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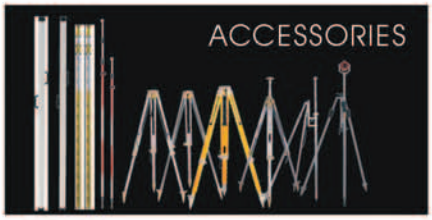

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# Building on capacities

According to various reports, a significant number of graduates in India are not suitable for employment.

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an environment that is conducive for analytical research

and that maintains high global standards.

This is especially essential for Geomatics education.

We need heroes from the academia of the developing world.

Not as exceptions, but as the norm.

**Bal Krishna, Editor**
**bal@mycoordinates.org**

# GNSS education in Asia Pacific: Miles to go

With our universities and numerous polytechnics offering Geomatic program, more is expected from them

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THERE seems to be numerous GNSS education and training programs around locally, with government's institutions and agencies taking the lead. Private industries such as GNSS vendors are also running specialized short courses, specifically hardware and software specific. Those taking the courses come from a huge variety of backgrounds - environmentalists, people working in local and central government, utility companies, the military and non-governmental organizations. And there seem to be about hundreds of different GNSS and related textbooks.

Yet, despite all this, GNSS education and training is astonishingly lacking behind and - in our view - is mostly stuck on historical tramlines. Since the emergence of GPS in the middle 1980's and lately GNSS, there has been a shortage of skills in its use at several levels. Most educators were of the view that the technical complexity of GNSS operations and their sophisticated implementation requirements made the design and development of GNSS difficult to understand.

**Table 1: General Trend in Knowledge Generation in Asia**

| Nation | GDP 1999 (US $Billion) | R&D Expenditure as % of GDP (1998) | US Patents Taken (1975-2000) |
|---|---|---|---|
| Japan | 4,357.7 | 2.90 | 426,702 |
| China | 991.2 | 0.69 | 1393 |
| South Korea | 406.9 | 2.68 | 19,935 |
| India | 440.5 | 0.67 | 1127 |
| Taiwan | 288.6 | 1.98 | 31968 |
| Indonesia | 151.9 | 0.09 | 153 |
| Thailand | 125.3 | 0.17 | 238 |
| Malaysia | 78.9 | 0.20 | 384 |
| Hong Kong | 158.6 | 0.25 | 4316 |
| Singapore | 84.9 | 1.79 | 1406 |
| Philippines | 76.5 | 0.08 | 228 |

## Background

In Malaysia, GNSS education and training programs appears under Geomatic field of study. Geomatic study primarily entered university curricula in the mid-1980s, although there are notable exceptions such as at the UTM which commenced its undergraduate program a decade before in the early 1970s.

Teaching of Geomatic through the 1990's continued to follow a largely conventional path with lectures on theory plus practical exercises using either the latest technology from the major vendors (such as Ashtech and Trimble) or more commonly through the use of more simplified PC-based, university-developed software products.

Since those early years, UTM, USM, UPM and UiTM have now established graduate programs in Geomatic, while individual service subjects have also been made widely available for students. However, there is now an increasing trend towards the recognition of Geomatic technology as a discipline in its own right, and complete programs are becoming available at the undergraduate and graduate level. Examples from UTM include: the Bachelor of Geomatic Engineering.

The current Geomatic undergraduate degree administered by the Department of Geomatics at the UTM is the Bachelor of Geomatic Engineering - a four-year professional course of study that meets the requirements of the Institution of Surveyors, Malaysia. The degree originally had its foundations in land surveying and mapping science, but in recent years has moved into the wider domain of Geomatic field. Nonetheless, it is still fundamentally a professional engineering degree structured around the requirements of the professional bodies and licensing authorities that accredit it.

However, the Geomatic engineering

Table 2: Number of Patents Produced for the Geomatic Field

| Period/ Country | 1982-1986 | 1987-1991 | 1992-1996 | 1997-2001 | Total |
|---|---|---|---|---|---|
| Japan | 3 | 7 | 117 | 108 | 235 |
| China | 2 | 10 | 1 | 1 | 14 |
| South Korea | 0 | 1 | 3 | 5 | 9 |
| India | 0 | 0 | 0 | 2 | 2 |
| Taiwan | 0 | 1 | 5 | 14 | 20 |
| Indonesia | 0 | 0 | 0 | 0 | 0 |
| Thailand | 0 | 0 | 0 | 0 | 0 |
| Malaysia | 0 | 0 | 0 | 0 | 0 |
| Hong Kong | 0 | 0 | 2 | 1 | 3 |
| Singapore | 0 | 0 | 2 | 1 | 3 |
| Philippines | 0 | 0 | 0 | 0 | 0 |
| Others | 413 | 667 | 1058 | 1018 | 3156 |

discipline has rapidly expanded over the last decade—to the extent that the geographic component of information technology has now become a major global growth area. Indeed, annual worldwide expenditure in this field (in terms of software, hardware, training and data) is estimated to grow tremendously. Thus, the demand for qualified graduates in this area is becoming more acute than ever before, and is certainly greater than the demand for graduates from the Department's mainstream professional engineering degree.

While the B. Sc. Geomatic Engineering degree has moved a long way towards helping to meet the shortfall in human capital in the GNSS industry, it is still constrained by its need to serve the land surveying and engineering professions, yet the rapidly growing locational information industry is continuing to demand at a greater heights.

## GNSS education

Generally, what is required in programs of GNSS education are topics covering understanding of the GNSS system, its capability and limitations, extent of applications, and other associated or related topics. These could be achieved through taught modules as well as hands-on sessions (Walter, 2002 and Merry, 2002).

Within the understanding of the GNSS systems, discussions could be made on the system architecture and working principles, hardware and operations. For example, users should understand that GNSS are radio navigation systems which uses satellites to transmit the navigation signals to its users. The satellites however are passive devices. It only re-transmitting back whatever information uploaded to its memory. The system is actually governed by a network of Ground Control Stations which maintains and defined the reference datum, as well as tracking the satellites to determine its orbital motion. The users on the other hand requires a suitable receiver to receive signals from the satellites to obtained its services. GNSS offers at least three services, namely location-based services (LBS), precise timing and military/scientific. For the LBS, users need to receive at least signal from four satellites and using a triliteration formula within the receiver's firmware, to compute its position with respect to the reference datum of specific system. For the precise timing applications, a single satellite is what is needed to give time accurate to about a millisecond. Signals of GNSS could also be used for scientific purposes, such as for the monitoring of the Total electron Content (TEC) of the atmosphere (Walter, 2003).

Users also need to know capabilities and limitations of GNSS. On a basic mode user operation, GNSS could give positioning accuracy to within several tenths of meters and height determinations to about three times as worse. On a differential mode (D-GNSS), a significant improvement could be achieved, with positioning accuracy to 2-3 meters only and height to about 5-7 meters. With the use of carrier-phase data of the transmitted signals, a more sophisticated receiver as well as rigorous data processing algorithm, user could determine their position up to couple centimeters and height to about several centimeters. Limitations to GNSS services are mainly things that interrupts the operation of its system, such as the delay in the propagation path of the signal caused by the atmosphere, signal blockage such as by dense tree foliage and structures such as building walls and tunnels. For sure, GNSS signals could not travels in water. GNSS need a reasonable area of open sky, to enable the receiver receiving its signal. GNSS signals could also be interrupted by other signal transmissions from such as radio and cellular services tower.

Users have to be aware that at least two of the existing GNSS, namely the GPS and GLONASS are military navigation system, hence having a dual-service signals, military and civilian. By this virtue, military usage of these systems takes precedent over the civilian usage. By default also, military services is of several fold better than the civilian services.

## GNSS education programs in Malaysia

GNSS education and training programs in Malaysia can be grouped into formal education programs, short-courses and other programs.

### Formal GNSS education programs

Formal GNSS education programs are carried out through taught course and research, leading to an academic award.

Universiti Teknologi Malaysia (UTM) is probably the only local university offering taught courses in GNSS. Masters in Science (Satellite Navigation) contains subjects such as Navstar GPS, GPS Navigation, Navigation Systems, and Intelligent Transportation System. While Masters in Science (Satellite Surveying) contains subjects of GPS Surveying, GPS Geodesy, GPS Navigation, and GPS Applications in Surveying and GIS. Two other programs, Masters in Science (Geomatic Engineering) and Masters in Science (Hydrographis Surveying) contain a couple of GNSS related subjects (FKSG, 2003).

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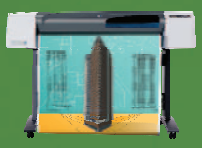

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UTM is also teaching several GNSS subjects in their Bachelor Degree of Geomatic Engineering, namely GPS Surveying, Satellite Navigation, and Hydrographic Positioning Systems. Post Graduate program through research works related to GNSS are also offered in areas of Satellite Navigation, Satellite Surveying, Geomatic Engineering, Hydrographic Surveying.

Universiti Putra Malaysia (UPM) teaches subject of Satellite Surveying in their Bachelor of Civil Engineering as well as subject of GPS in their Masters of Engineering (Remote Sensing and GIS) (Mansor, 2004). Universiti Teknologi Mara (UiTM) are teaching topics of GNSS in subjects such as Physical and Satellite Geodesy, Geodetic Surveying, and Hydrography, under their Bachelor of Surveying Sciences and Geomatic, as well as subject of Geodetic Surveying under their Diploma of Geomatic Science program (Rosdi, 2004). Universiti Teknologi Petronas (UTP) teaches topics of GNSS in subject Geomatic under their Bachelor of Civil Engineering, while Akademi Laut Malaysia (ALAM) also teaches topics of GNSS in their subject of Electronic Navigation Aids (ENA) (Matori, 2004). Universiti Sains Malaysia (USM) is also teaching GNSS and related topics in their Bachelor of Civil Engineering program (W. Ismail, 2004).

### Short-courses

The institutions mentioned earlier, from time to time offer short courses in GNSS and related topics. Apart from that, Institut Tanah dan Ukur Negara (INSTUN), under the Jabatan Ukur dan Pemetaan Malaysia (JUPEM) also offers short courses in GNSS and related topics, which are primarily for their own staff in-house HRD programs. These courses are mainly focused on subjects or topics. The other parties that offers short-courses, which on the other hand focuses on instrumentations – hardwares and softwares – are GNSS related local vendors.

### Other GNSS education programs

Local institutions also organize seminars and meetings on GNSS and its related fields.

Such meetings are (just to mentioned several of them, for example);

1) UNOOSA The first regional workshop was held in Malaysia in August 2001 for countries in Asia and the Pacific
2) International Symposium and Exhibition on Geoinformation series, started 2002 - current
3) National Seminar on Geoinformation, started 1997 – 2001
4) National Seminar on GNSS Applications, started 2004.

## The new geomatic & GNSS era

In this era of the so-called GNSS era, knowledge and innovation is considered as a crucial input in the industrialization and development of any nations. The GNSS economy is strongly influenced by the liberalization of international trade system worldwide where emphasis is given to competitiveness. With this scenario, the importance of knowledge as a factor determining the growth of nations is critically important. Malaysia, as a developing nation, sourced out its quest for high-tech knowledge from abroad, especially in the early stages of her development.

But the New Economy changed how businesses are conducted and the new rules of the game require speed, flexibility and innovation. A metal casting firm uses computer-aided manufacturing technology to cut cost, time and energy. A farmer who sows genetically altered seed and drives a tractor navigate by the GPS satellites. Or a toy manufacturer that uses the Internet to take orders from customers all over around the world. The New Economy gives birth to industry giants such as the Apple Computers from Steve Job's and Steve Wozniak's garage and Dell Computers from the trunk of Michael Dell's car. A nation's economic success will increasingly be determined by how effectively they can spur

**Table 3: Patent Counts of Other Sectors for Selected Asian Countries**

| Sector / Country | Advanced Material | | | | Automotive | | | | Health | | | | ICT | | | | Transport | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 82-86 | 87-91 | 92-96 | 97-01 | 82-86 | 87-91 | 92-96 | 97-01 | 82-86 | 87-91 | 92-96 | 97-01 | 82-86 | 87-91 | 92-96 | 97-01 | 82-86 | 87-91 | 92-96 | 97-01 | |
| China | 0 | 2 | 4 | 6 | 0 | 10 | 7 | 16 | 1 | 16 | 38 | 45 | 2 | 21 | 36 | 56 | 1 | 2 | 3 | 6 | 272 |
| | (12) | | | | (33) | | | | (100) | | | | (115) | | | | (12) | | | | |
| Hong Kong | 0 | 1 | 1 | 1 | 1 | 2 | 3 | 3 | 1 | 4 | 12 | 17 | 7 | 7 | 26 | 32 | 1 | 1 | 2 | 3 | 115 |
| | (3) | | | | (9) | | | | (34) | | | | (72) | | | | (7) | | | | |
| India | 0 | 2 | 6 | 6 | 0 | 0 | 3 | 4 | 11 | 15 | 57 | 65 | 1 | 4 | 41 | 49 | 0 | 0 | 3 | 9 | 276 |
| | (14) | | | | (7) | | | | (148) | | | | (95) | | | | (12) | | | | |
| Japan | 46 | 1329 | 1862 | 3053 | 2058 | 3754 | 3217 | 4326 | 1497 | 2510 | 3008 | 3867 | 7012 | 16208 | 25015 | 45924 | 432 | 1215 | 1560 | 2006 | 129899 |
| | (6290) | | | | (13355) | | | | (10882) | | | | (94159) | | | | (5213) | | | | |
| Malaysia | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 0 | 0 | 2 | 2 | 2 | 4 | 10 | 15 | 0 | 0 | 2 | 4 | 45 |
| | (1) | | | | (3) | | | | (4) | | | | (31) | | | | (6) | | | | |
| Singapore | 0 | 2 | 3 | 7 | 1 | 0 | 0 | 1 | 0 | 0 | 3 | 5 | 1 | 8 | 82 | 127 | 0 | 1 | 0 | 1 | 242 |
| | (12) | | | | (2) | | | | (8) | | | | (218) | | | | (2) | | | | |
| South Korea | 1 | 3 | 57 | 65 | 2 | 27 | 72 | 103 | 5 | 12 | 74 | 92 | 4 | 224 | 1629 | 3429 | 0 | 7 | 38 | 65 | 5549 |
| | (126) | | | | (204) | | | | (183) | | | | (5286) | | | | (110) | | | | |
| Taiwan | 1 | 9 | 45 | 83 | 15 | 109 | 204 | 326 | 4 | 8 | 34 | 101 | 12 | 113 | 1007 | 1743 | 1 | 22 | 39 | 47 | 3923 |
| | (138) | | | | (654) | | | | (147) | | | | (2875) | | | | (109) | | | | |

Note: Number in brackets is the total of each sector.

technological innovation, entrepreneurship, education, specialized skills, and the transition of all organizations—public and private—from bureaucratic hierarchies to learning networks.

