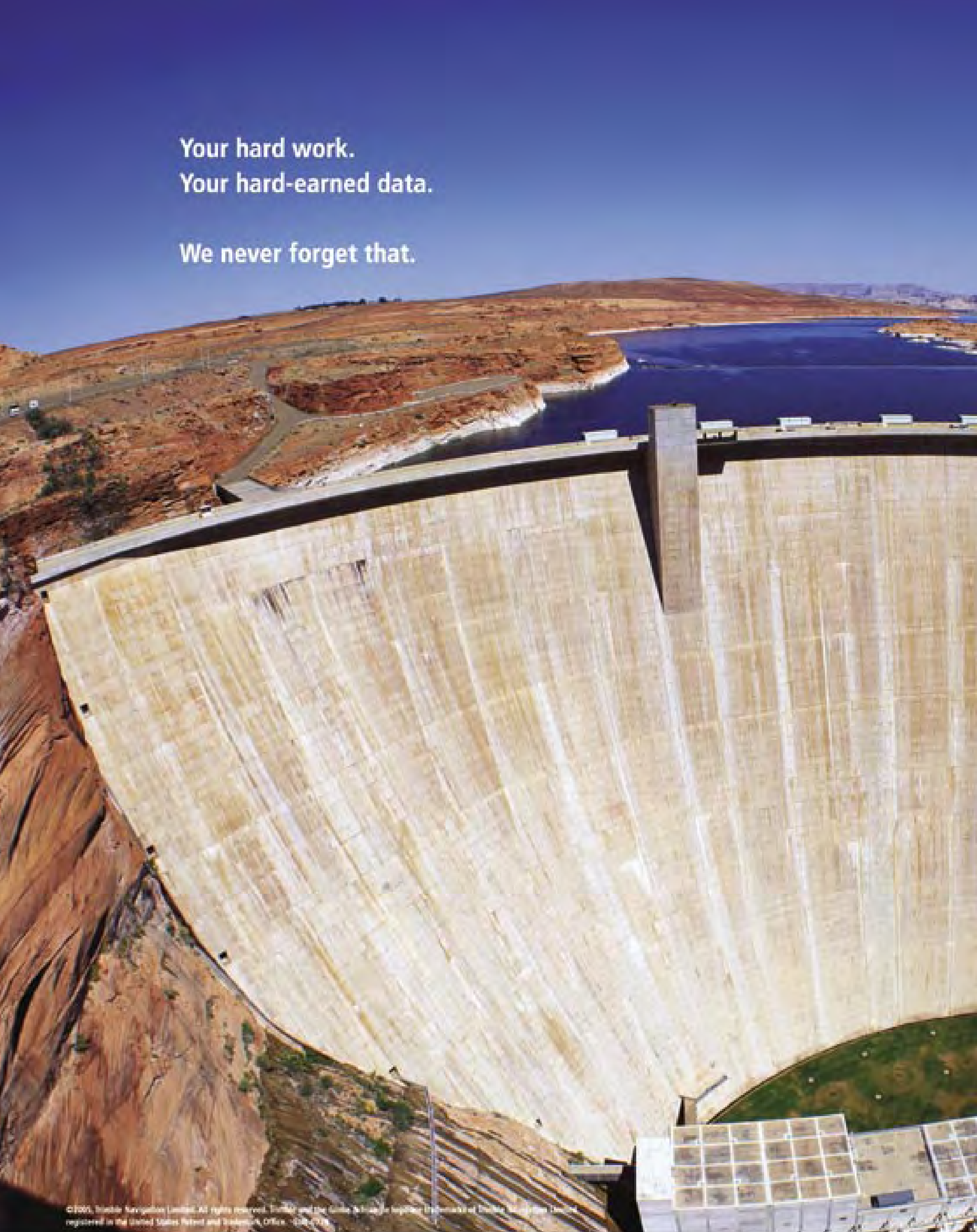
The Coordinates Class room espouse readers to graticules of Mathematics and Physics that epitomize the Geospatial Information Technology. A chain of structured presentations related to interdisciplinary principles that define Geodesy, GPS, GIS, Geospatial data management and Image processing are to be en suite in this section in each issue of the Coordinates. Initially the chain trembles with Geodesy which is the mother of technologies to position the Coordinates.


Your hard work.
Your hard-earned data.
We never forget that.

Reconfigurable software GNSS receiver in multipath environment

The paper discusses the Software Defined Radio implementation of a reconfigurable GNSS user terminal integrating both navigation and communication capabilities

Fabio Dovis, Massimiliano Spelat, Paolo Mulassano, Marco Pini

It is well known that the GNSS programme has given an important contribution to the research activity in the field of Satellite navigation, positioning and timing. The European Galileo project is going to constitutes an essential contribution to the satellite navigation market, taking into account that a relevant effort is being devoted to the design of Local Elements (LE) for providing local assistance data to users. Looking at the near future, it is well known that the Galileo system will introduce signal properties (e.g. in terms of modulations) that will be different for each channel and band, since they have been designed also with particular attention to the services requirements; the same will happen with the Modernized GPS.

As a direct consequence, the study and design of advanced terminals able to deal with both the Signal-In-Space (SIS) and other classes of signals transmitted by stations and satellite augmentations (EGNOS), become indispensable.

In this scenario, flexibility represents an essential feature for the User Terminals (UTs). The Software Defined Radio (SDR) approach constitutes a satisfactory solution bacause it allows for the development of reconfigurable devices realized on a modular architecture. It is clear that the reconfigurability aspect can play a key role in specific applications where the features of the environment surrounding the UT, change with time. A typical example is a user moving in an indoor scenario, where the performances of GNSS receivers could strongly limited by several factors: acquisition of weak signals is critical, visibility of a sufficient number of satellites is not guaranteed, and the SIS received at the antenna propagates via multiple paths.

Following these considerations in according to the most recent research works on GNSS receiver (Akos, 2003), the paper discusses a receiver architecture based on SDR techniques where functionalities are software-implemented on modular platforms composed by Field Programmable Gate Array (FPGA) and high speed Digital Signal Processor (DSP).

Analysis of GNSS modular receiver architecture for advanced algorithms implementation

The conceptual scheme of a reconfigurable terminal for positioning applications, based on SDR techniques is shown in Figure 1. Such an architecture represents the functional diagram of a hybrid Navigation/Communication (NAV/COM) user terminal based on FPGA and DSP, as considered for the work presented in this paper.

It is clear that the user terminal functions are distributed among the different functional blocks and modules:

1. The Algorithm Control Unit, an advanced routine implemented on DSP allows for the real-time configurability of the platform. It consists in a set of commands for the control of the System Control Unit internal modules.
2. The Navigation and Communication Units constitute the core blocks (FPGA-

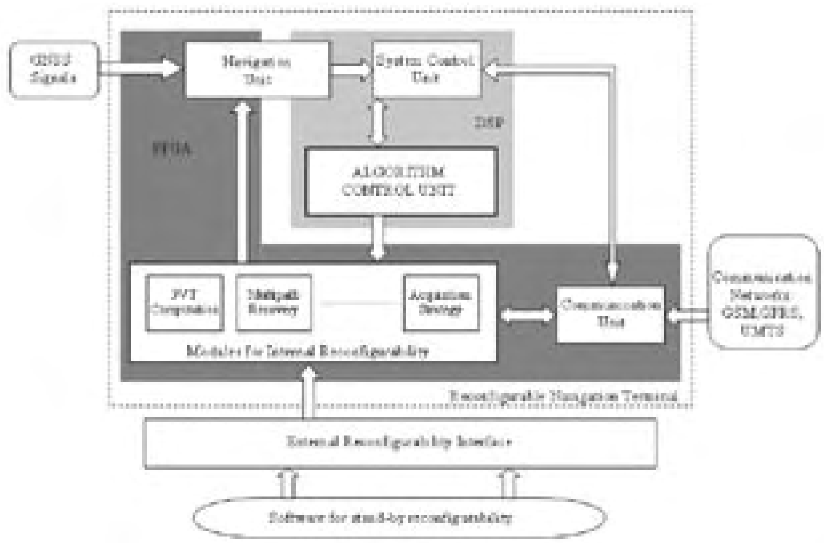


Figure 1 - GNSS Receiver Functional Architecture

implemented) of the system; in fact, they are able to acquire and tracking signals incoming from satellites and Base Tranceiver Stations (BTS).

