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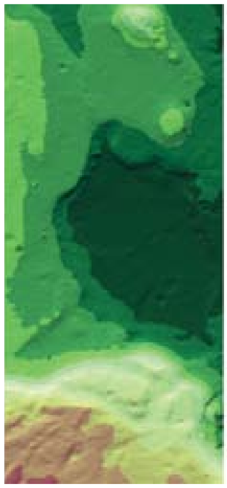
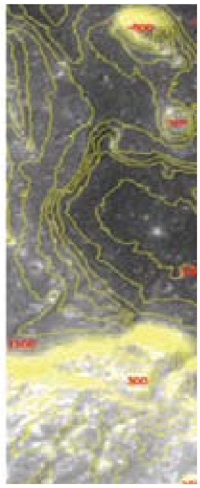
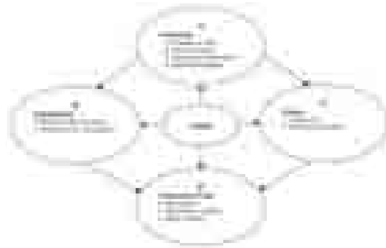


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Articles

Columns

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This issue of Coordinates is of 44 pages, including cover

The frequency (mis)match

China claims a frequency for Compass.

Europe also wants the same for Galileo's Public Regulated Service.

According to the International Telecommunications Union's policies, the first country to start using a specific frequency is granted priority status.

And some Chinese satellites are expected to start transmitting before European satellites can.

If China gains the ownership then, Europe has to seek permission from China for its use.

Not a comfortable situation for Galileo.

Stakes are high.

Reportedly, negotiations are on.

And so is the race for GNSS.

Bal Krishna, Editor
bal@mycoordinates.org

Exploring the moon in three dimension

This paper elaborates on the technology and processes being used to map the moon by the sensors on board the chandrayan-1 mission

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There has been a renewed interest in exploration of the moon and in the past four decades the exploration of moon has become a reality [1]. A number of missions have been flown to the moon by many countries. Many of these missions have carried imaging systems that, collectively, have returned an incredible wealth of information on the shape and surface characteristics of the moon. Mapping of moon began in the seventeenth Century by Galileo. Throughout history, maps and charts have played an integral role in the exploration of earth. Their importance holds true for moon exploration as well. Maps of the planets are needed by planners of spaceflights to design missions, including the selection of safe and scientifically fruitful landing sites, and are the framework for recording measurements from a wide variety of spacecraft instruments.

The making of moon maps requires development of new methods and techniques. Most of the commercial mapping software's support the map making of earth's surface features based on earth's projections and datums but the utilization of the same in the current form is not possible for mapping the lunar surface because of the absence of planetary projection and datum in the available software. Many of the basic principles derived from the mapping of the earth have to be reconsidered in the mapping of the moon. Chandrayaan-1 is India's first science mission to moon for remote sensing and mapping different aspects of the lunar surface.

Chandrayaan-1 was launched successfully on 22 October 2008 and began operations since November 2008. The primary objective of the mission are to expand the scientific knowledge about the origin and evolution of moon, upgrade India's technological capabilities and provide challenging opportunities to the young scientists working in planetary sciences. The scientific objectives of this mission are simultaneous geochemical, mineralogical and photo-geological studies and topographical mapping of the moon in visible, near infrared, low and high energy X-rays with high resolution of the whole lunar surface. Apart from technological and scientific gains, this mission provides the thrust to the basic science and research in the country. Chandrayaan-1 carries 11 different types of payloads for mapping and exploration of the moon in many aspects. Out of the eleven payloads five are Indian payloads developed indigenously.