## General trends in geomatic knowledge generation

It is well known fact that the innovative activity which, is the primary source of knowledge generation, concentrated only in a number of developed nations. Within these developed nations, these activities are only concentrated and dominated by only a small number of corporations.

In developing nations, the primary mode of promoting technology advances is through technology acquisition. However, in this new era of economy, the focus is on innovation and the creation of new technology and higher value-added activities by increasing basic and applied research. Malaysia, for example in the early years of its development has placed its primary emphasis on technology acquisition. As its per capita income increases, Malaysia is putting in place major fundamental research & development programs in the public and private sectors in an attempt to attain world leadership in key areas.

Table 1 shows two indicators of innovative activity for key Asian nations. These two indicators cover both knowledge 'inputs' as well as 'output'. R&D expenditures are considered the 'input' indicator of the innovative activity. The knowledge output indicator considered in this study is patents obtained by inventors from different nations at the US Patent and Trademark Office over the past 25 years period (1975-2000). There are other forms of knowledge generation activities such as copyright and trade secret. However, because patenting is the primary form of intellectual property protection, patent data are considered to be the most available, objective and qualitative measure of knowledge output. Thus, a nation's patenting activity is an indicator of the strength of its research enterprise and technological strengths, both overall and in particular fields of technology.

The table reveals that an extreme form of knowledge generation concentration with just three nations of Asia, which account for the bulk of all innovative activities in Asia. This top three nation's of Asia, that is Japan, Taiwan and South Korea account for as much as 80% of Asia resources spent on R&D activity annually. In terms of knowledge output, the same top three nations have the most number of patents issued. They account nearly 98% of the knowledge output in terms of patents taken out in the US. Hence, the concentration in terms of knowledge output is even more uneven than for the knowledge inputs. But the obvious trend is that the control over knowledge is directly related to the amount of fund allocated to its R&D. Malaysia for example, allocated only 0.20% of its GDP for R&D purposes and this is reflected in the number of patents awarded for the past 25 year period, which amounted to only a meager 384 patents. The trend shows that Japan is way ahead in their innovation activities with a total of 426, 702 patents issued to them.

Besides the patenting activity defined by a nation of the inventor in all type of sectors, trends were also analyzed by the number of patents issued that are related to the Geomatic field. Keywords related to this field such as GPS, GNSS, mapping, remote sensing, triangulation, spatial, and photogrammetry are among others that are used in the definition. Table 2 shows the number of patents produced for the Geomatic field for a period from 1982 to 2001.

Table 2 shows that Japan still leads in their patenting activities with a total of 235 Geomatic patents issued for the 20-year period. And this is followed by South Korea, Taiwan and China. Out of the total 3442 Geomatic patents issued by the U.S. Patent and Trademark Office, only 286 or 8% originates from the Asian countries. The remainder of the 92% of the patents mostly originates either from North America or Europe. The numbers shows that there is lack of innovative activities amongst the Geomatic professionals in the Asian region compared to their North American or European counterparts. What is more disturbing is that Malaysia, which boasted four higher education institutions (UTM, UPM, UiTM and USM) that offered Geomatic program does not possessed a single patent in the Geomatic sector. Ironically Singapore, which the number of Geomatic professionals is far less than that of Malaysia has already produced three patents that are related to the Geomatic sector.

To make a definitive comparison on the innovation activities of Geomatic sector to other sectors, data for five different sectors are compiled and tabulated for selected Asian nations. The sectors concerned are Advanced Materials, Automotive, Health, ICT and Transport. Table 3 shows the patents count of major Asian nations. The table is based on the indicators computed for the same four five-year periods: 1982-1986, 1987-1991, 1992-1996 and 1997-2001.

The table shows that Japan leads in all sectors in terms of the number of patents issued. But the technological capabilities of Korea and Taiwan are budding, with their growing strength most evident in the advanced materials and ICT sectors. In the transportation sector, Korea and Taiwan are showing steadily growing strength. On the other sides, three Asian nations of Malaysia, Hong Kong and Singapore do not have enough patenting activities in any of these five sectors to be identified as emerging competitors. Singapore for example allocated nearly 1.79 % of its GDP for R&D purposes and these percentage points is comparable to Korea or Taiwan, but still lags behind. The most probable reason for this trend is that these three nations lack what is called the indigenous R&D capability. For the most part, manufacturing and industrial development are currently supported by R&D done elsewhere.

Comparing the number of patents generated by Geomatic professionals with the other five sectors shows a very disturbing trend. Lets take Japan for example, leaders both in the number of Geomatic patents and number of all types of patents for Asian nation. For the 20-

year period, Japan has produced a total of 235 patents related to Geomatic sector. Among the five sectors, transport shows the least number of patents produced that is 5213 patents. Therefore, when compared to the weakest link of the five sectors, Geomatic still pale behind considering the number of patents produced. Even though Malaysia does not produce a single patent in Geomatic field, but all the other five sectors have some form of innovative activities in terms of the number of patents. The problem of lack of innovative activity is not only confined to Malaysia alone, but also to all other Asian nations as shown both in Table 2 and 3. The lack of innovative activities it seems is not confined to a particular nation but to the Geomatic professionals itself.

## Conclusions

Looking at the dismal performance of Geomatic professionals in terms of innovative activities in most part of Asian and Malaysia in particular, is it there is something that holding up these professionals from doing so? With our universities and numerous polytechnics offering Geomatic program, more is expected from them. Is it a problem of lack or inadequacy of skills? Or is it these professionals are too busy and being narrowly focused on doing something else?

Malaysian business are generally doing well, in large measure, as a result of our national investments in science and technology, and the innovation and competitiveness they yield. In this perpetual marathon that is global competition, now is the appropriate time to strengthen our effort into bringing the Geomatic field to greater heights.

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# Ordnance Survey rejects unlicensed web publication *Virtual London*

After a year of negotiations, academic geographers have conceded defeat in their attempt to find a way to make a pioneering 3D representation of the capital, Virtual London, available to all comers via the Google Earth online map. Virtual London is partly derived from proprietary data owned by, Ordnance Survey (OS). Its development was funded by another arm of the government, the office of the mayor of London. Virtual London, developed by the Centre for Advanced Spatial Analysis at University College, London, represents all of the capital's boroughs in 3D, including 3m buildings. It was intended to help citizens visualise the impact of new developments and hazards such as air pollution and flooding. The mayor's London Connects e-government programme has also sent copies of the model, running in Google Earth, to each of London's 33 local councils.

Then the problem emerged. Virtual London contains spatial data derived from OS's MasterMap, the definitive crown copyright database of Britain. Licences to use MasterMap data are a valuable income stream to OS, a trading fund required to earn a profit for the Treasury by selling products and data licences. There was no problem with London's boroughs using the 3D model in-house, because, like virtually all government bodies, they have licences to use OS data. What they could not do was post Virtual London on websites for London's citizens to use. http://www.guardian.co.uk/technology/2007

Coordinates sought the view point of Ordnance Survey. Scott Sinclair Head of Corporate Communications, Ordnance Survey responds

Virtual London data can be published on any London borough website and it could have been so on Google also if they had wished to license it. There were differences in what Google wanted and what our licensing framework permits that meant we were not able to reach agreement. We provide an open, fair and transparent set of terms for providers seeking to operate in the same commercial space as each other. We cannot therefore license Google in a different way to other providers. We are completely supportive of anyone putting our data on the web as long as they have a licence to do so. There is an existing licensing model that works for the original purpose of Virtual London - the availability to London boroughs. What Google wanted to do would take it out of those licensing arrangements and put it on a commercial footing. We therefore had to approach licensing on that basis as we would with anyone else.


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# Precision Agriculture

An emerging GNSS research and application area at the Universiti Putra Malaysia. An overview

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**Ebrahim Jahanshiri**
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UNIVERSITI Putra Malaysia (UPM) formerly known as Universiti Pertanian Malaysia was founded in 1971 through the merger of Faculty of Agriculture, University Malaya and Agriculture College in Serdang, State of Selangor. Since then UPM has evolved to become one of the leading universities in agriculture and science in Malaysia.

A variety of research projects at UPM utilize the GPS in the agricultural research through the process of precision agriculture (PA). PA determines the use of spatial aspect of agricultural data to enhance the management activities and decisions by down-scaling the management units from farm to plot, zone and eventually the plant itself. Since the accuracy of measurements is the key in PA, only GPS devices with accuracy of few meters can be used for data acquisition.

Some of the GPS devices are attachments of other agricultural equipment and are embedded into a system containing computers and sensors to collect data or work autonomously. The Veris system is an example of such a receiver that measures electrical conductivity and variable rate fertilizer and chemical spreader.


**Figure 1: The Veris system**

## Soil variability description for rice precision farming

Electrical conductivity is one of the non-inherent characteristics of soil that can be an indicator of soil nutrients and moisture which are critical for the growth of plants. Therefore it is important to gather information about the mean EC, such as its patterns of distribution in the field. The objective of this study was to determine the spatial and temporal variability of paddy soils using EC and to compare the data from soil sampling with that from the Veris system.

This study used DGPS model AgGPS 132, Trimble attached with VerisEC 3100. AgGPS 132 is mapping GPS differentiated by available beacon station in Lumut (transmission frequency is 298.00 kHz) and provided sub meter accuracy (Figure 1).

Soil samples were collected for EC zonal characteristics and their locations were recorded by a GPS GeoExplorer3, Trimble with lower accuracy of about 5-15 m. The mapping GPS AgGPS 132 system was successful in EC map generation with the overlay of soil sample location map.

## Rice evapotranspiration in paddy fields

Evapotranspiration (which is the sum of evaporation from the surface and transpiration from the plants) is a significant water loss from a watershed. Types of vegetation and land use significantly affect evapotranspiration. The measure of evapotranspiration is important for the estimation of water consumption, ability of soil water filtration and water movements in the soil of paddy fields.

The rice evapotranspiration was estimated using different methods: Lysimeters

GPS GeoExplorer3

Locating experiment sites

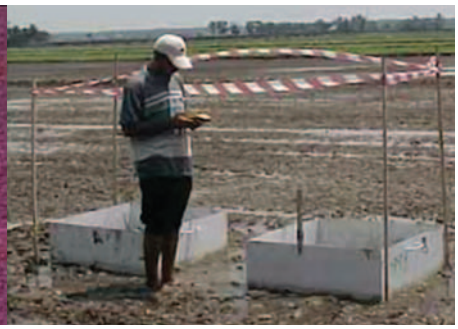

**Figure 2: The GPS and lysimeter that has been used for the study**

installed inside the paddy field, weather parameters from automatic weather stations installed in the field, and NOAA satellite data (imagery) using remote sensing model. Lysimeter is a device to measure the quantity or rate of downward water movement through a block of soil usually undisturbed, or to collect such filtered water for quality analysis. The location of each lysimeter was determined by hand-held GPS Geo Explorer 3 which has six channels to receive the signals and having 0.25 Mb data storage. The coordinate system for the GPS location data follows the WGS 84 (World Geodetic System 1984) format.

## GPS-aided INS for mobile mapping in precision agriculture

The application of GPS-aided INS for use in Precision Agriculture give farmers accurate and quick updates about the location of the field, even when there is no signal available under the canopy predicting the precision site-specific farming and ultimately contribute towards better yield monitoring and management. The research is in its initial phase and this paper provides an overview of Mobile Mapping Solution for Precision Agriculture by GPS-aided INS Approach. The objective of this study was to build an integrated system using IMU (Inertial Measurement Unit) and GPS Receiver, according to the requirement of Precision Agriculture.

Inertial Navigation is a dead reckoning technique (navigation by calculation), so it suffers from one serious limitation: drift rate errors constantly accumulate with the passage of time. Because its drift errors persistently accumulate, an inertial navigation system that operates for an appreciable length of time must be updated periodically with fresh positioning information. This can be accomplished by using an external navigation reference, such as GPS.