3. All modules for the on-fly reconfigurability are software uploaded (on the FPGA) and, during the stand-by phase, can be changed, upgraded and integrated employing the external reconfigurability interface.

In order to understand what are the potentialities of the SDR implementation, in the next session the architecture of the Navigation Unit is analyzed and some performance results are highlighted.

The navigation unit

Given the flexibility of the overall GNSS receiver architecture presented in the previous section, the Navigation Unit has been designed and implemented on reconfigurable hardware on the basis of the data processing rate. In particular, the resources have been mapped over a Xilinx FPGA Virtex II XCV2000EBFF896 and a Texas Instruments DSP C6416 (fixed point). Figure 2 shows the platform employed for the implementation, and the communication links between the FPGA, the DSP and a common PC.

Architecture description

A detailed block diagram for the Navigation Unit Architecture in the case of single channel is reported in Figure 3. The in-phase (I) and quadrature (Q) samples of satellite signals are computed and written into a binary file on the basis of the signals properties specified in the Signal-In-Space Interface Control Documents (SIS ICD) using a software simulator in C language. This file is then read and data are stored into the FPGA on-board Random Access Memory (RAM) in order to assure data stream continuity at the input of the base-band stage. I and Q samples are processed by the base-band channel implemented on the FPGA, which is in charge of correlating these samples with a local replica of the satellite signal (generated on the FPGA itself). Correlator outputs are fed to the DSP in order to apply advanced algorithms for computing corrections for both the acquisition and the tracking phases. Finally, these values are sent back to the Numerically Controlled Oscillator (NCO) which drives the local code generator.

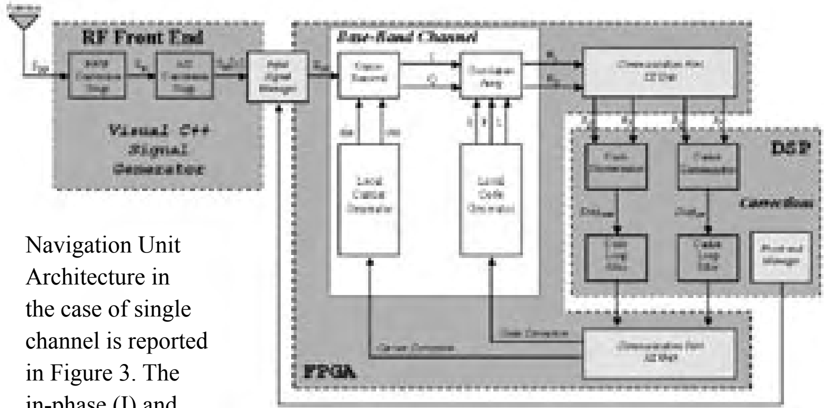


Figure 3 – Navigation Unit Architecture

During the acquisition phase, a specific DSP algorithm is responsible for the search of satellites in view and in particular, for the raw alignment between the incoming and the local code with a certain error. After the acquisition, the code and doppler shift computed are used to initialize the tracking loops, and both the discriminator and the loop filter algorithms (DSP implemented) are responsible for the fine alignment of the codes.

Section (one channel)	*Num. of slices*	*FPGA occupation*
Input Signal Manager	296	~3 %
TX Unit	280	~3 %
RX Unit	331	~4 %
Base-Band Channel	939	~9 %
(Local Carrier Gen.)	(160)	(~2 %)
(Local Code Gen.)	(242)	(~2 %)
(Correlators Array)	(456)	(~5 %)
Overall Structure	2115	~20 %

Table 1 – Navigation Unit: Resource Analysis

It is important to point out that the design of the structure implemented on the FPGA includes the realization of the "Input Signal Manager" block for the I and Q samples management, and the interfaces for the serial data transmission UART TX and UART RX, which assure a correct communication between the base-band stage (FPGA) and the correction stage (DSP).

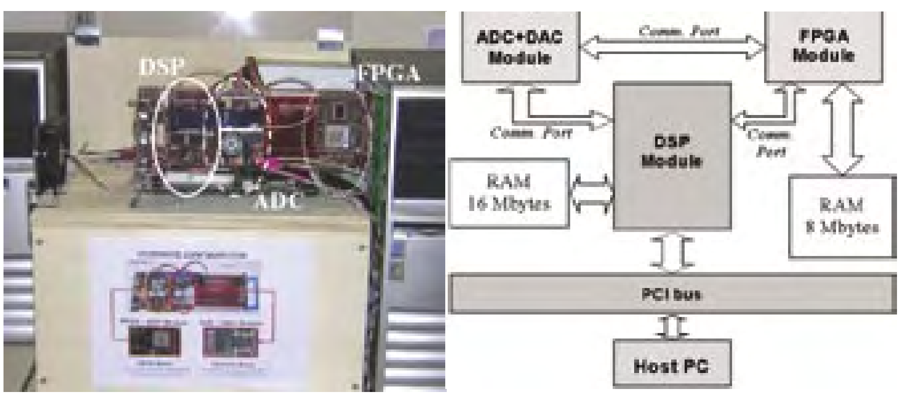
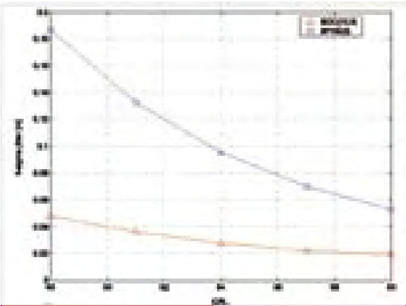
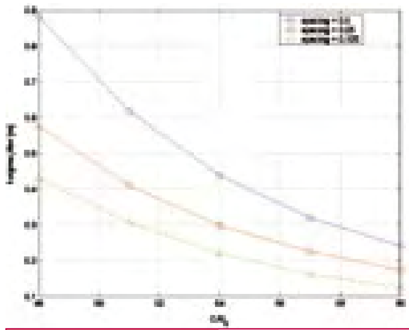


Figure 2 – SDR Platform and Communication Links between Programmable Devices



Platform	FPGA/DSP
IF Bandwidth	30 MHz
Sampling Frequency	43.648 MHz
Integration Time	4 ms
E-L Spacing	0.25 chips

Figure 4 - BPSK(5) vs BOC(10,5) code tracking jitter comparison on the FPGA/DSP platform



Platform	FPGA/DSP
Modulation	BOC (1,1)
IF Bandwidth	4 MHz
Sampling Frequency	4.3648 MHz
Integration Time	4 ms

Figure 5 - FPGA/DSP test to evaluate the effect of correlators spacing on the code tracking jitter for a BOC(1,1) modulation

Considering the overall architecture implemented on the Xilinx programmable hardware, which is constituted by 2,541,952 gates, it is important to provide an estimation of the resources used in order to understand the complexity of the Navigation Unit. Table 1 summarizes the FPGA implementation report in the case of one base-band channel.

Performance results for the navigation unit

In order to test the Navigation Unit performance, the tracking error has been analyzed in terms of pseudorange noise standard deviation in the case of BPSK(5), BOC(1,1) and BOC(10,5) modulations. The sample stream of the signal has been obtained in presence of noise considering different values of C/N_0 (60 to 48 dBHz) at the input of the RF filter. The IF filter (see Figure 3) is a 5th order Butterworth filter with a reconfigurable bandwidth dependent on the signal is employed for; therefore, the sampling frequency has been determined satisfying the Nyquist criterion. Table 2 is a summary on both the input signal characteristics and the FPGA/DSP platform configuration.