The Indian payloads and their prime objective are [5]:

- Terrain Mapping Camera (TMC); for preparing 3D mapping of moon with high spatial and vertical resolution
- Hyper Spectral Imager (HySI); meant for mineralogy mapping of moon's surface
- Lunar Laser Ranging Instrument (LLRI); to determine global topography of moon using laser altimetry data
- High Energy X-ray Spectrometer (HEX); to carry out spectral studies of moon's surface at hard X-ray energies using good energy resolution detectors
- Moon Impact Probe (MIP); for scientific exploration from near range and design, development & demonstration of technologies required for impacting a probe at the desired location

The six International payloads are:

- Chandrayaan-1 X-ray Spectrometer (C1XS – RAL, ESA, ISRO); towards chemical mapping of moon, used in conjunction with Solar X-ray monitor
- Miniature Synthetic Aperture Radar (MiniSAR – NASA) ; to detect water ice in the permanently shadowed regions on the lunar poles
- Sub KeV Atom Reflecting Analyser (SARA – ESA, ISRO) Imaging of Moon's surface composition including permanently shadowed regions and search for volatile-rich areas, surface magnetic anomalies. Studies of space weathering
- Near Infrared Red Spectrometer (SIR-2 – ESA); to Determine chemical composition of lunar crust and mantle and investigate the process of basin, maria and crater formation on the Moon
- Radiation Dose Monitor Experiment (RADOM – BAS); to characterise quantitatively and qualitatively dose rate and deposited energy spectrum in terms of particle flux in near Moon surface
- Moon Mineralogy Mapper (M3 – NASA); to characterize and map lunar surface mineralogy in the context of lunar geologic evaluation

All the instruments onboard, except for MIP & RADOM are meant for theme specific mapping of the lunar surface.

Ground Resolution	5 m
Swath	20 km
Spectral Range	0.5 – 0.85 µm
Quantization	10 bits
Optics	f = 14 cm, f number : 4
Integration time	3.23 ms
Detector Size	7 µm
B/H	1
FOV	± 25.02 deg (Along track) ± 5.7 deg (Across track)
Stereo	3 detectors (Fore, aft, Nadir)
Data Rate	12.7 Mbps / detector