## Precision system for mapping tractor-implement field performance

A novel precision system has been integrated on board a Massey Ferguson 3060 agricultural tractor for real-time mapping of tractor-implement performance. The basic system is capable of measuring, displaying, and recording in real-time, the tractor's theoretical travel speed, actual travel speed, roll angle, pitch angle, fuel consumption rate, drive wheel slippage and drive wheel torque and also implement's PTO torque, tillage depth, drawbar force, and three-point component forces. With the added DGPS option, the system can be used

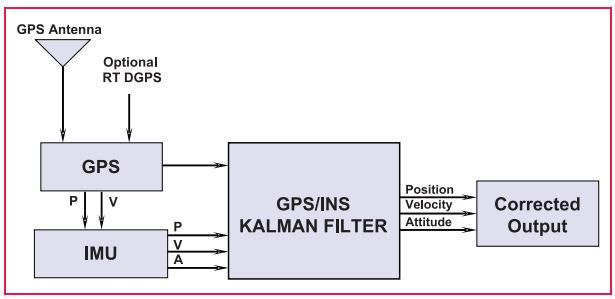


**Figure 3: Architecture of the system**

**Figure 4: Precision System for mapping tractor-implement field performance**

for spatial mapping of the tractor-implement field performances

A tractor-mounted, automated soil penetrometer–shearometer unit was designed and developed for the purpose of simultaneous in situ measurements of soil penetration resistance and shear stress. A personal computer data acquisition and differential global positioning system (DGPS) on-board tractor were used to assist in real-time measuring, displaying, and recording the tractor position, soil penetration resistance, and soil shear stress during the field sampling operation.

## Assessment methodology for impacts of land-use changes on watershed runoff

The objective of this project was to locate the rainfall and stream flow gauges for determining ground truth to test the accuracy of image interpretation and to clarify interpretation assumptions for the land use and land cover classification. For this study of the Upper Bernam River basin, Geoexplorer 3.0 was used that can collect attribute data along with the navigation and positioning. Thus, one can input predefined attribute data along with the automatic logging of the coordinates that are being recorded by the GPS.

## Precision Farming at Agricultural Park (TPU)

TPU has recently embarked on the precision farming projects and have recently acquired GPS receivers and embedded systems that utilize GPS as part of their operations. The National Survey and Mapping Department Malaysia (JUPEM) have set up a base station at UPM in cooperation with the Department of Biological and Agricultural Engineering and the specifications can be seen in Fighure 5. The GPS Pathfinder Pro XR receiver provides real-time sub-meter accuracy GPS with built-in SBAS, OmniSTAR, and beacon capabilities. Together with your field computer and software, the GPS Pathfinder Pro XRS receiver provides a two-way data flow between the field and GIS, facilitating the data collection and data maintenance processes, and ensuring current data for decision-making. Because the GPS Pathfinder Pro XRS integrates real-time DGPS, it is easy to navigate directly to an asset for verification and updating. By taking advantage of these real-time features, the need for post processing GPS data is eliminated.

The other system in the TPU is the Bogballe M1 Trend Variable Rate Applicator that is an automatic system for applying the fertilizer variably in the field. The system includes a PDA that has GPS for surveying the field and collecting the position of soil samples, a software that can produce the application maps automatically from the samples and estimate the amount that is needed, a calibrator that is used to manage the data and connect to the GPS and variable rate applicator that is responding to the change in the rate based on the position and data from the calibrator and changes the nozzle of the spreader.

The system is initially set up for the palm oil farms for spreading the solid fertilizer but it is also suitable for different kinds of crops. Universities in all parts of the world are responsible for the spread of knowledge and technology. In this case, UPM is considering taking initiative in the GNSS and spatial technologies through education and research and thus hopes to disseminate the GNSS skills for the benefit of society. UPM has already taken part in the partnerships and working with the government or private agencies to implement this new technology in the real life problem solving.

**Name:** UPMS
**Station:** UPM Serdang
**Location:** Jabatan Kejuruteraan Biologi & Pertanian
**Latitude:** 02° 59'36.224453"
**Longitude:** 101°43'24.635361"
**Ellipsoid Height:** 100.3544m

**Figure 5: Receiving Station at UPM**

## Acknowledgment

This article has been made possible with the contributions of several researchers at UPM or those affiliated with UPM. We will like to record our appreciation to all who helped make this article possible, especially, W. Aimrun, M. S. M. Amin, Mustafa Yusif, Desa Ahmad, M. M. Hanafi, C. S. Chan, Hassan S.M.H., M.M. Radzali., Shaikh, K.N., H. Jamaluddin, S. Mansoor, M. Tarmizi, Yahya, A., M.Z.Bardaie, A.F.Kheiralla, G.S.Kiat, Ng Eng Boon, Helmi Zulhadie, and Ahmad Rodzi Mahmud

Our heartfelt appreciation and gratitude to JUPEM for having strongly supported our GNSS related work that helped to jumpstart GNSS teaching and research at UPM.


**Figure 6: Bogballe M1 Trend Variable Rate Applicator (VRA) Meter Accuracy**

# Capacity building is a major challenge

Dato Dr. Abdul Kadir bin Taib on initiatives and programmes by the National Survey and Mapping Department, Malaysia (JUPEM)

**Dato' Dr. Abdul Kadir bin Taib**
Deputy Director General, JUPEM

## What's new in JUPEM?

JUPEM is working in tune with new technologies. One of the biggest project is e-Cadastre project. The project has started this year and will be completed by the end of next year.

The project envisages a complete digital cadastral database of high quality and integrity. For this purpose, advance techniques and methodologies have been employed like GPS etc.

## Are the people of Malaysia going to be benefited by this project?

The project aims to improve the delivery system especially the process of issuing land title. The benefit is in terms of time.

The process that earlier used to take two years time now take two months only. The ultimate beneficiaries of the project are the citizens of Malaysia.

## Are there any other projects that you would like to mention?

JUPEM has recently improved its geodetic infrastructure with RTK project. The geodetic products and services include information on horizontal control coordinates, vertical control heights, tidal prediction, coordinate transformation and GPS real-time kinematic network data.

One can get access to this services and products through JUPEM GeoPortal.

## What are the challenges before JUPEM?

Since JUPEM is modernized with new technologies like total stations, GPS etc, we need to have professionals who are well trained to use such technologies. We need to train not only government surveyors but also professionals from private sector as many work is outsourced to the private sector. I think that the capacity building is one of the thrusts as well as the challenge before JUPEM.

## What about data accessibility?

We have launched JUPEM GeoPortal for data dissemination. We have two sets of data- restricted and non-restricted. The non-restricted data are easily available from our website.

One can go to the site and register himself. Apply for the copyright license and pay the license fee through credit card or by post. The fee is nominal. Data is available large scale and small scale both. However, for the restricted data, the process includes the process of security vetting. After the clearance from defence and security, one can get the restricted data as well.

## What are major application areas for JUPEM data?

The data and information available with JUPEM is useful and being used for various applications like natural resource management, geological, land use information, flood management, etc. JUPEM provides the base data.

# Breaking distance barriers

JICA started JICA NET Distance Education from 2004 in cooperation with JSPRS

**Shunji Murai**
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*sh1939murai@nift5y.com*

JAPAN International Coorperation Agency (JICA) initiated RS course once a year since 1978FY with full sponsorship to invite 10-15 trainees per year from developing countries. JICA expanded to mapping & surveying, hydrographic survey, GIS etc. However JICA has changed the policy to introduce partially e-learning system in 2004 to improve the cost-efficiency. The reason is that the cost to invite a person from a developing country used to be 10,000 US dollars per month in average.

JICA plans to expand JICA NET, a telephone-line based communication system to about 30 developing countries to enable TV conferences between Japan and developing countries. They include Indonesia, Cambodia, Thailand, Philippines, Vietnam, Malaysia, Laos, China, Sri Lanka, Pakistan, Bangladesh, Turkey, Jordan, Palestine, Kenya, Argentine etc.

The objectives of JICA Distance Education are;

- To supplement or replace "Face to Face" training courses which had been adopted by JICA in the past.
- To increase cost performance with respect to number of trainees, high quality lecture materials and lecturers.
- To promote advanced education using IT.
- To support capacity building in developing countries.

JICA contracted with Japan Society of Photogrammetry and Remote Sensing (JSPRS) in 2003 that the fundamental frame work should be proposed by Technical Committee on Strategic Plan for JICA NET Distance Education under the chairmanship of Prof Shunji Murai on remote sensing and GIS including the mission and goals, modules and contents, teaching methods etc. In 2003 FY, JSPRS prepared six CDs in total with 3 CDs for RS and another 3 CDs for GIS respectively including power point teaching materials with video and voice and English text for explanation.

JICA started JICA NET Distance Education from 2004 FY in cooperation with JSPRS, JICA Offices in developing countries and a site facilitator representing from each developing country. Until now, eight rounds were implemented in the first three year project from October 2004 to March 2007 and a round has been just finished in the second three year project starting from August 2007.

## Problems of conventional JICA training courses

The conventional "face to face" teaching style in a class would be the best if the teacher and the teaching materials were perfect. But this condition will be difficult to acquire in many cases. The following problems are recognized

## Outline of RS and GIS course

| RS Course: | | GIS Course | |
|---|---|---|---|
| Module 1: | Fundamentals of RS | Module 1: | Fundamentals of GIS |
| Module 2: | Remote sensors | Module 2: | Data model and structure |
| Module 3: | Platforms for RS | Module 3: | Input of geospatial data |
| Module 4: | Microwave RS | Module 4: | Spatial Database |
| Module 5: | Data to be used in RS | Module 5: | Required hardware & software |
| Module 6: | Image interpretation | Module 6: | Plan for installation |
| Module 7: | Image processing system | Module 7: | Spatial analysis |
| Module 8: | Image processing (1) | Module 8: | Coordinate transformation |
| Module 9: | Image processing (2) | Module 9: | Interpolation techniques |
| Module 10: | Image processing (3) | Module 10: | DTM |
| Module 11: | High Resolution Satellite Imagery (HRSI) | Module 11: | Output of GIS products |
| Module 12: | Applications of RS (20 applications) | Module 12: | Applications of GIS (20 applications) |

by the Technical Committee.

1) It is too expensive for JICA to continue to invite trainees from developing countries to Japan. The cost as mentioned before will be about 10,000 US Dollars per person per month, which makes about 200,000 US Dollars if JICA invites 10 trainees for two month course.
2) There will be a limitation in term of the number of trainees; say 10 to 15 trainees per year for a course.
3) As there is also a limitation that JICA can find Japanese resource persons who can speak English fluently, some instructors prepared poor teaching materials without the aid of IT, which resulted in low quality lectures without inspection.

In order to overcome those problems, JSPRS recommended JICA to prepare high quality teaching materials and select eminent lecturers or resource persons, who can speak English well.

## Goals of JICA distance education on RS and GIS

Realizing the requirements of developing countries particularly in Asia, JICA and JSPRS agreed to set up the following two goals.

1) To promote capacity building for human resource development to support sustainable development of natural resources and environment using RS & GIS.
2) To provide self learning materials through e-learning to upgrade the capability of applicability.

The main target of trainees will be governmental staffs, who are operating RS and/or GIS on daily basis or are going to introduce RS and GIS in their technical projects. Teaching faculty and researchers of universities will be also accepted as trainees.

## Basic design of a course

1) Power Point materials: 25-35 slides per module for 11 modules in total. The 12th module is a special module on application of RS or GIS which is composed of 20 applications respectively. Each module except the 12th module will take about 30 minutes lecture with voice and video. The lecture will be delivered at each site using CD and LED projector. The text of explanation in English is distributed to each participant.
2) After watching the power point materials with voice and video, about 30 minutes will be given to Q&A session through TV conference for three or four developing countries. A resource person should be responsible for answering questions on site. E-mail services will be also provided in case when there are some more questions which are not accepted at TV conference due to time limitation.
3) The contents of Q&A session are recorded in writing materials and distributed to the participants afterward. Q&A session will be supported by a facilitator at each site, whose knowledge will be high enough to bridge between the resource person and participants.
4) A course on a day will be three hours and half which accommodate three modules including Q&A sessions. In consideration of time difference between Japan and a developing county, the time difference of six hours in maximum will be the limitation to accept the JICA NET Distance Education. Those limited countries include Kenya, Jordan, Turkey, etc.
5) 12 modules each for RS and GIS can be managed for four half days including examination on the fourth day.
6) Those who attended 75 % and more the lectures and passed examination with more than 60% completion will be conferred Certificate of Successful Completion in the name of JICA and JSPRS.
7) Three or four developing countries are selected under the condition that JICA local office is requested by the developing country and a facilitator can be assigned who will call for participants and serve as an assistant through all courses.
8) The maximum number of each country will be less than 40.

## Course for applications of RS and GIS

The application module has been added since 2005 FY. This module was designed without a pressure of examination.

The objectives of application module are as follows.

1) To follow up those courses on theories and techniques from Module No. 1 to No. 11,
2) To introduce a variety of examples of typical and interesting applications in remote sensing and GIS for better management of environment and natural resources,
3) To demonstrate how remote sensing and GIS have been successfully used in the actual projects as well as research and development, and
4) To make decision makers, managers, scientists and graduate students understand how remote sensing and GIS can be applied with success.

The list of applications for RS and GIS is shown below.