With a FPGA on-board clock of 130.944 MHz, samples at the input of the base-band channel are correlated with the local replica over a time of 4 ms, i.e. 1 code period in the case of BOC(1,1). The value at the output of the correlator is acquired from the DSP, which compares it with a threshold searching for the peak in the Correlation Pattern. The DSP also shifts the local code replica in order to span all the possible delays. At the end of the acquisition phase, the delay between the two codes is used to track the signal; during this phase the DSP drive the local code generator in order to obtain the fine alignment. In particular, an "Early-Late Envelope Normalized" discriminator (Equation 1) with a 2nd order FIR filter are implemented in the DSP tracking algorithm.

$$Discr\_output = \frac{\sqrt{I_E^2+Q_E^2}-\sqrt{I_L^2+Q_L^2}}{\sqrt{I_E^2+Q_E^2}+\sqrt{I_L^2+Q_L^2}} \quad (1)$$

In order to show the possibility of implementing different kind of modulations, Figure 4 represents a comparison between the BPSK(5) and the BOC(1,1) in terms of tracking jitter error.

Signal Generation Parameters	
IF Filter Order	5th (Butterworth)
Code Rate	BOC(1,1): 1.023 MHz BPSK(5): 5.115 MHz BOC(10,5): 5.115 MHz
Code Length	BOC(1,1): 4092 chips BPSK(5): 5115 chips BPSK(5): 5115 chips
Signal Duration	40 sec
C/N0	48 to 60 dBHz
Multipath	No
Input Signal Quantization	1 bit
FPGA Parameters	
Master Clock	130.944 MHz
Num. of BB Channels	1
Local Code Quantization	1 bit
Local Carrier Quantization	1 bit
DSP Parameters	
FLL Noise Bandwidth	20 Hz
PLL Noise Bandwidth	10 Hz
DLL Noise Bandwidth	2 Hz

Table 2 - platform parameters used during the tests

The flexibility of the platform allows to easily change via software the spacing between early and late replicas, and an example of the obtained performance is depicted in Figure 5, where the code tracking jitter for the BOC(1,1) is depicted in case of spacings ranging from 0.5 down to 0.125.

Multipath tracking algorithm for reducing the code alignment error

It is well known that multipath errors become particularly significant in urban or indoor navigation, where the presence of many scatterers around the receiver may be relevant. When a SIS replica, delayed within one chip with respect to Line Of Sight (LOS), arrives at the receiver the S-curve of the DLL is distorted. The punctual local code replica of the DLL can not be exactly aligned to the LOS and a systematic error in the pseudorange estimation is experienced. The architecture implemented (introduced in Dovis et al., 2004) in the

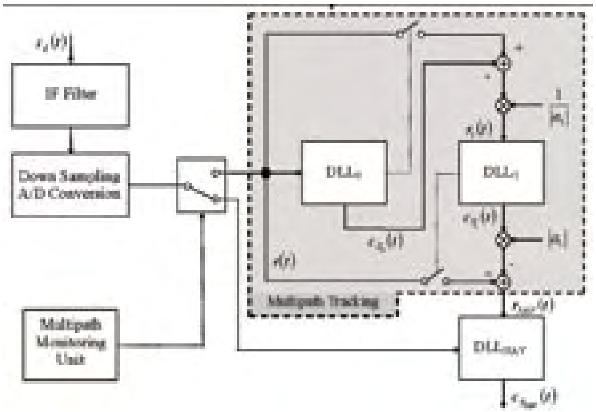


Figure 6 – Multiple DLL Architecture for one channel within the navigation receiver.

reconfigurable hardware is depicted in Figure 6. A key role is played by the multipath Monitoring Unit which is in charge of activating the multistage architecture according to the scenario. In particular it has to:

- estimate the number of replicas impinging at the antenna employing an algorithm
- compare them with a predefined threshold to roughly determine their relevance to the distortion of the S-curve
- activate the multistage procedure for the tracking loop

Figure 6 shows the innovative architecture in the case of one multipath arriving at the receiver, but it can be easily extendable to the general situation in which the input signal arrives at the antenna via n-th different paths.

The local code replica of the DLL_0 is usually delayed with respect to the LOS code due to the distortion of the S-curve. Such a code instance is subtracted from the filtered incoming code r(t), giving a signal $r_1(t)$ as input for the DLL_1, which is therefore able to track the multipath. After a transient phase, the first DLL tracks the incoming LOS and the second multipath replica. The local code of DLL_1, that follows the evolution of multipath, is then subtracted from the incoming code r(t) and the resulted signal is sent as input for the DLL_{NAV}. The local code of this last DLL can be used for pseudorange estimation.

Figure 7 shows the result obtained by simulation of the module in case the multipath and LOS signals have the same phase rotation, the multipath is 0.7 chip delayed with respect to LOS and its amplitude is half the LOS amplitude. It can be noted that using a single DLL narrow correlator (0.125 chip spacing), no reasonable tracking is possible; in fact, the mean of the tracking jitter is about 0.07 chip apart from the correct zero crossing (dashed line in Figure 7) for all the C/N_0 values considered. Figure 7 also reports the performance of a single DLL when no multipath is present (dotted line), and the performance of the innovative architecture (solid line). It can be observed from the picture that employing the new scheme, the systematic error can be significantly reduced for all C/N_0 values.

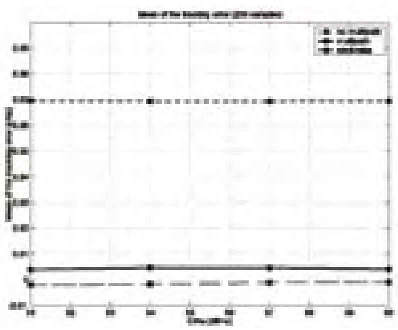


Figure 7 – Comparison of the mean of the tracking jitter: common DLL with no multipath (dotted line), common DLL with multipath (t1 = 0.7 chip) (dashed line), innovative multiple DLL (Figure 6) with multipath (t1 = 0.7 chip) (continuous line).

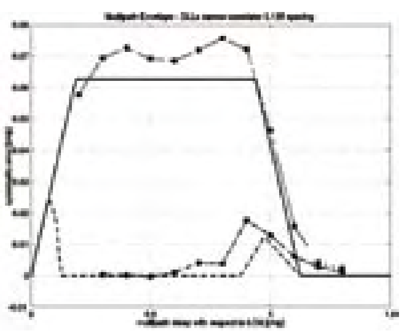


Figure 8 - Theoretical and simulated multipath envelopes of a single narrow correlator (solid and dotted lines), theoretical and simulated multipath envelopes of the simil-RAKE architecture (dashed and dashed-dot lines)

Figure 8 shows the theoretical multipath envelops of a single DLL narrow correlator and of the whole simil-RAKE architecture compared to the systematic error obtained by simulation. Both simulation results and theoretical envelopes show that using the innovative architecture, it is possible to drastically reduce the systematic error for all the multipath delays considered.

Conclusions

This paper has discussed the implementation of innovative functionalities for the realization of GNSS receiver according to the SDR philosophy. The study has been conducted highlighting novel aspects of the architecture which allows several degrees of reconfigurability. In particular, the implementation of the Navigation Unit has been analyzed and finally, the adaptive multipath rejection algorithm has been discussed presenting the simulation results of the implemented architecture.

References

Akos D M (2003) The role of Global Navigation Satellite Systems (GNSS) software radios in embedded systems, GPS solution, vol. 7, no. 1

Braasch M. W. (1996) Performance Comparison of Multipath Mitigating Receiver Architecture, IEEE PLANS 1996

Buracchini E (2000) The Software Radio Concept, Commun. Mag., vol.38, no.9, pp. 138-143

Dovis F, Gramazio A, Mulassano P (2002) SDR Technology Applied to Galileo Receivers, ION GPS 2002

Dovis F, Mulassano P, Pini M (2004) Multiple DLL Architecture for Multipath Recovery in Navigation Receivers, IEEE VTC 2004

Laxton M C, De Vilbiss S L (1977) GPS Multipath Mitigation During Code Tracking, in Proc. of the American Control Conference

Mitola J (1995) The Software Radio Architecture, IEEE Commun. Mag., vol.33, no.5, pp. 26-38

Mulassano P, Dovis F, Avagnina D, Gramazio A (2001) REGAL: A Reconfigurable Receiver for GPS and Galileo, GNSS 2001

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Galileo update

Galileo – the European Programme for Global Navigation Services for civil purposes is an initiative led by European Union. We provide regular updates to our readers on the Galileo programme.