Table-1: TMC Specifications

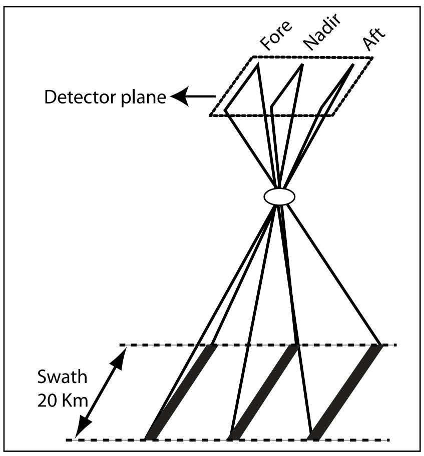

Figure-1: Viewing Geometry of TMC

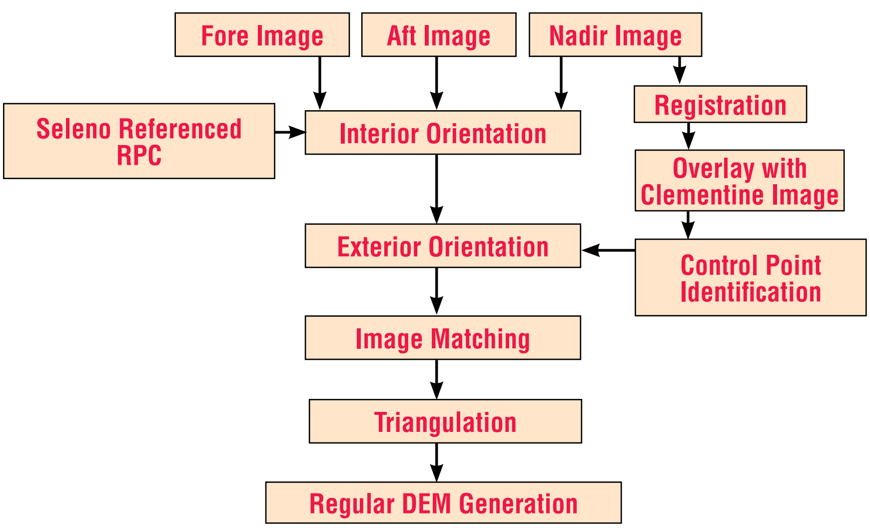

Figure-2: Flow diagram of DEM Generation Methodology

Stereo image viewing has been the most common method of elevation modelling used by the mapping (or three dimensional exploration), photogrammetry and remote sensing communities. One of the instruments (out of 11) carried by Chandrayaan-1 is Terrain Mapping Camera (TMC), which is a line scanner with three linear arrays of 4K detectors, Fore, Nadir and Aft looking at +26, 0 and -25 degrees respectively for acquiring the stereo imagery of the lunar surface. The swath and resolution of the TMC are 20 km and 5 m respectively. Terrain Mapping Camera provides three images (triplet) of the same object with full overlap. The viewing geometry of TMC is given in figure-1. Table-1 provides the TMC specifications. The aim of TMC is to map topography in both near and far side of the Moon and prepare a 3-dimensional atlas with high spatial and altitude resolution. Such high resolution mapping of complete lunar surface will help us to understand the evolution process and allow detailed study of regions of scientific interests. The digital elevation model (DEM) available from TMC along with the Lunar Laser Ranging Instrument (LLRI) on Chandrayaan-1 will also improve the Moon gravity model. Usage of digital elevation model from TMC in the science analysis of the data from the other instruments can greatly enhance the capability of the deriving the information. In addition the information obtained from chemical, radioactive and mineral mapping has to be superimposed on a topographic map to identify the areas of interest [4].

TMC provides global coverage with the stereo triplets, which can be used for generating Digital elevation Models (DEM) for 3D mapping of the entire moon surface. The definition of Lunar Atlas and the methodology of generation are given in the subsequent sections.

DEM Generation

Digital Elevation Model is the most important component (layer) of 3D mapping of any surface and sensor orientation to generate the accurate digital elevation is the key element. To precisely orient the sensor and derive the relation between the image point and object point, we need a mathematical model. The Rational Function Model (RFM) is a general version of the polynomial model that can describe more complex image-to-object point transformations. It is also called Rational Polynomial Coefficients (RPC) model and is used as an alternative solution for the rigorous physical sensor model. It is widely used by Earth Observation Sensors whenever complex sensor model is not provided. The RPC model forms the co-ordinates of the image point as ratios of the cubic polynomials in the co-ordinates of the world or object space or ground point.

A set of images is given to determine the set of polynomial coefficients in the RPC model to minimise the error. RPC model is first time being employed for relating image and object space for lunar mapping. The Chandrayaan-1 data processing team at Space Applications Centre (ISRO) has developed RPC models for the imaging geometry of Chandrayaan-1 TMC. A schematic of the workflow is shown in Figure 2. The production and quality control of stereo DEMs and orthoimages is carried out in LPS general-purpose digital photogrammetric workstation (DPW) environment. Reference for control point is obtained from the available Clementine mosaic of moon along with the ULCN2005 control network [6, 7].

Stereo image matching is performed to generate image conjugate points. Conjugate points are the common points in overlapping areas of two or more images. They connect the images in the block to each other and are necessary input for the triangulation. LPS implements a fast area based stereo-correlation algorithm that determines correspondences between points in two images.

Parallax between corresponding points is then used to determine 3D location. A surface generation step interpolates the calculated 3D points, and resamples the surface on a regular grid to produce the output DEM and corresponding co-registered image.

The DEM is generated using the mass points obtained from automatic matching process. First, we extract the exterior orientation of the two images in a stereo pair from Chandrayaan-1. Intersection calculation is then performed to determine the 3D coordinates of the corresponding matched points. Once the 3D locations of image points have been determined, the 3D points are interpolated using a triangle mesh interpolate. This mesh is then sampled at regular intervals in latitude and longitude. Vertical datum is based on spherical figure of the Moon and a lunar radius of 1737400 m. All elevations thus generated are in meters and represent the true values as the input ULCN points. These calculations are performed under the IAU 2000 Cartesian coordinate system.