### RS Applications

- Land Cover Map based on Satellite Imagery
- Countrywide Land Cover Mapping
- Monitoring of Urban Growth in Hanoi
- Urban Change Study in Mongol
- Updating Forest Map
- Height Measurement of Trees by Lidar Data
- Flood Damage Map in Bangladesh
- Flood Damage Mapping for Rice Fields
- Monitoring of Water Quality
- Monitoring Shrimp Farming
- Application to Fishery
- Topographic Mapping from IKONOS Stereo Imagery
- Automated Extraction of Roads
- 3D Measurement of Volcanic Crater
- Monitoring Earthquake Damage
- Earthquake Damage Detection using HRSI
- Monitoring Rice Growth by SAR
- Global Mapping
- Assessment of Desertification in Arid Area
- Image Mapping System using Kite Balloon

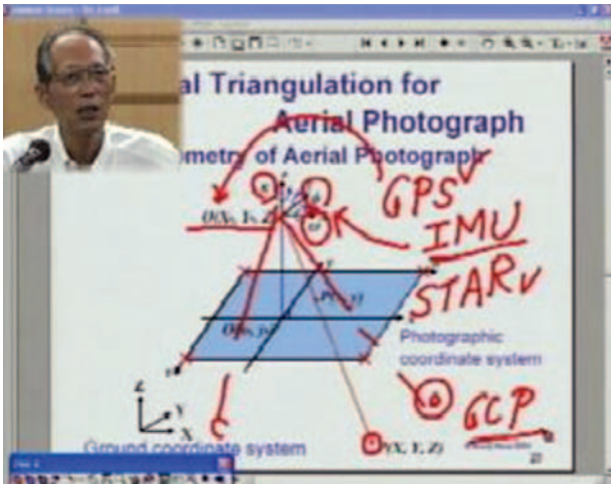


**Figure 2 The lecturer of the above courses was Prof. Shunji Murai, who answered more than 400 questions each for RS and GIS.**

### GIS Applications

- Suitable Land Selection for Agricultural Development
- Optimum Vehicle Routing
- Real Time GIS Data Capturing
- Environmental Study with GPS, Digital Camera and GIS
- Flood Hazard Map
- Flood Free Route Location
- Flood Simulation with Lidar Data
- Shelter Suitability Analysis
- GIS Database for Management of Irrigation Facilities
- Drought Risk Assessment
- Height Measurement of Buildings with Lidar Data
- Contour Mapping with Lidar Data
- 3D City Model with IKONOS and Lidar Data
- Superposition of Historical Maps onto Present Map
- Visibility Analysis of Mt. Fuji
- Crime Mapping and Analysis
- Disaster Management System for City Gas Network
- GIS Map for 1995 Kobe Earthquake Damage Assessment
- Time-space Mapping
- Scheduling for Day Care Service

## Implementation

The following eight rounds in the first three year projects were implemented since October 2004 until March 2007. The results of examination for each round are shown with respect to remote sensing and GIS course as follow.

- 1stRound (2004): Malaysia {65/85%}, Thailand {90/95%} and Turkey {71/77%}
- 2nd Round (2005): Vietnam {100/96%}, Philippines {92/95%} and Laos {6/44%}
- 3rd Round (2005): Kenya {74/100%}, Sri Lanka {80/91%} and Thailand {91/100%}
- 4th Round (2005): Jordan {71/100%}, Turkey {60/100%}, Vietnam {100/100%} and Philippines {89/100%}
- 5th Round (2006): Malaysia {76/91%}, Cambodia {27/80%} and Laos {60/60%}
- 6th Round (2006): Palestine {94/94%}, Bangladesh {94/94%}, Sri Lanka {92/96%} and Kenya {82/97%}
- 7th Round (2006): Thailand {57/79%}, Vietnam {65/100%}, Mongol {100/64%} and Philippines {59/79%}
- 8th Round (2007): Jordan {100/100%}, Kenya {69/94%}, Cambodia {10/53%}

The total number of registered participants for remote sensing course was 661, number of participants who challenged examination 573, number of participants who got successful completion of examination 413 and failed 170 for 13 countries.

The total number of registered participants for GIS course was 665, number of participants who challenged examination 582, number of participants who got successful completion of examination 582 and failed 61 for 13 countries.

## Advantages of JICA net distance education

According to the questionnaires answered by participants, the following advantages are recognized.

1) It will be possible for beginners to study RS and GIS systematically.
2) Many participants from different organizations and different countries can share knowledge and experience through the distance education. Particularly TV conference was appreciated by participants for the interactive communication between the lecturer and participants in cooperation of facilitator. Figure 1 shows a big TV screen which showed class rooms of four countries.
3) The record of Q&A session in written form was evaluated very useful to understand many parts and items which are not mentioned in the lectures and the text.
4) The examination with the submission of certificate for successful completion had become incentive to concentrate into the lecture and Q&A session.
5) Those participants can repeat self-learning with given CDs at any time and anywhere.
6) E-mail service for extra Q&A session after ordinary session was sometimes useful for those participants to make special questions to the lecturer.
7) IT technology such as touch panel can be applied as shown in Figure 2.

## Conclusions

1) JICA NET Distance Education contributed to developing countries in terms of capacity building of remote sensing scientists, technicians, engineers and/or managers who are engaged in governmental projects and university lecture and research.
2) JICA NET Distance Education proved successful with respect to the cost effectiveness as compared with the conventional "face to face education". The number of trainees in the distance education will reach about 200 for three courses in a year, while the conventional training just 10 to 15. Until now since 2004, more than 1,000 trainees including RS and GIS courses have completed the Distance Education with less than 20 times expenses.
3) The interactive TV conference for Q&A session is highly appreciated to supplement the mechanical feeling of "video show type" lecture.

# What is Extended Particle Filter?

The implementation of an Extended Particle Filter (EPF) was proposed as an estimation technique for integrated GPS and low-cost inertial MEMS navigation systems

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**NAVIGATION** comprises of different methodologies to estimate the time varying position and attitude of moving objects by measurements such as Inertial Navigation systems (INS) and Global Positioning System (GPS) (Aggarwal, 2007). GPS provides long term accurate measurements and is highly portable, has low power consumption, and hence is well suited for integration with other sensors. However, GPS does not work in all environments, and provides navigation data only when a direct line of sight between four or more satellites and the receiver antennas exists. This is not always possible for example when vehicle is going through a tunnel or under trees, bridges etc. In contrast, Inertial Navigation Systems (INS) are self-contained units consisting of gyroscopes and accelerometers and do not require any external signals. Hence INS is capable of working in all environments where GPS has difficulties. It is very useful to bridge GPS outages and provides high frequency data during these periods. However, the accuracy of INS deteriorates in the long-term due to the combined effects of errors like noises, biases, drifts and scale factor instabilities (Schwarz and Wei, 1995). In order to combine the advantages of the two technologies, an integrated INS/GPS system are used. Accurate positioning information from GPS is typically used to provide frequent updates to the INS to correct its errors; while the GPS signal outages will be compensated by using the short term accuracy of the INS derived position and velocity.


**Figure 1: MP placement on Test Vehicle**

Earlier usage of these integrated sensors were restricted to military and aerospace areas because of high manufacturing cost of INS, but with the development of low cost system, such as Micro Electro Mechanical Systems (MEMS), the possibility of using inertial sensors for automobile industry has been generated. MEMS has enabled the sensor technology to evolve from discrete, expensive and inflexible units to smart, self-calibrating, silicon-based devices which are integrated, low-cost and small. MEMS is an enabling technology with a massive global market, predicted to be at 180 billion US $ in 2007. The MEMS sensors are used for measuring angular velocity and acceleration in these navigation systems but the errors in these sensors are more than that of the higher grade sensors due to their miniature size, and light weight. For MEMS sensors, the errors like the nonlinearity of bias or scale factor with respect to temperature become huge and therefore cannot be neglected, unlike navigation grade sensor errors.

For GPS/INS integration, estimation techniques, such as EKF and UKF, are commonly used for the system error estimation and compensation. In EKF, Taylor series expansion is applied to the nonlinear system and measurement equations to obtain first order linear system (Grewal, 2001). The EKF assumes that the posterior probability density functions along with system and measurement noises are Gaussian distribution. Moreover, the derivation of the Jacobian matrices, i.e., the linear approximations to the nonlinear functions, can be very complex and lead to implementation difficulties (Julier, 2000). Also, only small errors are allowed to be delivered to the EKF and hence the first order approximations can cause

inconsistency of the covariance update and lead to filter instability in the presence of higher order effects (Lerro, 1995).

On the other hand, the UKF was proposed in the GPS/INS navigation community to overcome the limitations of EKF instabilities and Jacobians matrices evaluation. UKF is based on the principle that it is easier to approximate a Gaussian distribution than to approximate an arbitrary nonlinear function (Julier, 2000). UKF deterministically samples fixed number of minimal points, named sigma points, from the Gaussian distribution, which are used to estimate the true mean and covariance of gaussian distribution. These sigma points are then individually propagated through the true nonlinear models, to capture posterior mean and covariance more accurately. However, when the non-linearity is pronounced, even the best-fitting Gaussian distribution will be a poor approximation to the posterior distribution (Doucet, 2000).

Therefore use of an Extended Particle Filter (EPF) to approximate the posterior distribution in cases of highly nonlinear integrated navigation systems is proposed here. Particle Filters (PFs) [Maskell, 2001; Gordon, 1993] have a number of characteristics that make them attractive for navigation applications. They are non-parametric, can efficiently deal with non linearities and non Gaussian noises, and are relatively easy to implement. It is proposed here to use an EPF for estimating the state vector with the aim of obtaining more accurate results and efficiently dealing with high non-linearities or non-Gaussian noises. Furthermore, in the PF implementation, there are no assumptions necessary about the form of the posterior distributions. PFs give an approximate solution to an exact model, rather than the optimal solution to an approximate model unlike KFs (Gustafsson, 2002).

## Basic Particle Filter (PF) Algorithm

Particle Filter constructs a point mass representation of a state vector by large number of random samples, called particles that explore the state space. Basic Particle filters are based on the sequential Monte Carlo estimation (SMC) method, which is integration of Monte Carlo and Importance Sampling methods (Arulampalam and el, 2002). The MC method (Doucet, 2000) states that if we can draw out independent, random and equally weighted samples N from the required posterior distribution, then the required probability density function is approximated by the average or collection of these samples or particles. Monte Carlo method assigns equal weights to these generated particles. The PF is used to update the weights of these particles when measurements become available. The location and weight of each particle reflect the value of the posterior density in the region of the state space. However, it is not always possible to draw out independent and uniformly distributed samples from the required density function as it might be multivariate, nonstandard or multimodal. In these cases, the Importance Sampling method is used. Importance Sampling method (Haug, 2005) states that if it is difficult to obtain a sample directly from the required distribution, then samples can be generated from importance or proposed density function, which is similar to the desired distribution. The weights of these generated samples are then corrected to represent the target function as closely as possible. The most popular and easy option is to take the transition prior as the proposal density function. This proposal distribution simplifies the particles weight calculations greatly. The basic Particle filters namely Sequential Importance Sampling (SIS) and Sequential Importance Re-Sampling (SIR) Filters assume the transition prior density as the importance proposal distribution.

The pseudo code for Sequential Importance Sampling (SIS)/Re-Sampling (SIR) Particle Filter is summarized below:

### Sequential Importance Sampling/ Resampling (SIS/R) Particle Filter

1. Generate independent and identically distributed (i.i.d.) N samples $\{x_0^i\}_{i=1}^N$ from the previous posterior density function $p(x_0)$ according to Monte Carlo principle.
2. On receiving the measurements $y_k$, update weights of these generated according to eq 1.
   (a) Updating weight of each particle $i$=1.....$N$

$$w_k^i \;\alpha\; \frac{p(y_k \mid x_k^i)\,p(x_k^i \mid x_{k-1}^i)}{q(x_k^i \mid x_{k-1}^i)} \qquad (1)$$

   As the importance density function is taken to be equal to the prior density function $p(x_k|x_{k-1})$, the above weight update equation simplifies to

$$w_k^i \;\alpha\; p(y_k \mid x_k^i) \qquad (2)$$

   i.e. weights of the particles are proportional to the likelihood function.
   (b) Normalized the weights of the particles

However this simple implementation of the SIS particle filter causes particle dispersion because the variance of the particles increases without bound with time. After few iterations, all but one particle has negligible weight. This increase in variance of the particles causes dispersion phenomenon and is called degeneracy of the particle filter. In order to reduce this problem, re-sampling step is incorporated into the above SIS particle filter, leading to Sequential Importance Re-Sampling particle filter (SIR) formation. Re-sampling eliminates the particles with less weight and multiples the particles with higher weights. However resampling at every time step can easily lead to sample impoverishment as similar particles will be repeated number of times. Therefore to avoid this additional problem, resampling is only done when degeneracy of the filter is high. To measure this degeneracy of the PF, effective sample size $N_{eff}$ is calculated along with threshold value $N_{th}$ as stated in Eq. 3. Only if effective sample size is less than the threshold value, re-sampling is performed.

3. Compute the effective and threshold weights according to below eq

$$N_{eff} = 1/\sum_{i=1}^{N}(w_k^i)^2 \quad \text{and} \quad N_{th} = 2N/3 \qquad (3)$$

   where $N_{eff}$ is the computed effective weights and $N_{th}$ is the threshold value.
4. If $N_{eff} > N_{th}$, particles remain as such, else resample particles and assign equal weights to them.
5. Once resampling is done, time epoch is incremented, new particles are

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predicted and steps from 2 are repeated.

6. This process is repeated till end of the test trajectory is reached.

As stated before, re-sampling step decreases degeneracy issue but causes sample impoverishment (Doucet, 2000). Moreover large numbers of particles are required to obtain high level of accuracy of the state vector estimation. In order to overcome the limitations of large number of particles required, different methods were developed to optimize proposal distribution that approximates the importance distribution. One such method is to incorporate the most current observation with the approximation of the state (Merwe, 2000) through local linearization. Usages of this principle lead to the developed of Extended Particle Filter (EPF).