CPS partners to play key role in improving Galileo system performance

Cambridge Positioning Systems have announced that it will partner with LogicaCMG in a major pan-European project to drive new mobile location technology and applications development for the multi-billion Euro Galileo satellite programme.

The Application of Galileo in the Location-Based Services Environment (AGILE) project aims to foster widespread adoption of Global Navigation Satellite Services (GNSS) for both enterprises and consumers.

AGILE will create a detailed development roadmap for new high accuracy Location-Based Services (LBS) leading up to the launch of the first Galileo satellites in 2007.

The project will also promote the benefits of new location technologies to a broad stakeholder group, including key government decisions makers, investors, regulators, mobile operators as well as services and applications developers.

LogicaCMG, which is already working on four Galileo-related contracts worth more than 6 Million Euros, invited CPS to participate in this project because of the key role its network-based Matrix high accuracy location technology plays in improving satellite system performance.

Earlier this year, CPS announced the launch of its Enhanced Global Positioning System (E-GPS), which combines satellite positioning with its Matrix technology to deliver high accuracy location technologies across all environments, including indoors and dense urban areas where satellite technologies face major performance challenges.

E-GPS provides faster location fixes than standard GPS - a critical factor in the take-up of mobile data applications. CPS is already working with leading GPS companies, such as Trimble and SiGE, on the development of low cost E-GPS solutions.

Initially, LogicaCMG and CPS will focus on the development of trial systems for European network operators, based on the integration of CPS' Matrix technology with LogicaCMG's Location Enabled Server and applications portfolio.

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Indoor positioning in wireless LAN

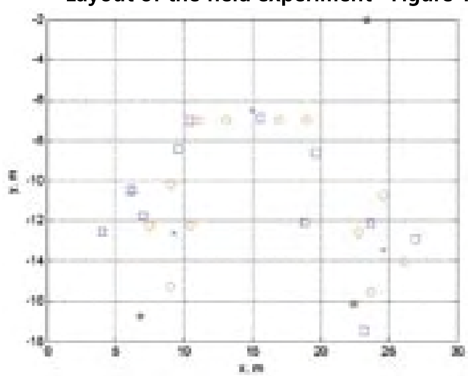
There are difficulties in applying GPS directly to indoor positioning because of the weakness of GPS signal in an indoor environment

JAYWON CHEY, JANG GYU LEE, GYU-IN JEE

Recently mobile location based services (LBS) are provided via a mobile terminal such as a personal digital assistant (PDA), a cellular phone and so on. The location method that searches where the mobile terminal of a user is accurately is a key factor for providing convenient and useful LBS. The most well known method associated with positioning system is GPS. The signal of GPS satellites can be always acquired outdoors and this system provides comparatively accurate location information. However, there are difficulties in applying GPS directly to indoor positioning because of the weakness of signal. And the positioning using the mobile communication signal between a base station and a cellular phone does not provide adequate accuracy due to some technical limitations of communication systems when applied to navigation. In addition, severe multipaths are present in an indoor environment. So a new wireless communication technology is required for indoor positioning to achieve a better and appropriate accuracy. Wireless local area network (LAN) has been installed in a number of indoor areas such as office, terminal, campus, and park with interests in mobile Internet. Therefore, it is expected that a wireless LAN signal would be easily acquired for indoor positioning. Various positioning measurements like time of arrival (TOA), time difference of arrival (TDOA), and received signal strength may be employed for indoor positioning. Employing TOA or TDOA measurements requires a time synchronization between a transmitter and a receiver. But, a time synchronization between a transmitter and a receiver is very difficult if not impossible in a wireless LAN. Therefore, it is more appropriate to use signal strength for indoor positioning with a wireless LAN.

One method for indoor positioning uses a location fingerprint that can be an average value of signal strength over several seconds at one location. It stores signal strength of the APs as measured at each sample point in a database beforehand. It then compares signal strength of a mobile user with stored signal strength in the database to find a sample point nearest to the user. However, this method needs a number of sample points and requires to build the database of received signal strength at each sample point and to update it since any modifications of indoor structures change the signal strength at sample point. Another method is based on a propagation model that describes how a radio wave loses signal strength as it travels through an environment. The amount of loss is dependent on the propagation environment. The signal strength is typically modelled by using a log distance path loss model with a path loss exponent. The value of the path loss exponent depends on surroundings and building type. The range from a mobile user to an AP can be calculated by the signal strength loss over space. The location of mobile user is determined by triangulation after an estimation of more than three ranges from the user to APs. However, this method has a limitation in that a received signal strength changes over time because of an obstruction and multipath. It requires huge number of sample points and stores each sample point's signal strength to compute an estimated path loss exponent in the propagation model in advance. Then the location of the mobile user is determined by using the propagation model with the previous estimated path loss exponent and the received signal strength of the user. The location accuracy is poor when a present path loss exponent in this model is not the same with the estimated path loss exponent since any modifications of indoor structure or human movements change the received signal strength at sample points.


Layout of the field experiment - Figure 1


Location result - Figure 2

Additional reference point can be installed with APs in wireless LAN to determine a location of a mobile user regardless of any changes in an indoor environment. Reference points and a mobile terminal of a user is needed to resolve a difficulty of inconsistently received signal strength over time due to changes of an indoor environment. The main idea of the reference point is generic enough to be used for other wireless network technologies as well. A reference point is chosen appropriately in the middle of an interested room or indoor area to receive signals with enough strength from all APs. The least square method estimates the path loss exponent in this propagation model. The path loss exponent should be determined for each AP. The signal strength of the APs as measured at additional reference points is used to estimate path loss exponents. And the ranges from the user to all APs are calculated by the signal strength of a mobile user and estimated path loss exponents. Finally the location of the user is determined instantly by triangulation. Differently with conventional propagation method, this method does not assume a path loss exponent in a propagation model as constant because it estimates the path loss exponent by using received signal strength at reference points when mobile user request his location in an indoor environment.

This indoor positioning can be implemented in two ways. One is handset-based implementation and the other is network-based implementation. Handset-based positioning system consists of three parts, which are one mobile terminal of a user, several APs and several reference points. The mobile terminal stores a known location of each AP and a location of each reference point in advance. Each reference point monitors signal strengths received from all APs. A mobile terminal also monitors them similarly at the same time. The mobile terminal estimates the path loss exponent in a propagation model with the received signal strength of reference points. Next, it determines the location of the user with an estimated propagation model and received signal strength of the mobile terminal and already known APs' location and reference points' location. Network-based positioning system consists of four parts, which are one mobile terminal of a user, several APs, several reference points and one additional positioning server. Positioning server instead of the mobile terminal stores known APs' location and known reference points' location in advance. Each reference point monitors signal strengths received from all APs and transfer the received signal strength to positioning server. At the same time received signal strength of the mobile terminal is transferred to positioning server similarly. The positioning server estimates a path loss exponent in a propagation model with already known APs' location and reference points' location and signal strength received from reference points. Next, it determines the location of the mobile user with an estimated propagation model and signal strength received from the mobile terminal.

A test bed for a field experiment is established on the sixth floor of the Automation and Systems Research Institute building in Seoul National University. The layout of this testing area is depicted in Fig. 1. It has dimensions of thirty meters by seventeen meters with ten different rooms. Three APs are installed at the locations indicated with star marks and three reference points are chosen in the middle of two rooms and a hallway at x marks. The signal strength of reference points received from all APs is collected. Three 3COM wireless LAN access points are used for APs in IEEE 802.11b infrastructure. And four Orinoco wireless LAN silver network interface cards are used for three reference points and one mobile terminal of the user. Mobile handsets for reference points and a mobile user are assumed as laptop computers. An HP laptop computer is used for the user and three Samsung laptop computers are used for three reference points. Each AP acts as a wireless signal transmitter and the reference point. The mobile terminal acts as the wireless signal receiver using a laptop computer with Lucent Technology Orinoco wireless LAN card. This wireless LAN card can detect the signal strength received from APs. The mobile user is assumed to go around two large rooms and a hallway, each of which has a reference point. An experiment has twelve test points and eight signal strengths received from APs are collected at each test point for two seconds.