Initial Results from Chandrayaan-1 TMC

There are four possibilities of stereo image processing for the DEM generation. The combinations are Fore - Aft, Fore-Nadir, Aft – Nadir and Fore-Aft-Nadir images as a pair. Out of many cases, an area in the south polar region acquired on 15-11-2008 is given here as a sample case for DEM generation. The region is a part of the crater Moretus with location -70.6 deg lat and -1.4 deg long.

The DEM generated for all the cases are shown in figure-3. The three camera triplet image (Fore-Aft-Nadir, figure-3e) produced the best matching results with 100 % success in point matching while nearly 87% success in pattern matching.

Due to the relatively large angles between FORE and AFT the matching was poor, which was shown as dark points in the DEM (figure -3c). A colour coding of the DEM is also shown in figure-3f, which clearly show the height range of the crater from -1500m to 4000 m with respect to the mean radial surface of the moon.

A large strip of 1800 km (location: Coulomb C crater) has been divided into 3 individual strips of 600 km and DEMs have been derived for all three strips separately. This break up is done to reduce the processing time in DEM generation. The DEMs and their visualisations are shown in figures-5, 6 and 7.

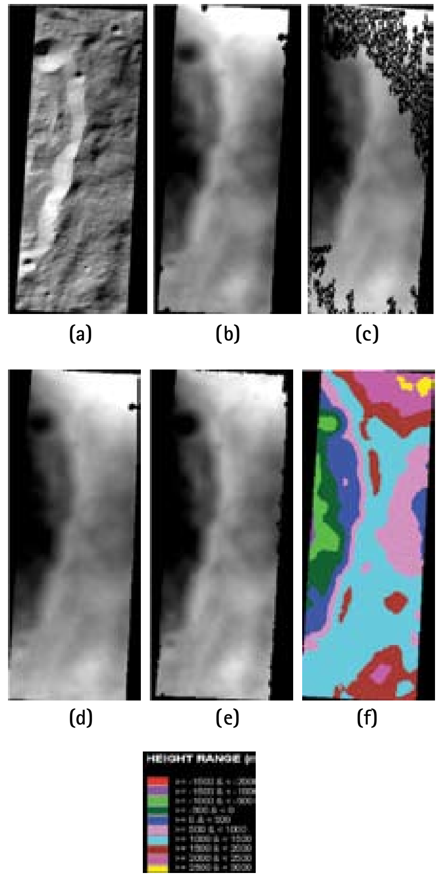

Figure-3: Moretus Crater (a)Orthoimage (b) DEM extracted using Aft-Nadir (c) DEM extracted using Fore-Aft (d) DEM extracted using Fore-Nadir (e) DEM extracted using Fore-Aft-Nadir (f) Color coded DEM

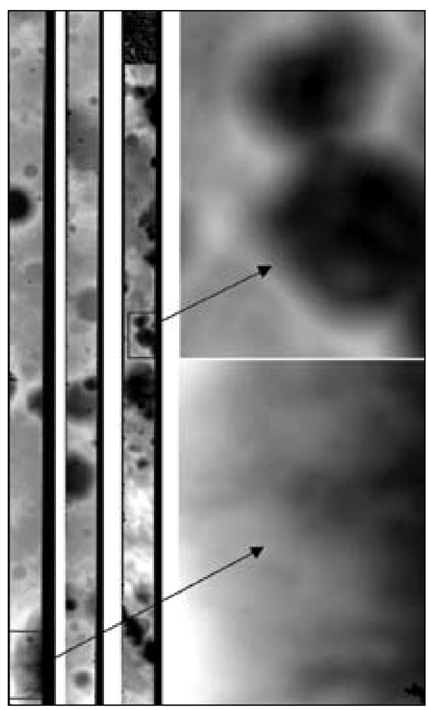

Figure-4: Overview & Full resolution (in box) of DEM generated for three strips of 600 km each