## Methodology for Implementing Extended Particle Filter

In case of SIS/SIR filters the latest observation is not considered to evaluate the weights of the particles as the importance function is taken to be equal to the prior density function. This choice of Importance Sampling function simplifies the computation but can cause filter divergence. In cases where the likelihood function is too narrow as compared to the prior function, very few particles will have significant weights which might lead to divergence. Hence a better proposal distribution is desired that takes the latest observation into account. Kalman filters like EKF or UKF incorporate the latest observation in the update state. Hence if EKF/UKF is used to generate the proposal distribution, the latest observation can be included. Therefore the incorporation of the most current observation with the approximation of the state is through local linearization of the state vector by EKF/UKF ( Merwe, 2000). This hybrid filter is called the Extended Particle Filter (EPF) where the proposal distribution is generated by the EKF. For our application UKF and EKF gave similar performance, so in order to simply EPF implementation EKF is used instead of UKF. In fact, a separate EKF is used to generate and propagate Gaussian proposal distribution for each individual particle i.e.

$$q(x^{(i)}_k \mid x^{(i)}_{k-1}, y_k) = N(x^{(i)}_k, P^{(i)}_k) \quad \text{i=1.....N} \quad (4)$$

where $x^{(i)}_k$ and $p^{(i)}_k$ are the mean and covariance of the 'i$^{th}$' particle generated by the EKF. Once all the particles have been updated by the EKF, sample particles are selected from the proposal distribution and the above process of SIR filter is repeated. The complete algorithm for the EPF is given below

## Pseudo Code for Implementing EPF

1. Generate independent and identically distributed (i.i.d.) N samples $\{x^i_0\}^N_{i=1}$ from the previous posterior density function $p(x_0)$.
2. For k = 1,….. till end of trajectory
   Importance Sampling Step
   - For i = 1..N, where N is the total number of particles, update the particles with EKF equations which are given below:
     i. Calculate Jacobians $F^{(i)}_{k-1}, G^{(i)}_{k-1}, H^{(i)T}_k$ of the models.
     ii. Update the state vector by following eq.

$$x^{(i)-}_k = f_{k-1}(x^{(i)}_{k-1|k-1})$$

$$P^{(i)-}_{k|k-1} = F^{(i)}_{k-1} P^{(i)}_{k-1|k-1} F^{(i)T}_{k-1} + G^{(i)}_{k-1} Q_{k-1} G^{(i)T}_{k-1}$$

$$K_k = P^{(i)-}_{k|k-1} H^{(i)T}_k (H^{(i)}_k P^{(i)-}_{k|k-1} H^{(i)T}_k + R_k)^{-1}$$

$$x^{(i)}_{k|k} = x^{(i)-}_k + K_k (y_k - h(x^{(i)-}_k))$$

$$P^{(i)}_{k|k} = (I - K_k H^{(i)}_k) P^{(i)-}_{k|k-1}$$

   - Sample particles from obtained updated particles i.e. proposal density

$$\{x^i_k\}^N_{i=1} \sim q(x^{(i)}_k \mid x^{(i)}_{k-1}, y_k) = N(x^{(i)}_k, P^{(i)}_k) \quad (5)$$

3. For i = 1……N, evaluate the importance weights of each particle according to eq. 6.

$$w^i_k = w^i_{k-1} \frac{p(y_k \mid x^i_k)\, p(x^i_k \mid x^i_{k-1})}{q(x^i_k \mid x^i_{k-1})} \quad (6)$$

   where the proposal density is obtained from EKF.
4. Normalize the weights of the particles
5. Compute the effective weights and threshold according to eq 3.
6. If $N_{eff} > N_{th}$, particles remain as such, else resample particles and assign equal weights to them.
7. Once resampling is done, time epoch is incremented, new particles are predicted and steps from 2 are repeated.

**Table 1: State Vector Design**

| | | |
|---|---|---|
| $x$ | $r^k$ | Position Error ($\varphi$, $\lambda$, $h$) |
| | $v^k$ | Velocities Error ($v_N$, $v_E$, $v_D$) |
| | $\varepsilon$ | Attitude Euler angles Error ($\phi$, $\vartheta$, $\psi$) |
| | $b_g$ | Gyroscope Biases |
| | $b_a$ | Accelerometer Biases |
| | $s_g$ | Gyroscope Scale Factors |
| | $s_a$ | Accelerometer Scale Factors |

8. This process is repeated till end of the test trajectory is reached.

The state vector for this Extended Particle filter (EPF) is given in Table 1. In EPF, the system process comprises of the INS mechanization and the sensor error models. Sensor errors are being modelled as a random process (Hou, 2004) to compensate the effect of biases and scale factor errors on the INS measurements. The INS mechanization applied in this paper is described in (Shin and El-Sheimy, 2004,2005).

To compensate for large sensor errors, these are modelled as component of the state vector as given in Table 1. Differential GPS (DGPS) is used as aiding source for the EPF after compensating for the lever arm effect between the IMU unit and the GPS antenna.

## Results

### Field Test Data Description

Field tests using MicroElectroMechanical Systems (MEMS) based IMUs were conducted. The MEMS units being tested is the BEI Motion Pak II, which is (gyro drift rate of 1200 deg/hr) a solid-state MEMS six degree of freedom inertial sensing system that uses micromachined quartz rate sensors and silicon based accelerometers. The field tests were conducted in March 2005, where Motion Pak II was mounted on the test vehicle and the NovAtel OEM4 GPS receivers were mounted on the vehicle as shown in Fig 1. Using this setup, test trajectories was generated for Motion Pak II as can be seen.

The test trajectory covered number of vehicle dynamics and throughout

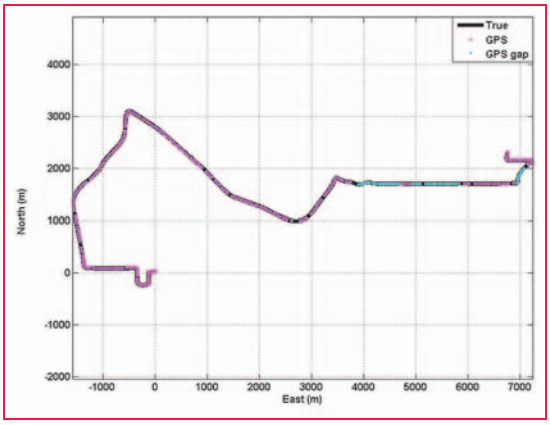


Figure 2: Field Test Trajectory for ADI and Motion Pak II (MP)

## GPS Outages Results

The results obtained from implementing EKF for Motion Pak II are shown in Fig 3 and for EPF are shown in Fig 4 respectively.

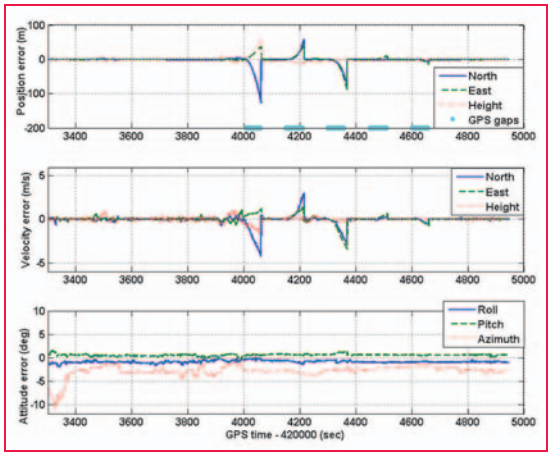


Figure 3: EKF Results for MP

In these simulations, five 60 sec GPS signal outages are simulated for Motion Pak II.

The input data file is at 50 Hz while the output file is at 10 Hz. Table 2, lists the drift errors obtained at all the five outages for both EKF and EPF for Motion Pak II sensor. The table clearly indicates that EPF gives slightly better results (2 % improvement) than that of the EKF when GPS outages occur. The individual maximum drift errors for each GPS outage along with the mean of all these maximum drift errors are also provided. Here the numbers of particles used are 35 as this value gives best results.

the test a minimum of seven satellites was visible, except for several short natural GPS signal outages caused by bridges or trees. These natural outages are avoided for testing purposes, while simulated GPS outages have been carefully picked to cover number of vehicle dynamics as shown in Fig 2.

For comparison purpose, a tactical grade IMU (LN200) was combined with DGPS data to obtain the assumed true solution for the trajectory.

## Conclusions

In this paper, the implementation of an Extended Particle Filter (EPF) was proposed as an estimation technique for integrated GPS and low-cost inertial MEMS navigation systems. The

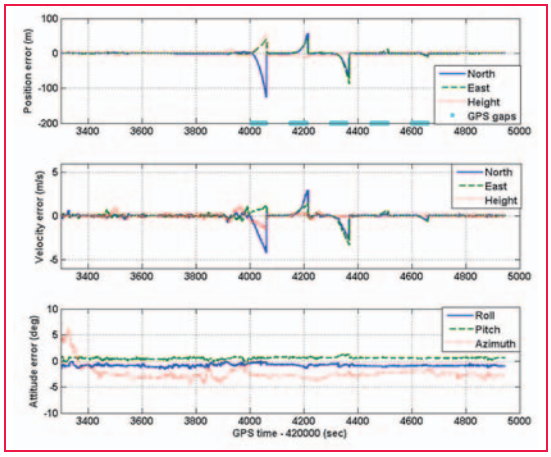


**Figure 4: EKF Results for MP**

performance of the proposed algorithm was compared to the corresponding performance of the commonly used Extended Kalman Filter (EKF) using field test INS/GPS land-vehicle data set.

The results showed that both of the EPF and the EKF provided comparable navigation errors in cases of full GPS signals availability. However in cases when short period (60 sec) GPS outages were simulated in the test trajectory, EPF performance is slightly better than that of EKF. It was also deducted that the performance of EPF is highly dependent on the number of particles used in the implementation. Generally the number of particles required varies within 15 to 100 particles for each state variable. For Motion Pak II, 35 particles gave best results.

Generally, in cases when non-linearities are dominant, the EKF performance is known to be greatly degraded. However, this is not the case for the EPF since the EPF principle is based on the fact that a single state vector is represented by number of particles and therefore, it is more reliable for highly nonlinear cases. To further improve the performance of EPF, further investigations are required including the tuning of the process noise, measurement noise and the importance sampling step. These techniques are currently being investigated.

**Table 2: Results for MP Field tests**

| Outages | EKF (m) | EPF(m) |
|---|---|---|
| # 1 | 135.304 | 134.769 |
| # 2 | 56.761 | 56.355 |
| # 3 | 79.396 | 77.038 |
| # 4 | 11.004 | 11.021 |
| # 5 | 19.041 | 16.734 |
| Mean Value | 60.312 | 59.183 |

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# India-Pakistan maritime boundary: Issues and approach

**Rear Admiral K R Srinivasan** AVSM, IN (Retd) is a Hydrographic and Oceanographic Expert and was the Chief Hydrographer to the Government of India from August 1994 to June 2004.

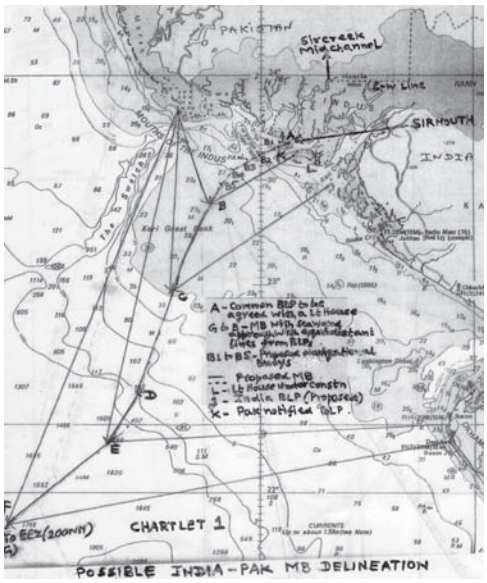
MARITIME Boundary Delineation (MBD) with neighbouring States is an essential need for national security and offshore development, more so for developing States with sizeable Exclusive Economic Zone(EEZ) and Continental Shelf Areas. Whilst it is laudable that India had finalized the MBD with 5 of her 7 neighbouring maritime states(mostly based on equidistance principle), her inability to achieve an acceptable maritime boundaries with Pakistan and Bangladesh, is hampering offshore economic development to the full extent, especially on the Energy( oil/gas/gas hydrates) and Food ( fish,etc) Securities. What is hampering a fairly simple MBD based on international law(UNCLOS) and accepted technical principles, is Pakistan linking it to other disputes like Kashmir. Adoption of the well established international law, principles, practices and some political push to accept minor concessions will ensure an amicable MBD with Pakistan.

## Framework for Maritime Boundary Delimitation(MBD)

For any satisfactory resolving of the MBs, the UNCLOS 1982 provides reasonable frame work, even in the light of the aspirations for Maritime Zones like EEZ and Continental shelf(CS). Delays in MBD unduly push up cost of Investments at Sea, especially in a liberalised World Economy. Specific provisions of the National Maritime Zones Acts of Pakistan (including rules thereunder), not in conformity with the UNCLOS provisions, have also contributed to the complication. Historical waters concept can be applied to some areas, as was done by India in the MBD with Sri Lanka in Palkbay. Fortunately, there are a number of MBD Agreements worldwide between Maritime States and some of the nuances for resolving the MBD with India's Neighbours, including the Riverine Sir Creek area, can be learnt from such Agreements. Equidistance principle from the Baselines under Article 15 of UNCLOS, Thalweg Principle on Centre of the Navigable River/Channel, proximity of the Islands to the mainland coast/river/channel, can resolve many MBs. The promulgation of the BL system in accordance with UNCLOS provisions will help legal enforcement and reduce undue tensions. India, regrettably, has not taken the important aspect of state practices with all the security needs with seriousness, especially in Sircreek area.