Fig. 2 shows the location accuracy using three reference points for indoor positioning in the field experiment. First, the three APs' location is represented as star marks and the three reference points' location as x marks in this figure. Next, the true position of the mobile user is represented as circle marks and the estimated position of the user as square marks. The mean of location error is 2.8m and the standard deviation of location error is 1.7m from all test points.

The meter-level accuracy for indoor positioning is obtained from these results. This method has the advantages that there is no need to construct the database of the received signal strength of a number of sample points in advance and update it periodically. The obstruction such as wall, human and spatial structure in the indoor environment need not be considered for positioning as well. In summary, the location of a mobile user can be determined by indoor positioning method using wireless LAN received signal strength.

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Shorten the road to done

JAMFEST, A cost effective solution to GPS vulnerability testing

JAMFEST, was aimed at providing low to no cost, realistic, GPS jamming scenarios for testing GPS-based navigation systems, as well as, training personnel in unique GPS denied environments

Lt Col Eric Lagier, Capt Desiree Craig, Paul Benshoof

The 746th Test Squadron (746 TS) has conducted complex GPS jamming experiments since the early 1990s and played a key role "behind the scenes" creating multiple high-profile jamming environments for programs such as the Joint GPS Combat Effectiveness (JGPSCE) exercises and Quick Reaction Tests. These programs, conducted to support real-world operations, enhanced the 746th TS's ability to recreate realistic jamming environments and resulted in the 746 TS earning the reputation as the recognized experts for open-air GPS vulnerability testing.

The 746 TS conducted JAMFEST as an opportunity to broaden both the operational and test communities' awareness of GPS vulnerabilities by offering a cost-effective, operationally realistic venue to facilitate testing and training objectives. This opportunity was truly important to the operational and test communities because GPS signals use very low power and are vulnerable to both intentional and unintentional interference. These effects can adversely impact the position and timing accuracy of various receivers and navigation devices employed by military and civilian users.

Because of this adverse impact, it was critical to the success of the program that the jamming environment be both operationally realistic and beneficial to the military and civilian users. Specifically, it involved coordinating frequency clearances, securing range space, developing jamming scenarios, deploying personnel and equipment, operating the threat assets, data reduction and analysis, reporting, and securing funding for the program. By capitalizing upon their unparalleled experience base, the 746 TS easily met and overcame these tasks.

The 746 TS designed innovative vulnerability scenarios that streamlined test conduct into a one-week event that maximized set-up efficiency and significantly reduced costs to the participants. This was the first in a series of recurring events.

Objectives/Resources

The overall objective of JAMFEST was to provide and characterize the GPS jamming environment in multiple configurations to enable the participants to test, train, or gain experience in a GPS jammed scenario. Each participant used JAMFEST to execute their own objectives, which included the following:

- Evaluate the effects of jamming on a representative set of GPS receivers to determine the effective range from the jammers and the power level that disrupts GPS tracking;
- Evaluate potential benefits of anti-jam technology available to civil operators;
- Collect performance data against specific targets/environments that will confirm proper operation of the overall locator system and sub-system;
- Subject anti-jam systems under test to high GPS jamming/Signal (J/S) environments and compare results;
- Collect jamming environment truth data to improve and verify laboratory modeling and simulation tools, vulnerability prediction analysis, and mission planning software;
- Validate tactics, techniques and procedures (TTPs) using hand held receivers (HHRs).

To effectively execute these objectives, the 746 TS employed multiple test assets to configure an operationally representative GPS jamming environment. The ground jamming configuration was set up on White Sands Missile Range (WSMR).

One of the primary test resources used to create the jamming environment was the Portable Field Jamming System (PFJS). The PFJS (see Figure 1) is a modified Ford 350 van with a full suite of GPS Electronic Warfare (EW) equipment, which included TMC Advanced Threat Emulators (TATEs) and TAVIA-32 Emulators (TAVIAs) as well as a variety of high power adjustable amplifiers. The onboard EW equipment was programmed to provide a wide range of jamming scenarios and signal modulations. The system records time-tagged amplifier power output for test analysis and time correlation to the test item.

Another key resource employed was the Tactical Field Jamming System (TFJS). The TFJS (see Figure 2) is designed to supply the same capabilities as the PFJS, but in a vehicle capable of accessing terrain

Figure 1. Portable field jamming system

Figure 2. Technical field jammer system

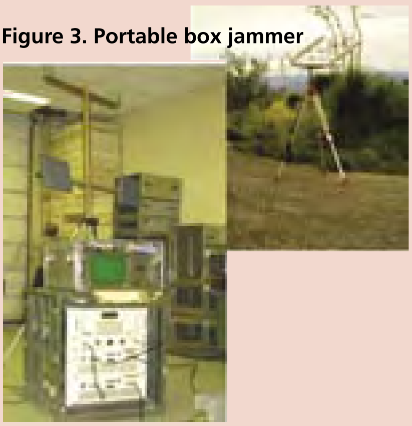

Figure 3. Portable box jammer

Figure 4. C-12J

that is more rugged. Each TFJS is a modified High Mobility Multi-Purpose Wheeled Vehicle (HMMWV) that comes equipped with a full suite of GPS EW equipment, which includes TATEs and TAVIAs, as well as a variety of high power adjustable amplifiers. Due to the TFJS's ability to be positioned in areas inaccessible to most vehicles, these jammers were set up in remote territory and controlled via radio modem.

Portable Box Jammers (PBJ) (see Figure 3) in conjunction with the PFJSs and TFJSs, were set up along designated range roads and remote locations to help create the jamming environment. Each PBJ is a stand-alone jamming system designed to supply the same capabilities as the PFJS and TFJS, but in a smaller, more versatile package. Each system was equipped with portable generators, a portable antenna mast and tower, and a full suite of GPS EW equipment that included TATEs and TAVIAs, as well as a variety of high power adjustable amplifiers.

The 586th Flight Test Squadron (586 FLTS), a sister squadron to the 746th TS, characterized the jamming field using the C-12J (see Figure 4). The C-12J is a Beechcraft 1900 twin turbo-prop aircraft that has been modified to for GPS/inertial guidance and navigation components and systems tests. Its capacities include a 16,600-pound maximum gross weight and a maximum of four test stations or equipment pallets. The aircraft was configured with controlled reception pattern antenna (CRPA) ports and fixed reception pattern antenna (FRPA) ports on the top and bottom of the fuselage.

During JAMFEST, the C-12J carried 746 TS equipment designed to collect airborne reference measurements of the GPS jamming environment. It flew data collection sorties that spanned the airspace and altitudes used by the systems under test.

In any test environment where navigation aids are evaluated, it is paramount that the truth reference data is preserved and collected. This is particularly difficult to achieve in a live GPS jamming environment, because many reference systems use GPS to obtain an accurate truth source. To overcome this obstacle, the 746 TS developed the CIGTF Reference System (CRS); this was the reference system used for JAMFEST. The CRS is a rack-mounted (see Figure 5), loosely/tightly-integrated system, consisting of navigation sensors/subsystems, Data Acquisition System (DAS), and post-mission processing mechanization (see Figure 6).

The DAS, a DOS-based computer, performs the primary functions of data collection and real-time control for the following subsystems: (1) Embedded Global Positioning System (GPS)/Inertial Navigation System (INS) (EGI) navigation system, (2) GPS receiver/receivers, (3) Standard Navigation Unit (SNU) INS, and (4) Cubic CR-100 Range/Range Rate Interrogator/Transponders System (RRS). Other subsystems supported in the CRS architecture are the GPS Environment Monitoring System (GEMS), data link, altitude encoder, and Satellite Reference Station (SRS) receiver supporting differential GPS (DGPS) algorithms. The post-mission processing mechanization utilizes combinations of the subsystem measurements in an extended Kalman filter/smoother algorithm to produce an optimal reference trajectory.

Nominal performance accuracies of the reference trajectory characterized for JAMFEST are detailed in Figure 7.