## India-Pakistan MBD

The issue of India- Pakistan MBD is delayed, not for complexity on International Principles amd state practices, but because of its linkage to other politically sensitive issues. Historically,Sircreek dispute started over a pile of logwood on her banks in 1900s, which led the then rulers of Kutch and Sind provinces referring the issue to the then Govt of Bombay. The agreed Resolution of 1914 was documented in the form of Map S44. This map was implemented in 1925 through Pakistan Map B74 with the Centre of the Navigable Channel as the Maritime Limit upto SirMouth. Sircreek is approximately 60 KM long upto the Northern Point and the East-West boundary line is 38 KM long. The Western Boundary Tribunal, agreed to by both parties, gave the award in 1968, which upheld 90% of the Indian claim in the Rann of Kutch along the E-W line, but left the Sircreek Maritime Demarcation to the dotted lines in the centre of the Sir Creek channel. Out of the 68 pillars erected along the East-West line,only 38 pillars are intact in 2005. Despite a clear way ahead, role of the interlocutors and substantial



rounds of talks under the Composite Dialogue on Confidence Building Measures(CBM),both countries have failed to arrive at an acceptable MBD.

The British Govt had maintained records of the Geomorphology of Sircreek area, which provide reasonably good data to resolve the MBD on historical data basis. The Resolution of 1914 between the then Sind Province and the State of Bombay was laudable. However the actual demarcation over maps in 1924 created the present issue of whether to give credence to the well established International Principle of Thalweg( the centre of the Navigable Channel in Sircreek) or the broad green ribbon line to broadly indicate( and not delineate!)land boundary as per then prevalent cartographic principles. India has carried out proper hydrographic surveys using modern surveying equipment in the area from time to time to update the Navigational Charts for the safety of mariners, which has revealed perceptible changes in Geomorphology, including the crucial centre of the Navigable Channel in Sircreek. The shift in stand from historical data to joint survey on the part of Pakistan seems deliberate to keep better options and derive more maritime areas. It is also important to note that any further delay in MBD from EEZ to Sircreek beyond 2009, may result in the Continental Shelf areas of both countries coming under the ambit of the International Seabed Authority(ISBA) under UNCLOS provisions, unless the deadline is extended by the State Parties again in their meeting at the United Nations in 2008.

## The Indian Stand

The consistent Indian stand is based on historical data, international/State practices and UNCLOS provisions. India wants the East-West horizontal line(marked by the erected pillars) as the land boundary, the centre of the Navigable Channel upto Sirmouth marked by the dotted lines in 1914/1924 agreements as the MB within Sircreek and the common BLP at the centre of the SirMouth based on legally published Navigational Charts. India has also officially protested the BLP "K" of Pakistan on the eastern bank of Sircreek. The historical use of Sircreek waters for fishing by the Indian Fishermen over decades further strengthens Indian position. Provisions of paras 9 & 10 of the1914 resolution is reflected by the dotted lines in the Centre of the Sircreek channel in all Maps and Charts, including the final map of 1924 on delimitation. India has suggested a seaward approach from EEZ and highlighted the urgency in achieving the MBD view Continental Shelf claims deadline in 2009.

## The Pakistan Stand

Pakistan has argued that Sircreek is not Navigable, common BLP should be their point "K", Equity under MZP Act and joint survey be carried out to establish the changes in the Geomorphology of the area. Their desire to control more areas in Sircreek by shifting the East –West horizontal line southwards and MB within Sircreek channel to point "K" is obvious.

## Implications for India on MBD with Pakistan

Pakistan's tactical approach from historical to present survey data lies in the Geomorphological changes caused by reported artificial melting of their Glaciers with attendant river training since 2002 and the Satellite Imageries of the area, indicating shifting of the centre of the Navigable Channel Eastwards, coming close to their BLP 'K'. The Joint Survey carried out in early 2007 may not fully alter the picture, except that now a fully modern coordinated system is now available for the joint survey data. The Equity Principle of Pakistan is not tenable under Articles 69 & 70 of UNCLOS, since Pakistan is neither Geographically Disadvantageous nor Land/Shelf locked, but has its own Maritime Zones upto the EEZ and possibly the Continental Shelf. If the claim of Pakistan is accepted, high value targets in Gujarat will come closer to their reach for land/sea/air attacks, besides Political and Economic repercussions, especially on the Fisheries and Natural Resources wealth,with some reduction in Indian Territorial Waters/ EEZ. The inability of India to promulgate her Baseline System(despite being finalised in 2003)has further weakened our position and legal enforcement of violations. MBD in Sircreek must avoid a repeat of Kachativu(SriLanka) with attendant prolonged irritants in relationship. It is important to underline that any major concessions made by India is likely to be sought elsewhere also.

## Likely MBD with Pakistan

There is merit in both India and Pakistan resolving the MBD through a compromise of Historical and Joint Survey data, but with adherance to established principles of Thalweg(ie the centre of the navigable channel)and the UN Handbook on MBD without unduly affecting each others concerns. It would be pragmatic to adopt the Seaward Approach from 200 NM to approx 20 NM from Sircreek, based on Equidistance principles from both main coasts and without involving any disputed BLPs in Sircreek and thereafter resolve the balance 20 NM of MBD upto Sir Mouth. Thus approx 180 NM of well coordinated MBD would facilitate Confidence Building and enable both countries to exploit their Natural Resources in an ever increasing investment costs with attendant effects on Energy and Food Security. Common BLP in Sircreek can then be finalised based on historical and joint survey data with minor adjustments.

## Imperatives for Peaceful MBD with Pakistan.

Whilst agreeing on a just Maritime Boundary, some least cost measures must be adopted that would minimise future irritants, out of which a CBM on Fishing is a top priority. A well coordinaed mechanism between the Security Agencies of both countries in conflict situations, will go a long way in minimising tensions that both States had witnessed since Independence. An established navigation system of Lighthouse/ Lighted buoys will help guide the fishermen and

security agencies against entering each others legal waters. The general light house accepted for establishment at Kori Creek as per Godbole Committee on internal security in 1999, be established without any further delay, even by resorting to an offshore platform mode with the help of oil exploration firms.

Resolution of the Maritime Boundary with Pakistan on established principles of UNCLOS with some adjustment is most desirable for lasting Peace and Economic benefits. It is essential to learn from past MBD worldwide and ensure a more comprehensive agreement( including modern cartographic aspects), that will ensure lasting peace in Maritime Areas, especially from the angles of Fishermen from both sides and Offshore resources Exploitation. India would do well to promulgate the already finalised BaseLine System and claim her Continental Shelf areas with supporting Scientific and Technical data before the UNCLCS by 2009 and prepare to negotiate MBD on overlapping Continental Shelf areas with Pakistan. It is important for india to note that there will be common threads in the MBD with Pakistan and Jurisprudence is necessary in the principles and adjustments.

## Conclusion

Resolution of the Maritime Boundary with Pakistan on established principles of UNCLOS with some adjustment is most desirable for lasting Peace and Economic benefits. It is essential to learn from past MBD worldwide and ensure a more Comprehensive Agreement that will ensure lasting peace in Maritime Areas, especially from the angles of Fishermen from both sides and Offshore resources Exploitation. India would do well to promulgate the already finalised BaseLine System and claim her continental shelf areas with supporting Scientific and Technical data before the UNCLCS by 2009 and prepare to negotiate MBD on overlapping Continental Shelf areas with Pakistan, Srilanka and Indonesia. It is important for india to ensure jurisprudence in the principles and adjustments of Maritime Boundary.

# Tsunami Early Warning Centre inaugurated

The Hon. Minister for Science, Technology and Earth Sciences, Shri. Kapil Sibal inaugurated the National Tsunami Early Warning System that has been set up at the Indian National Centre for Ocean Information Services (INCOIS), Hyderabad on October 15, 2007.

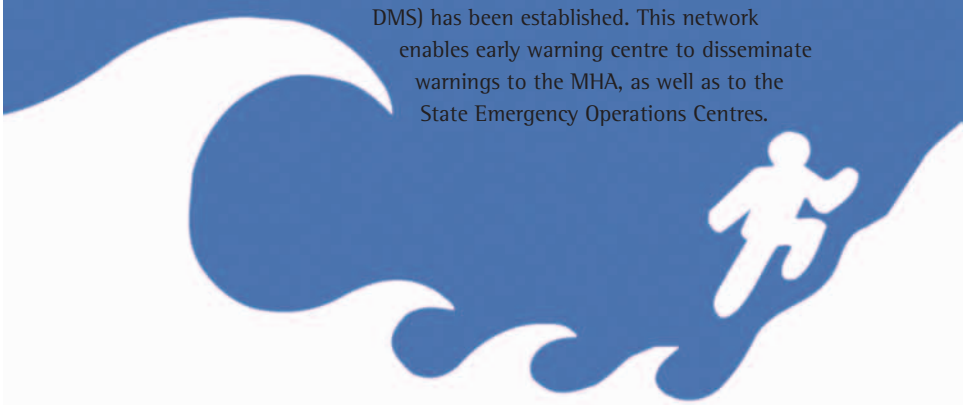
The Warning System has been established by Ministry of Earth Science as the nodal ministry at a cost of Rs.125 Crore in collaboration with Department of Science and Technology, Department of Space and the Council of Scientific and Industrial Research.

The east and west coasts of India and the island regions are likely to be affected by tsunamis generated mainly by subduction zone related earthquakes from the two potential source regions, viz., the Andaman-Nicobar-Sumatra island arc and the Makran subduction zone north of Arabian Sea. The Indian Tsunami Early Warning System comprises a real-time network of seismic stations, Bottom Pressure Recorders (BPR) and tide gauges to detect tsunamigenic earthquakes and to monitor tsunamis.

The system detects all earthquake events of more than 6 Magnitude occurring in the Indian Ocean in the less than 20 minutes of occurrence. BPRs installed in the Deep Ocean are the key sensors to confirm the triggering of a Tsunami. The National Institute of Ocean Technology (NIOT) has installed 4 BPRs in the Bay of Bengal and the 2 BPRs in Arabian Sea. In addition, NIOT and Survey of India (SOI) have installed 30 Tide Gauges to monitor the progress of tsunami waves. Integrated Coastal and Marine Area Management (ICMAM) has customised and ran the Tsunami Model for 5 historical earthquakes and the predicted inundation areas. The inundated areas are being overlaid on cadastral level maps of 1:5000 scale. These community-level inundation maps are extremely useful for assessing the population and infrastructure at risk. High-resolution Coastal Topography data required for modelling is generated by the National Remote Sensing Agency (NRSA) using ALTM and Cartosat Data.

A state-of-the-art early warning centre is established at INCOIS enabling reception of real-time data from all the sensors, analysis of the data, generation and dissemination of tsunami advisories following a standard operating procedure. Seismic and sea-level data are continuously monitored in the Early Warning Centre using a custom-built software application jointly developed with M/s Tata Consultancy Services (TCS) that generates alarms/ alerts in the warning centre whenever a pre-set threshold is crossed.

The National Early Warning Centre will generate and disseminate timely advisories to the Control Room of the Ministry of Home Affairs for further dissemination to the Public. For the dissemination of alerts to MHA a satellite-based virtual private network for disaster management support (VPN DMS) has been established. This network enables early warning centre to disseminate warnings to the MHA, as well as to the State Emergency Operations Centres.