Event conduct

JAMFEST testing began on 24 May 04 at 2000 MST and spanned 5 days. A total of 12 military organizations, DoD contractors, and civil agencies participated, all with very different goals and objectives.

During the test week, 746 TS engineers conducted GPS jamming

Figure 5. CIGTF reference system

operations from 2000 to 0400 hours on each test day, and characterized the jamming field with ground and aviation monitoring equipment. Additionally, the 746 TS deconflicted all customer flight and ground operations and provided on-site technical experts to help resolve customer difficulties and ensure each objective was met. In some cases, this required significant instrumentation and analysis support.

On each test day, two types of scenarios were offered: (1) Operationally realistic and (2) Experimental scenarios. Operationally realistic scenarios included threat laydowns consisting of one, four, and seven jammers broadcasting on L1 and L2 frequencies and using a variety of waveforms and power levels. Experimental scenarios, on the other hand, were useful for research and development efforts requiring high jamming levels capable of stressing robust anti-jam electronics. These scenarios were achieved by using seven close-proximity jammers focused in the same direction.

Most JAMFEST participants utilized their own test beds and recorded their own receiver data and reference information. These participants either mounted their equipment in rental vehicles, government vehicles and aircraft or walked through the jamming environments. In other cases, the 746th TS provided support to participants who could not supply their own test beds, data collection systems, or reference data. In this situation, customer assets were mounted into the 746 TS land navigation vehicles. Customer assets were connected to FRPAs, CRPAs or prototype antennas, depending on the customer's desires and asset availability.

The jamming scenarios were carefully developed to maximize efficiency and meet everyone's goals. A total of 59 jamming scenarios with different threat laydowns were executed during the test week. Jammer placement was carefully planned to maximize the number and variety of scenarios offered while minimizing relocation and set-up time. Figure 8 depicts three sample jammer placement scenarios.

Utilizing a configuration similar to the one depicted, permitted the execution of one jammer, three jammer and seven jammer scenarios without relocating any of the jammers. This offered the most scenario flexibility while limiting the number personnel required to operate the jammers at these locations. For example, in a one jammer scenario, only the jammer at TX 8 may be used or in a three jammer scenario, the jammers at TX 6, TX 7 and TX 1 may be used. Lastly, in a seven jammer scenario the jammers at TX 1, TX 2, TX 3, TX 4, TX 5, TX 6, and TX 8 may be used. Typically, when these jammers were turned on, vehicles would drive down the corresponding range road, park at a predesignated location or fly though the jamming field. While most participants drove or flew during testing, other participants tested hand-held receivers and walked near the jamming field.

During testing, the jammer configuration alternated between operationally realistic and experimental scenarios. All scenarios utilized a variety of waveforms at low, medium, high, and ramped power levels. The specific waveforms broadcast included Bi-Phase Shift Key, Broadband, Partial Band, Continuous Wave and Swept Continuous Wave, and Pulsed Continuous Wave on both L1 and L2 frequencies.

Another jammer laydown used, involved placing multiple jammers along a predesignated range road all pointed in the same direction. Participants drove into and out of the field to test their equipment in a concentrated GPS jamming environment. Regardless of the means or scenarios used, the participants successfully met their objectives.

Following each test day, 746 TS

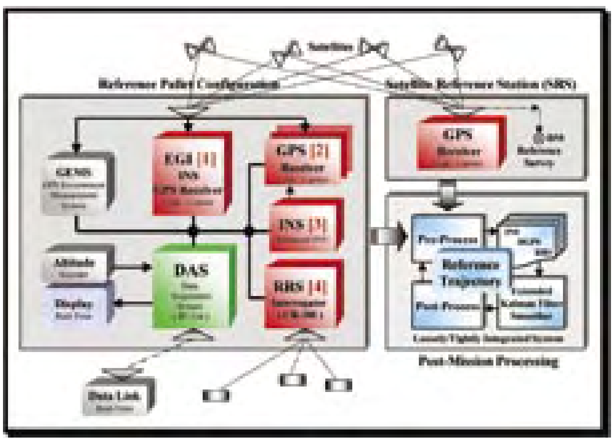

Figure 6. CRS processing mechanisation

Subsystem Configuration	RMS Position (m)		
	Horz	Vert	3D
[1] [2] GPS Code	2.00	2.25	3.25
[1] [2] DGPS Code[1]	1.75	1.75	2.50
Carrier[2]	0.30	0.20	0.35
[4] RRS	1.40	1.00	1.70
SRS Range Constraints: [1] 300-500 nm [2] 50-100 nm			

Subsystem Configuration	RMS Velocity (m/s)			
	East	North	Up	3D
[1] INS/EGI	0.010	0.010	0.010	0.017
[3] INS/ESNU	0.005	0.005	0.005	0.010
Attitude Accuracy: 20 arcsec (Roll,Pitch,Heading)				

Figure7. Reference system accuracies

personnel checked ground jammer logs and collected reference data for accuracy and proper format and provided this information to each participant in the form of a data package. The purpose of the data package was to accurately document the event, cite any necessary deviation(s) from the test plan, detail exact scenarios as they are transmitted, and provide reference data that describes the signals received. Information in the data package was sufficient for each participant to evaluate their own data and generate defensible conclusions.

Summary

JAMFEST serves as an affordable avenue to identify system limitations in a GPS jamming environment so that system designers and users can begin to identify and mitigate vulnerabilities in their specific applications. This is particularly valuable information to civil users who otherwise would not have access to such vulnerability scenarios. After participating in JAMFEST customers are better armed with realistic vulnerability data, to better understand their system limitations, work to mitigate these effects, and apply backup systems or procedures as appropriate.

In addition to civil GPS users, JAMFEST also benefited operational military units who are likely to experience GPS jamming during operational conflicts but may not have actually experienced the effects of jamming during training maneuvers. Training in such electronic warfare environments raises vulnerability awareness and affords the opportunity to devise, implement, and practice countermeasures.

Figure 8. Sample Jammer laydown

Acknowledgements

The authors would like to acknowledge the support of the GPS Joint Program Office, White Sands Missile Range, and the 46th Test Group.

References

1. NAVSTAR GPS System Protection Guide, GPS JPO, LAAFB, CA; 13 Jun 97.
2. 46 TGI 99-1, Safety Review Process; 01 Jun 01.
3. 46 TGI 99-101, Test Management; 30 Aug 01.
4. AFI 10-1101, Operations Security; 31 May 01 (including AAC Sup 1; 08 Apr 99 vice 31 Mar 95).
5. AFI 35-205, Air Force Security and Policy Review Program; 02 Nov 95 (Rev. 17 Jan 97).
6. AFI 91-202, The US Air Force Mishap Prevention Program; 01 Aug 98.
7. MIL-STD-882D, Standard Practice for System Safety; 10 Feb 00.

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"Information from Imagery"

Ian Dowman, President, ISPRS explains the mission and activities of ISPRS. He also discusses the current trends in GPS technologies

Please tell us more about ISPRS?

The International Society for Photogrammetry and Remote Sensing (ISPRS) is a non-governmental organisation devoted to the development of international cooperation for the advancement of photogrammetry, remote sensing and the spatial information sciences and their applications. The Society's scientific interests include photogrammetry, remote sensing, spatial information systems and related disciplines, as well as applications in cartography, geodesy, surveying, the natural, Earth and engineering sciences, and environmental monitoring and protection. Further applications include industrial design and manufacturing, architecture and monument preservation, medicine and others. In short ISPRS is concerned with acquiring and using Information from Imagery, and this stretches from information from imagery from space to imagery from electro microscopes, and the applications range from global climate to monitoring tooth decay.

What are the activities of ISPRS?

ISPRS works on a four-year cycle with the Congress being held every four years and the Commission Symposia being held in the year mid way between the Congresses. Working Groups hold meetings in the other years. The next Congress is in 2008, to be held in Beijing. In addition, ISPRS has a number of publications designed to provide high quality peer reviewed papers, conference proceedings in quick time, and a new bulletin. We publish the International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences and the ISPRS Journal of Photogrammetry and Remote Sensing which contain scientific and technical articles. ISPRS Highlights is the official bulletin of the Society. The ISPRS Book Series was started in 2003 and contains collections of high quality scientific papers, usually presented at ISPRS events, after peer-review.

What is the mission of ISPRS?

The objectives for ISPRS during the next four years, were set out during my speech as incoming President at the Congress:

- Sustain and develop the scientific programme based on international excellence in research and in collaboration with other international scientific unions;
- Expand the international role of ISPRS by building on our existing links and developing a presence in developing countries;
- Continue the role of ISPRS in education and technology transfer in collaboration with international partners;
- Develop the Foundation and attract $500 000 of funds by 2008.

An excellent team of Working Group chairs and co-chairs has been appointed and over 30 workshops have already been held or are planned for 2005. The planning for the eight Technical Commission Symposia in 2006 is well advanced.

What is the international role of ISPRS?

We attend meetings of international organisations such as UN COPUOS, GEO, UN CODI and UN Cartographic Conference for the Americas. The objective of involvement in these meetings is to put the view of the photogrammetry and remote sensing community forward to the policy makers and purse holders in the international arena, and also to seek opportunities for ISPRS members and working groups to become involved in international projects and initiatives.

What is the role of ISPRS in education and technology transfer?

Technical Commission VI is responsible for Education and Outreach and has working groups which deal with various aspects of this. ISPRS Council also has a strategic role in planning outreach activities, especially in collaboration with other organisations such as UN. Council has decided to concentrate capacity building efforts on Africa as there is a clear need in this region, and it also an area where ISPRS members need support. We will maintain contact with African members through an email network, by attendance by a member of Council at one meeting in Africa per year and the organisation of a members meeting every 2 years. We will also support capacity building though collaboration with other organisations, such as ESA, CEOS or UN OOSA, to run tutorials and training courses; through sponsorship of people to workshops and regional meetings, possibly jointly with our Ordinary and Regional Members, and to collaborate with the ICSU GeoUnions in GeoInformation for Africa.

What is the funding source of ISPRS?

Of course if we are to do all of this properly, we need funds. ISPRS relies on subscriptions from members and some income from symposia and the Congress to fund its work. The ISPRS Foundation was launched in Istanbul in order to attract donations from other sources, and already we have attracted donations of $US50,000. Council has also decided to transfer $200,000 from our reserves to the Foundation as a loan to allow support for worthy activities to start as soon as possible.

Do you have any specific programme to encourage positioning technologies like GPS?

ISPRS has an interest in positioning technologies where they impinge of the collection of image data. Obvious examples are establishing the position and orientation of platforms with sensors in space and on aircraft for LiDAR and IfSAR. Another important example is mobile mapping systems. We have working groups that cover these topics and which investigate aspects of positioning.

What future you see of GPS technology?

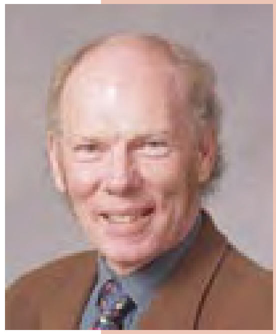
As I have already indicated positioning is already important for acquisition of imagery, and will become more so as equipment becomes smaller and less expensive; but the future will see the combined use of GPS and other GNSS, and this will make such technology more accurate and more reliable.

Do you think that ISPRS has played a significant role in bringing technology to developing world? Any significant impact?

I like to think that we have played a role through our programme of workshops and symposia. The Commission VII Symposium which was held in Hyderabad in 2002 attracted many people from India and neighbouring countries and we also held a technology transfer workshop in Dar es Salaam in 2001. It is because we feel that we could do more, that we have decided to focus on Africa during the current four-year period and we hope to work with regional organisations and with other international societies to become more effective in the future.

Would you like to mention the three key achievements of ISPRS?

I believe that the most important achievement of ISPRS is to have created a network of over 100 national and regional organisations, which can exchange ideas and develop the science and technology of photogrammetry and remote sensing through discussion between scientists, industry and users. We have also made the voice of the photogrammetry and remote sensing community heard in international circles through our membership of United Nations fora, the International Council of Science, GEO and CEOS. A third major achievement is to have created a Youth Forum which will enable young people to appreciate the importance of our science at an early stage in their careers, and to start to make ISPRS stronger, and hence able to reach more people, especially in the developing world.



Ian Dowman has worked as a photogrammetrist for 40 years in the field of applying photogrammetric techniques to a wide range of image sensors for surface and feature extraction. He has developed geometric models for accurate 3D modelling from SPOT data, and for a range of subsequent sensors, including RADAR and LIDAR systems. He has been a principal investigator for SPOT, ERS, JERS and RADASAT. In recent years the main thrust has been in the generation of digital elevation models and features from high resolution sensors and in using such techniques for the automation of registration of images to other images and to maps. He has been the project manager for the EU 4th Framework ARCHANGEL project for registration and change detection and has also carried out numerous research projects for Ordnance Survey, DERA and UK industry in the areas of feature extraction from imagery. He recently won a Joint Research Equipment Infrastructure grant from EPSRC worth £419K for equipment for 3D image measuring, processing and presentation, in collaboration with LH Systems and Laserscan. Current research focuses on use of LiDAR and IfSAR data, particularly with high resolution image data, and on the use of DEMs for geotectonic studies. Ian Dowman has been awarded the President's Medal of the Photogrammetric Society in recognition of his contributions to advancement of Photogrammetry. From 1996-2000 he was the President of ISPRS Technical Commission II, 2000-2004 he was Secretary General and is now President of ISPRS. From 1996 to 1998 he was Dean of Engineering at UCL.

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Beginning of a cycle of innovation

A report on ION GNSS 2005, 13-16 September, Long Beach, USA

GLEN GIBBONS

Recent evolution of the ION Satellite Division's flagship conference - - named after GPS for the first 15 years, GPS/GNSS in 2003, and GNSS since 2004 – received triple validation at this year's event: in the plenary session, in the content of the technical program, and in the multi-system products introduced at the exhibition.

A revived Russian GLONASS system and a European Galileo program on the eve of its first satellite launch have joined the US NAVSTAR Global Positioning System to usher in a new era in space-based positioning, navigation, and timing (PNT). But presentations at ION GNSS 2005 in Long Beach, California, revealed just how early in the process we are. Many years will pass before the full benefits of current GNSS modernization efforts are felt. More than 300 papers presented this year, counting those submitted for two off-site classified sessions held at Boeing's Seal Beach facilities.

At the system level, each of the three GNSS programs reported new developments: earlier this year, the GPS Joint Program Office (JPO) broke the GPS Block III acquisition into two contracts – one for new satellites and one for upgrading the operational control segment. JPO plans to award those contracts in summer 2006, JPO Director Col. Allan Ballenger told the plenary session audience. Meanwhile, the first launch of the modernized Block IIR-M satellite had been rescheduled for September (and subsequently took place on September 26), the first Block IIF launch is now set for 2007, and Block III spacecraft will go into space beginning in 2013. The Block IIR-M satellite will be the first transmitting the new military signal (M-code) and a second open civil signal at the L2 frequency (L2C).

Luis Ruiz, a member of the technical division of the Galileo Joint Undertaking (GJU) that is overseeing this phase of the Galileo project, told that the GJU hopes to complete a contract by December for a concessionaire to complete and operate Galileo. The agency is negotiating with a consortium of leading European aerospace and telecommunications companies, with financial details of the concession expected to be completed by April or May 2006, Ruiz said.

Galileo program officials also finally have acknowledged that the system will not be fully operational until early 2011, two years late. With funding, satellites, and a concession contract nearly in hand, a new question appears to have replaced the previous ones at the top of the Galileo FAQ: Will Galileo really be built, or when will the first satellite be launched? Now the leading question for Galileo officials seems to be, "When will the Galileo ICD (interface control document) be completed and published and where can GNSS designers and manufacturers get a copy of it?" "We have published 90 percent of the Galileo [open signal] ICD and presented it in European standardization bodies," Ruiz said . "Once intellectual property rights are put in place, the full ICD will be published."