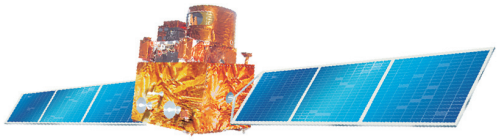


# Another Twenty20 from India!

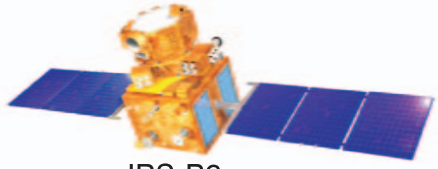
## Indian Remote Sensing Satellites (IRS) serving Global Earth Observation needs through 20 International Ground Stations and 20 IRS Resellers

*now, enriched by the start of commercial sales from Cartosat-2*

Cartosat-1

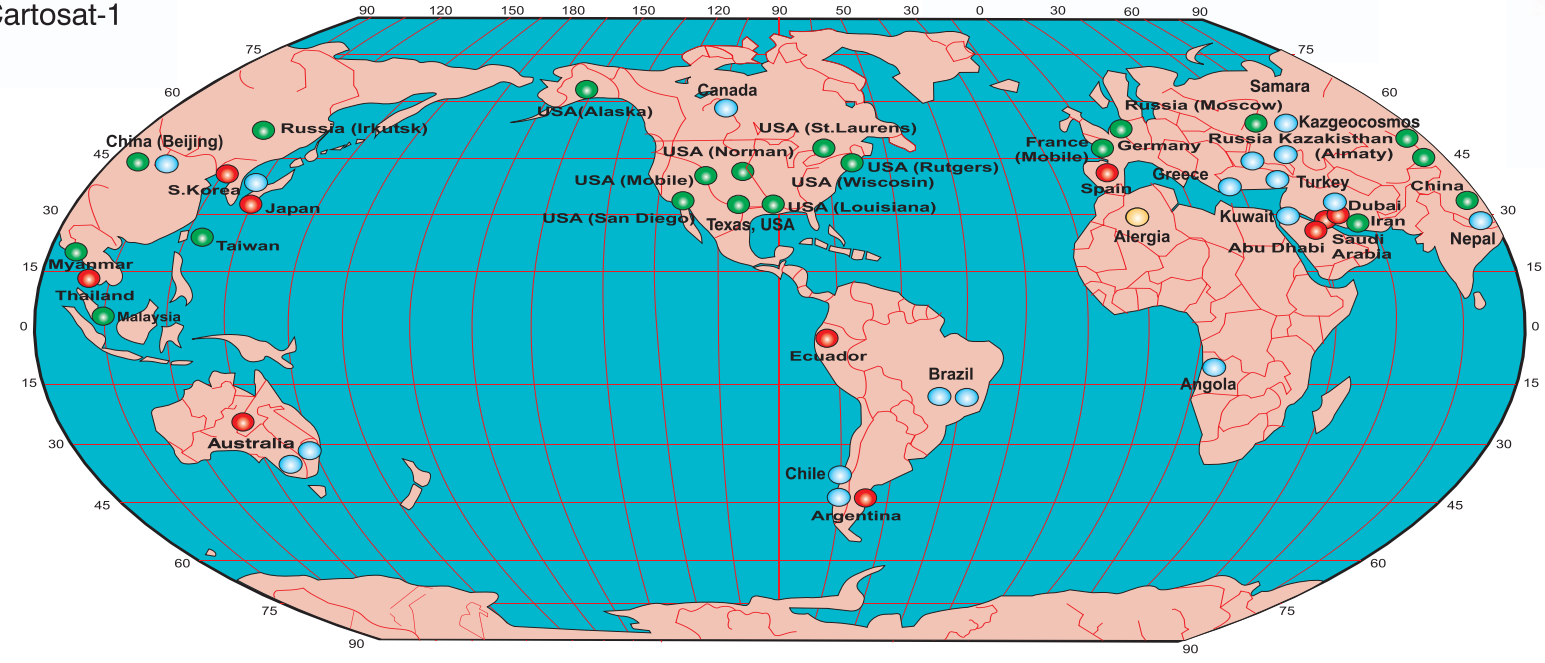


IRS-1C/1D



IRS-P6

Cartosat-2

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Fax : +91-80-2341 8981
Website : www.antrix.gov.in
email : mail@antrix.gov.in

## Magellan introduces its CrossoverGPS

Magellan, enters the consumer driver space with its CrossoverGPS, it caters for road, hiking/off-road and nautical navigation. It comes with high battery life and with a ruggedised sleeve to protect from drops and the map data comes from Navteq. *www.magellangps.com*

## Topcon GTS-750 and GMS-2 Pro introduced

Topcon Europe Positioning has released new total stations, the GTS-750 Series. It also released the GMS-2 Pro, an integrated distance meter, offset measurement, an image height/width measurement and a high level of mobility in the well known handy format of the GMS-2. *www.topconpositioning.com*

## Leica Geospatial Imaging - Develops TAMS, Launches Leica ADE

Leica Geosystems Geospatial Imaging announces the development of a new Tactical Airborne Mapping Surveillance (TAMS) system. It is a platform agnostic, with a multi-sensor payload capable of in-theater fixed wing, helicopter and Unmanned Aerial Vehicles and Unmanned Aerial Systems (UAV/UAS) deployment.

It has also released Leica ADE, with the ability to handle Oracle 11g data. It contains web-based and mobile enterprise applications for editing Oracle Spatial data in both connected and disconnected environment. *www.leica-geosystems.com*

## Surrey Satellites Sign-up for 2008 Launch

Surrey Satellite Technology Ltd (SSTL) is to launch two new enhanced Disaster Monitoring Constellation (DMC) satellites - Deimos-1, which was built for Deimos SL (Spain) and SSTL's UK-DMC2 in the fourth quarter of 2008. Both will carry an enhanced version of the DMC wide area imaging system, providing 600km wide swaths of the Earth in three spectral bands at a ground resolution of 22-metres.

## Earthmine Develops New Virtual Mapping System

Earthmine, has developed an original system that goes beyond street-level panoramic views, by georeferencing every pixel in the images — thereby allowing users to add georeferenced tags, measure buildings, build 3D models, and export this data into GIS and mapping systems.

## GIS Wide Used in China

China's self-developed GIS technology has been widely used in the spheres of land survey, mineral exploitation, water conservancy and many other aspects. The industry has registered 400 billion yuan in aggregate output value last year and hired more than 300,000 people, according to Zhong Ershun, deputy president of the China Association for Geographic Information System.

## PCI Geomatics upgrades Geomatica Software

PCI Geomatics has announced the release of Geomatica 10.1.1. This release features notable enhancements to sensor support as well as additional functionality within the software. It also supports Kompsat-2, the high-resolution of Korean Aerospace Research Institute (KARI). *www.pcigeomatics.com*

## Leica Reference Stations in Department of Sustainability & Environment in Australia

CR Kennedy, Leica Geosystems partner in Australia shall supply new Continuously Operating Reference Stations (CORS) to Spatial Information Infrastructure of the Department of Sustainability and Environment (DSE) in Victoria. The tender requested Global Navigation Satellite Systems (GNSS) equipment to support GPSnet modernization and densification.

GPSnet is a cooperative network of 31 GNSS reference stations located across Victoria. providing static data for post processing to a comprehensive network providing both post and real time processing services. Modernization of GPSnet will increase the progress of migration to a GNSS CORS infrastructure capability. It will also be deployed into Victoria's GPSnet as a part of the AuScope Geospatial Infrastructure to be installed over a 5 year period (2007-2011) ultimately forming part of the nationwide GNSS CORS network of approximately 100 sites.

DigitalGlobe unveils first Worldview-1 images

## Applanix POS MV Technology for Arctic Survey Trip

Applanix announced POS MV™ will be working with nautical sensors aboard the U.S. Coast Guard icebreaker Healy. The system will assist onboard marine echo sounder systems and other vessel sensors during bathometric mapping by accurately measuring sensor and ship positioning and orientation during data capture.

## Trimble brings Pence-per-Day fleet management to Europe

Trimble has launched its wireless fleet productivity systems for the European commercial vehicle market. It utilizes monitoring, mapping and reporting tools as well as wireless communications, messaging and automated workflow to help fleet operators and field service providers. *www.trimble.com*

# Hexagon acquires NovAtel

NovAtel Inc.and Hexagon AB have entered into a definitive agreement under which the Swedish company will acquire all the outstanding shares of NovAtel for $50 per share, or approximately $390 million. The move continues Hexagon's move into the GNSS industry; at the end of 2005 it acquired Leica Geosystems. NovAtel has had a long-standing partnership with Leica Geosystems; it has been a core supplier of precision components to Leica since 2002.

Under the terms of the agreement, Hexagon will commence a cash tender offer to acquire all of the issued and outstanding shares of NovAtel. The $50 share price represents a 31 percent premium to NovAtel's 30-day volume weighted average share price, according to the companies.

Meanwhile, NovAtel Inc. has acquired privately held Antcom Corp. (Antcom), located in Torrance, California. Antcom is a communication company that specializes in the design, development and manufacturing of antenna and microwave products for commercial and military customers in the space, ground and avionics telecommunications markets. Under the terms of the agreement, NovAtel will acquire Antcom for $5 million in cash and an additional $1 million in cash subject to Antcom's achievement of certain financial goals for this year.

In an interview with Coordinates Farlin Halsey, VP Corporate Strategy & Alliance shares his views on significance of these acquisitions

**NovAtel is acquired by hexagon? What is the impact of this acquisition in the market of precise positioning?**

Assuming the tender offer is successfully transacted, we believe that NovAtel will become a central element to Hexagon's strategy of building a leading international presence in positioning-based technologies and solutions. Joining with Hexagon, NovAtel should be able to benefit from new opportunities within Hexagon's family of market leading business units. These opportunities should allow NovAtel to expedite its strategy of integration with other technologies.

**Will this acquisition affect anyway the current focus, activities or functioning of NovAtel?**

No, we expect it will be business as usual. We believe Hexagon's strategies for our business going forward are in line with our own goals. As a result, this transaction offers expanded opportunities for our customers and employees. Joining with Hexagon, we expect to be able to benefit from new opportunities within Hexagon's family of market leading business units and assure our customers and employees of NovAtel's ability to continue to provide the most advanced precision GNSS components and subsystems.

**NovAtel's antennas are designed to enhance its precise positioning receivers. What's the significance of acquisition of Antcom by NovAtel?**

The acquisition of Antcom by NovAtel is significant for a number of reasons. It broadens NovAtel's portfolio of products, giving our worldwide customer base convenient access to an expanded offering of GPS, GNSS and other antenna products for satellite and terrestrial communications; it expands NovAtel's total addressable market; and it represents a growth platform for NovAtel, due to the numerous customer, market and technology synergies between our two companies.

**This is the era of acquisition and mergers. Please comment.**

Quote from Jonathan W. Ladd, President & CEO: "Whenever you have a fast-moving, large-growth market and you have a lot of different niche players, I think it's a fairly standard evolution that a lot of the larger players want to broaden their reach." (Globe & Mail, Oct. 9, 2007)

## HTC Launches GPS Phone P3300 in India

High Tech Computer Corp. launched HTC P3300, a GPS phone in India. It allows users to take pictures outdoors and then automatically embeds the satellite coordinates into the picture. The MapKing R12 is the mobile mapping system which comes with the P3300. *www.tech2.com*

## Nokia will use Navteq technology for pedestrian navigation

Nokia plans to use the mapping technology from recently acquired company Navteq to develop the mapping applications. An area it believes is "totally underdeveloped" is pedestrian location-based services having "basically zero penetration among the 3 billion mobile devices uses globally" *http://techdigest.tv*

## SiRF unveils development platform for location services

SiRF unveils SiRFstudio, a location services enabling platform that can simplify and speed the development and deployment of location-aware applications across a broad range of mobile devices. It offers LBS developers a set of tools to develop their applications faster and port them to multiple devices. *www.sirf.com*

## Polar releases G3 GPS to compliment RS800

Polar has released G3 GPS, a lightweight and compact module that communicates with the RS800 using W.I.N.D (Wireless Integrated Network Device technology). It is a wrist mounted unit, or it can be kept in a pocket or backpack or mounted to the handlebars. *www.roadcyclinguk.com*

## Integrated GPS functionality for MC70

Motorola Inc. has introduced MC70 mobile computer, featuring integrated GPS capability. It will allow organisations, such as postal companies, to track and manage dynamic, real-time tasking, as well as verify specific locations of activities and provide mobile workers with pinpoint navigation support *www.motorola.com*

## Vodafone launches two Blackberry models in India

Vodafone, has introduced two of its Blackberry models, Curve 8310 and 8820 in India, recently. Curve 8310 is RIM's latest innovation for customers who demand a feature-rich multimedia and GPS-enabled smartphone. *www.newsgaze.com*

## Apple devices to get location-based services

Apple will open its mobile platform to third party developments through a Software Development Kit (SDK). With a SDK there will be ways to connect an external GPS Bluetooth receiver to the iPhone. *www.gpsbusinessnews.com*

## Helio chooses Navteq for LBS offerings

Helio has selected Navteq to be its map supplier for its LBS applications. It has launched several end-user applications that incorporate Navteq data, including Helio's proprietary GPS-enabled friend-finder application, Buddy Beacon. *www.navteq.com*

## Chinese Handset Vendor Gets Unicom Cdma Order

China's Hi-Tech Wealth to provide China Unicom with 100,000 CDMA GPS mobile phones. It will provide 50,000 units each of its C66 and C68 model CDMA GPS mobile phones, and the majority of the 100,000 unit order will be shipped in the fourth quarter of 2007.

## NIM Claims Two Million Paid Mobile Phone Navigation Subscribers

The location based services provider, Networks In Motion (NIM) has surpassed two million paid users of its real-time navigation and local search services on GPS-enabled mobile phones based on the company's LBS NavBuilder platform. NIM is also the power behind some specialized third-party branded LBS applications like AAA.

## KLG Systel and SAP introduce Vidushi

KLG Systel Ltd, in collaboration with SAP has developed an enterprise solution, Vidushi. It is developed on SAP Netweaver and is designed to complement the functionalities of SAP IS-Utilities (Industry Solutions for Utilities) to meet the specific needs of the electricity distribution utilities. It is designed to provide a web based solution for GIS based Consumer Indexing and Loss Analysis Solution to the distribution utilities. *http://press-releases.techwhack.com*

## National Geographic and MetaCarta introduce CartaLens

National Geographic Maps and MetaCarta, Inc has announced CartaLens, an innovative geospatial digital asset management solution. It shall be able to search and retrieve location-based information from both structured content and a broad base of digital content enabling users to fuse digital assets with maps and metadata in a collaborative and interactive viewing environment. *www.marketwire.com*

## GIS solution for Banking Industry in Nigeria

STL -Nigeria's GIS solution provider released an integrated GIS solution designed for the financial industry in Nigeria. It involves the use of mapping software to interact with digital mapping data and business data such as with the location of banks, customer data, to make informed business decision. *www.spatialtechnologiesltd.com*

## GIS mapping for flood-affected Bihar, India

ACTED has started its emergency response operations in Bihar with the primary aim of assisting flood-affected populations upon return to their homes. In addition to its field activities, ACTED will also support the wider flood response operation by promoting the use of GIS mapping among emergency response stakeholders. *www.acted.org*

## Elephants tracing with the help of GIS

As per a study by Chandaka Dampara Sanctuary, India authorities, the movement pattern of specific elephants, can now be known through proper GIS mapping over the years. The month-wise flow of elephant movements out of the sanctuary in co-ordination with different parametres like cropping pattern and water availability inside the sanctuary and their co-relations can be found out from the GIS study according to officials. *www.newindpress.com*

## GIS to help farmers with soil fertility

Farmers will be able to avail themselves of information about soil fertility at their district and block headquarters that would also help the Department of Fertilisers to prepare and monitor equitable distribution of fertilizers and micro-nutrients. A methodology for preparation of district level digitized soil fertility map has been standardized. The Indian Institute of Soil Sciences (IISS) at Bhopal has undertaken the work for developing the digitized soil fertility map using GIS and GPS. *www.hindu.com*

## Impact of Climate Changes on Gray Whale Feeding Grounds Tracked with GIS

The 40-ton gray whale is nourished by microscopic phytoplankton plants that contain chlorophyll. Researchers at Coastal Ecosystems Research Foundation, Canada, link the concentration of chlorophyll to gray whale distribution to better understand the relationship between whales and their feeding grounds by tracking the concentration of chlorophyll in the ocean using GIS. CERF collected data on the number and distribution of gray whales visiting the summer feeding grounds since 1996 by means of sight and satellites. This descriptive information was put into GIS, to generate maps, which depict the factors that influence a specific whale's choice of feeding grounds and show changes in those factors over time. By determining the range that whales traveled, the team quantified core areas and home ranges.

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**Email**: export@southsurvey.com
**Website**: www.southsurvey.com/english/index.asp

## Satski's GPS Device for skiers

A company called Satski has launched GPS navigation system for skiers giving an interactive map of the mountain that will guide, assist and record movements. The system will constantly update the current position on the map, give statistics and record coordinates, altitude, speed, and distance. *www.about-electronics.eu*

## GPS to allow Sydney buses to 'prioritise' traffic lights

The New South Wales Government shall equip more than 4,000 buses with on board GPS devices that will link them to the traffic light control system. If a bus is running late it will get priority at traffic lights. *abc.net.au*

## Modernized GPS Satellite Launched

The fourth US Air Force modernized Global Positioning System Block IIR satellite has been launched successfully. It is the 4th in a series of eight Block IIR-M spacecraft that Lockheed Martin Navigation Systems has modernised for its customer, the Global Positioning Systems Wing, Space and Missile Systems Center, Los Angeles Air Force Base,CA, USA. Each satellite includes a modernized antenna panel providing increased signal power to ground receivers, 2 new military signals for improved accuracy, enhanced encryption and anti-jamming capabilities for the military, and a second civil signal that will provide users with an open access signal on a different frequency.

## Mumbai Police modernisation plan using GIS/GPS

Under the modernisation plan, the Mumbai Police department control room has equipped itself with GIS that has the digitised maps of the city with its landmarks and routes. The GIS integrated with the GPS devices fitted on police vehicles provides the personnel manning the control room with the exact location of the vehicles. So far, Rs 240 crore has been allocated for these programmes which have been given an extension till the year 2010 from 2005.

# Galileo update

## Parliament votes to boost funding for EIT and Galileo

The European Parliament has voted to boost funding for the European Institute of Technology (EIT) and Galileo, the European satellite navigation system, at its first reading vote on the draft budget for 2008. The MEPs voted to reverse over €1.5 billion of cuts made by the Council to payments under the headings 1a (competitiveness, growth, employment) and 1b (cohesion). In particular, the Parliament is keen to boost funding for Galileo and the EIT, and therefore voted to set aside an additional €739 million for the financing of these two projects. The Parliament supports the Commission's proposal to revise the financial perspectives to ensure both Galileo and the EIT receive adequate funding over the 2007 to 2013 period. *http://ec.europa.eu/*

## Merkel promises opposition on Galileo sat-nav

German Chancellor Angela Merkel said that she would keep up opposition to the way the European Union is managing proposals for the Galileo satellite-navigation system. Speaking at a Berlin conference on transport, the chancellor said Berlin would "cheerfully" stand up for German national interests on the issue. Berlin has criticized EU proposals to finance an investment budget shortfall of 2.4 billion euros (3.4 billion dollars) for the global-positioning system mainly from its own budget. Merkel said that since Germany was "a major financial contributor" it had to have preference when contracts were awarded. The EU has suggested open tendering for the contracts.

## MPs demand analysis of Galileo's benefits

The House of Commons Transport Committee has questioned transport minister Rosie Winterton over the value of the 26-satellite programme that will provide Europe with navigation services independent of the US-owned GPS system. So far only four orbits have been designed and developed and the cost to the EU has hit £1.1bn, way above initial estimates of £750m. The UK is set to contribute 17 per cent of the total cost, which is estimated to reach £5.5bn over two decades.

The UK contribution is equivalent to major domestic transport schemes, said committee chairman Gwyneth Dunwoody. "Galileo has given us considerable concern," she said. "How far are we prepared to go before we say Galileo is not having any more money?"

The government is continuing cautious support for the scheme because it offers greater resilience for commercial uses and the possibility of a broader range of applications. *http://www.itweek.co.uk/*

## EU still deadlocked over funds for Galileo

The European Union failed again to break a deadlock over how to fund the ambitious but troubled Galileo satellite network. "It's too early to talk about a consensus on financing," said Portuguese Finance Minister Fernando Teixeira Dos Santos, whose country holds the EU's rotating presidency, after a meeting of finance ministers in Luxembourg. EU transport ministers were unable to overcome the impasse a week ago. *http://afp.google.com/*

# INTERGEO 2007


THE three days of INTERGEO, which was held at the Leipzig Exhibition Centre this year, have confirmed that the world's largest congress trade fair for geodesy, geoinformation and land management has a special place in the industry.

Many of the 16,500 visitors travelled a long way to attend the fair; some 50 percent of visitors travelled more than 300 kilometres to be a part of the event. Just under 35 percent of those questioned said that they had travelled between 100 and 300 kilometres. The international importance of INTERGEO was underlined by the fact that it attracted guests from more than 50 countries.

The exhibitors were delighted with the high profile of the visitors, many of whom come to INTERGEO as decision makers. In fact, many companies wait until they have attended the trade fair each year before making decisions on investments. More than 85 percent of exhibitors said that they had achieved their aims in showcasing themselves at INTERGEO 2007. Some 90 percent of exhibitors said that they intend to visit the fair in 2008 too. 13 percent of those questioned plan to increase the size of their stands in Bremen. 70.7 percent of companies rated their present situation as "favourable to very favourable".

The congress maintained its high attendance rate, attracting 1,500 participants. It also managed to cover all key topics, with 89.5 percent of participants saying that they could not think of a specific topic that had been missing from the congress. The congress is used primarily for keeping up-to-date with developments (68.5 percent). 50 percent said that they used the event to exchange information with other specialists, and two-thirds said that the show provided them with general information.

"The congress and trade fair dovetail with each other and show common future trends. The Earth as a scientific object and limited habitat for the human race is the focus of the congress held under the theme of 'Knowledge and action for planet Earth'. We are thus making our contribution to overcoming the challenges faced by our society", said Hagen Graeff.

The INTERGEO Forum, which is part of the congress programme, is organized by the exhibiting companies and thus creates the central bridge between the trade fair and the congress. Almost forty presentations were held, giving participants the opportunity to get practical information first-hand on topics that are driving the industry.

The Focus Forum – where exhibiting companies at the trade fair make use of a platform by focusing on current requirements and solutions in related industrial sectors, thus creating an environment for knowledge transfer – was very well received. The premiere of the international subject areas, which were held in English, also drew substantial interest. More than 90 percent of those who attended the Focus Forum had good things to say about the event. INTERGEO underlines that it also has something to offer related areas of interest, and that it is looking to establish links with them, by holding special events such as the Day for Architects and Building Planners and Property Day. Olaf Freier, Project Manager of INTERGEO and CEO of HINTE GmbH (the company responsible for organizing the trade fair) confirmed the event's new direction: "The modified forum concept, which focuses more on specialist target groups and is used as an international dialog platform, was an unqualified success and helps unlock new potential". He emphasized that the organisers will continue to drive the internationalisation of the trade fair year by year.

After the successful premiere of the Open Source Park in Munich in 2006, the event was also a resounding success in Leipzig, a fact that was underpinned by visitors and exhibitors alike.

Additionally, the profile and acceptance of the online community, which went online at the start of September at www.ask-intergeo.com, has grown significantly. Approximately one-third of visitors are now familiar with the community, which currently lists 525 exhibitors from 31 countries with a total of 990 products. More than 50 percent of visitors who are familiar with the community make considerable use of it to systematically prepare for their visit to INTERGEO.

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### November 2007

**Growing Galileo**
14-15 November, 2007
Brussels, Belgium
**donna.reay@gsa.europa.eu**
**www.gsa.europa.eu**

**27th INCA International Congress**
Visakhapatnam, India. 21-23 Nov 2007
**http://www.hydrobharat.nic.in/lst_Circular_INCA_2007.pdf**

**14th Session of the Asia-Pacific Regional Space Agency Forum**
21-23 November
Bangalore, India
**www.aprsaf.org/text/ap14_info.html**

**ESRI South Asia User Conference 2007**
29 - 30 November
Singapore
**uc2007@esrisa.com**
**http://www.esrisa.com/pages/uc2007**

### December 2007

**Navigation & Location 2007**
December 4 - 5
San Jose, CA , USA
**abbie@telematicsupdate.com**
**http://www.telematicsupdate.com/navUSA2007/**

**IGNSS2007**
4-6 December 2007
Sydney, NSW, Australia
**rob@ignss.org**
**www.ignss.org/**

**MEST 2007: 4th Middle East Spatial Technology Conference and Exhibition**
10-12 December 2007
Kingdom of Bahrain
**bseng@batelco.com.bh**
**http://www.engineer-bh.com/mest2007/**

### January 2008

**ESRI Asia Pacific User Conference**
17-18 January 2008, Tokyo, Japan
**www.esri.com/events/apuc**

### February 2008

**GSDI-10 St. Augustine, Trinidad**
February 25-29, 2008
**http://www.gsdi.org/gsdi10/**

**Munich Satellite Navigation Summit**
19 - 21 February 2008, Residenz München, Germany
**http://www.munich-satellite-navigation-summit.org/**

### April 2008

**GEO-SIBERIA 2008**
April 22 – 24, 2008
Novosibirsk , Russia
**strutz@sibfair.ru**
**http://geosiberia.sibfair.ru/eng/n**

### June 2008

**International Conference: "Studying, Modeling and Sense Making of Planet Earth"**
1 – 6 June, 2008
Department of Geography, University of the Aegean, Mytilene, Lesvos , Greece
**http://www.aegean.gr/geography/earthconference2008/ en/main_fr.htm**

### August 2008

**ESRI's 28th annual International User Conference**
August 4-8, 2008 in San Diego, California
**www.esri.com**

**ISPRS2008**
3 – 11 July, 2008
Beijing, China
**www.isprs2008-beijing.org/**

IKONOS | collected 22 July 2007
2008 Olympic Games Venues | Beijing, China

# Progress as Seen by GeoEye

## Today and Tomorrow

**Today** ▶ Everyday, GeoEye's IKONOS satellite captures noteworthy events taking place around the world, including the development of the Beijing 2008 Olympic Games venues. IKONOS has the agility, accuracy, and frequent revisit times for providing imagery that is ideal for planning, analyzing, and change detection.

**Tomorrow** ▶ GeoEye will continue its tradition of bringing you the world's most advanced imagery, with GeoEye-1—its next-generation commercial imaging satellite. GeoEye-1 will have unparalled positional accuracy as well as the highest resolution, color imagery in the world—.41-meter panchromatic and 1.65-meter multispectral.

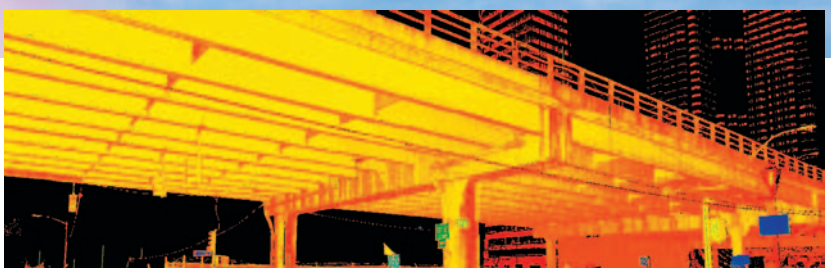
**GeoEye Imagery Sources**

IKONOS | OrbView-2 | GeoEye-1 [2008]

GeoEye

www.geoeye.com | +1.703.480.5670


# Leica ScanStation 2
# Exceptional Speed, Outstanding Versatility



## 10-fold scan speed increase makes ScanStation™ category even more productive and versatile

ScanStation 2 adds a whopping 10-fold increase in scan speed to the landmark ScanStation instrument category– the industry's most versatile and popular laser scanner. This huge increase – from 4,000 to 50,000 points/sec, max – combines with ScanStation's four fundamental total station features to take High-Definition Surveying™ (HDS™) to the next level for as-built & topographic surveys.

**ScanStation 2 sharply increases the types of as-built and topographic projects where HDS makes good business sense:**

- 2-lane & suburban roads, not just urban interstates.
- 100+ acre sites, not just one or two acres.
- Simple sites & structures, not just complex ones.
- Building interiors, not just exteriors.
- Small, everyday projects, not just big ones.

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**www.leica-geosystems.com/hds**

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