The Russian program GLONASS is the only one that has delivered in recent years on the schedule as planned. Following a brief period 1996 when a full constellation was operating on orbit, the Glonass constellation dwindled to fewer than eight operating satellites in 2001. A re-examination of the program a few years ago led to a new commitment by Russia to rebuild and modernize the system. It has 13 operating satellites. Since December 2003, a modernized spacecraft (GLONASS-M) has been broadcasting an open signal at L2 as well as at L1. Another GLONASS-M satellite is still undergoing on-orbit testing and two more are scheduled for launch on December 25. The Russian Space Agency plans to have 18 operational satellites on orbit and broadcasting by early 2008 and 21 satellites by around 2010, according to Sergey Revnivykh of Satellite Navigation Control Center's Space Mission Center, Central Research Institute of Machine Building.

Another new GNSS program discussed at the plenary is Japan's Quasi-Zenith Satellite System (QZSS), a regional constellation that would put three or more spacecraft into geosynchronous orbit. QZSS is designed to ensure a GPS-like signal high overhead for users in Japan's challenging signal environments in large cities and mountainous terrain. The current program schedule calls for a first experimental QZSS satellite launch in 2008 and a second in 2009 with full deployment by the end of that year.

When all these efforts reach fruition by 2013, GNSS users will have access to more than 80 satellites transmitting three open signals and another set of encrypted services, some of which will be available commercially. Also, space- and ground-based augmentation systems will be operating in several regions: the U.S. Wide Area Augmentation System, the European Geostationary Overlay Service, Japan's MSAT Space-based Augmentation System, India's GPS and GEO Augmented Navigation (GAGAN), and Australia's Ground-based Augmentation System (GRAS).

In addition to the progress in expanding and modernizing a complementary GNSS infrastructure, we may be entering a new era in which cooperation replaces – or, at

least, accompanies – the currently competitive relationships. As plenary speaker Ray Swider – a U.S. Defense Department program analyst for GPS, positioning, and navigation – observed, "We need more political leadership. We need to be more frank and get our cards out on the table and figure out what this GNSS compatibility is all about."

Amid the myriad papers on signal processing algorithms and multipath mitigation techniques, several avenues of technical exploration stood out. GNSS software radios, which first appeared in ION technical sessions a few years ago, continue to evolve steadily – primarily as analytical tools for product designers, but with the promise of commercial applications in their own right in the future.

At the exhibition, NovAtel released preliminary specs for an L1/E5a receiver card capable of tracking L1 and L5/E5a Galileo, GPS, or SBAS signals in either a stand-alone Euro card form factor or integrated into the company's Galileo Test Receiver rack mount enclosure. Javad Navigation Systems announced its 72-programmable channel GeNiuSS chipset reportedly capable of tracking GPS and GLONASS L1/L2 C/A and P-code signals and Galileo L1, E5, and E6 signals. Topcon Positioning Systems introduced its 72-channel G3-Paradigm chipset that will be the basis for a new generation of Topcon GPS+ products and will first appear in the new Net-G3 reference receiver. Septentrio, which is under contract with ESA to develop Galileo test user equipment, offers its GeNeRx1, a combined GPS/Galileo receiver that can be flexibly configured to simultaneously track Galileo as well as GPS satellites in multi-frequency mode. And NordNav announced a Galileo Upgrade Package for its R-30 software receiver. GPS/inertial products were represented in the exhibition by several exhibitors including Honeywell, BAE Rokar, BEI Systron Donner, and Crossbow.

Glen Gibbons Editor, Inside GNSS
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MARK YOUR CALENDAR

November 2005

International Conference: "Earth Observation foaterr vegetation monitoring and water management"
10-11 November Naples, Italy
durso@unina.it

10th Internatonal GIS Seminar in Korea, 14-15 November 2005,
Seoul Education & Culture Center, Seoul, Korea
junghkim@krihs.re.kr

Qatar GIS Conference & Exhibition 2005
14 -16 Nov, Qatar, Doha
info@gisqatar.com
http://www.gisqatar.com

7th Gulf Water Conference - Water in the GCC - Towards an Integrated Water Resources Management (IWRM)
19-23 November Kuwait
gwater7@kisr.edu.kw

First National GIS Symposium in Saudi Arabia
21 November - 23 November 2005
Eastern Provice,Saudi Arabia
http://www.saudigis.org

South East Asian Survey Congress
21 - 25 Nov , Brunei
secretarygeneral@seasc2005.org.bn
http://www.seasc2005.org.bn/congven.html

GEO-INFO Congres
23 - 25 November 2005
Amsterdam, The Netherlands
info@geo-info.nl
http://www.geo-info.nl

25th International Cartographic Congress
28 Nov – 1st Dec 2005Sagar, M.P. India
rkt_sagar@hotmail.com,
inca25_sagar@yahoo.com
www.incaindia.com

Short term course on "GPS Surveying"
28 November - 2 December 2005
IIT ,Roorkee
gjkumfce@iitr.ernet.in

Navigation 2005
30 Nov-1 Dec, The Hilton, San Jose, CA
www.telematicsupdate.com/navigation2005
register@telematicsupdate.com

2nd International Conference 'Earth from Space'
30 Nov - 2 Dec, Moscow, Russia
http://www.transparentworld.ru/conference/

December 2005

First International Symposium on Health GIS
1 - 2 Dec, Bangkok, Thailand
healthgis@gmail.com

Middle East and Africa Conference for ESRI Users 2005
6 – 8 Dec 2005
meauc2005@qs4it.com
www.qs4it.com/meauc2005

ISPRS Workshop On Spatial Planning & Decision Support **Systems**
8-10 December Macres, Kualalumpur Malaysia

25th ISRS Annual Convention and National Symposium
6 - 9 December 2005
secretary@isrs2005.org
http://www.isrs2005.org

42nd Annual Convention and Meeting of the IGU
Earth system processes related to earthquakes, tsunamis and volcanic eruptions Back
7-9 Dec 2005,India, Bhopal
ak_gwal@yahoo.co.in
http://www.igu.in/schedule.htm

GNSS 2005
8 – 10 Dec, Hong Kong, China
lswuchen@polyu.edu.hk
http://www.lsgi.polyu.edu.hk/GNSS2005

Gulf Traffic - GIS Zone
12 - 14 December, Dubai UAE
davyd.farrell@iirme.com
http://www.gulftraffic.com

ITC 55 years Lustrum Conference
14 - 16 Dec 2005
The Netherlands, Enschede
verburg@itc.nl
http://www.itc.nl/news_events

January 2006

First Asia-Pacific Conference for ESRI Users
January 12-13, 2006 · Hong Kong, China
http://www.esrichina-hk.com/apuc2006/

International Symposium: Informatics for Geoinformatics
23-25 January 2006 Ostrava, Czech Republic
www-gis@vsb.cz.

Regional GBIF training workshop for Southeast Asia
25-27 January 2006.
Lucknow, India
www.gbif.org.

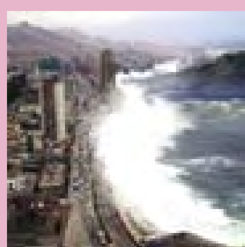
February 2006

International LIDAR Mapping Forum 2006
13-14 February, Denver, U.S.A
organizer@lidarmap.org.

42nd Annual Conference

Annual Convention and Meeting on "Earth System Processes Related To Earthquakes, Tsunamis And Volcanic Eruptions"

December 7-9 2005, Gyan Vigyan Bhavan, Barkatullah University, Bhopal



Topics to be covered

- Solid Earth Geophysics
- Atmosphere, Space and Planetary Sciences
- Marine Geosciences
- Theoretical and Experimental Geophysics
- Environmental Geophysics
- Geoscientific Instrumentation
- Exploration Geophysics

EXHIBITION - An exhibition of Geophysical and Allied Instruments will also be organized The exhibition will enable delegates to gain a comprehensive overview of the products and services available as well as an opportunity to discuss the latest developments with representatives from the major companies serving the needs of the exploration industry.

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Dr.P.R.Reddy Phone No.040-23434662 (O), 27006534 (R) Fax No.040-27171564, 23434651 E.mail: igu123@rediffmail.com

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