Lunar Atlas [2, 3] with TMC Data

The high level data products defined for Chandrayaan-1 mission are the Lunar Atlas and maps. The objective of Chnadrayaan-1 lunar atlas and map products are to prepare maps for the entire surface (~37.8 Million Sq. km) of moon and it's visualisation. Atlas will consist of Terrain Mapping Camera (TMC) and Hyper Spectral (HySI) orthoimage and Image mosaics, Digital elevation model derived from TMC triplets, Contributory themes from each payloads and annotations. Lunar atlas will be in softcopy while in the hardcopy form it will be represented in map catalogue form. Maps of earth's surface have been produced primarily by piecing together large-scale sketches and diagrams since centuries. Control networks were derived through extensive and laborious ground surveying. By the late nineteenth century, regional maps were produced in this fashion that was relatively accurate. With twentieth-century technology, the ability to obtain the synoptic view has emerged. Photographs taken from earth-orbiting satellites enabled the rapid production of accurate maps. When combined with well established control networks, these maps have enabled surface features on earth to be located precisely. Planetary explorers, on the other hand, have had the global perspective from the beginning, and they have progressed from global, through regional, to local vantages. The naming of features is as much a part of map making as is the measuring and plotting of their locations. Without names, communication of ideas is impossible. The names applied by explorers on earth often bear their provincial outlook. Ambiguities abound; settles on different parts of the same river often know the river by different names. The tradition that the privilege of naming belongs to the discoverer resulted in hopeless ambiguities, redundancies and inconsistencies. The International Astronomical Union (IAU) has therefore assumed control of the naming process. It's working groups are composed of planetary scientists from many nations. The main inputs for the planned lunar atlas from Chandrayaan-1 are the DEM and Orthoimages from TMC and other associated layers from the other payload data along with annotations. The absolute accuracy of the Lunar DEM in turn depends on the basic control used in the modelling the imaging geometry. As the initial results show, it is possible to derive relatively accurate DEMs from Chandrayaan-1 TMC imagery, which is the prime input for DEM generation towards Lunar Atlas preparation. Three CCD imagery in the triplet form, when compared to stereo pair leads to a good DEM in terms of detail due to the better point and pattern matching accuracies. The DEMs at 25 m grid interval depicts a very good representation of the terrain, which can be a prime input to the science analysis, when used along with the other payload data sets from Chandrayaan-1, in addition to its usage in the 3D mapping of moon.

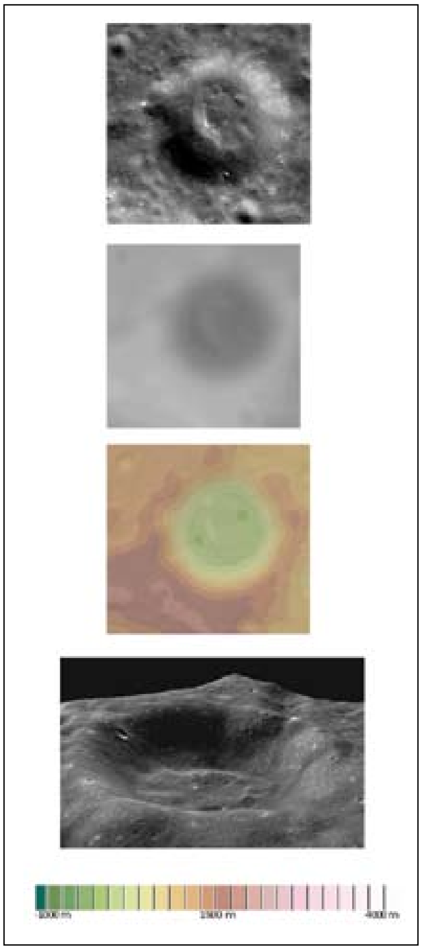

Figure-5: Orthoimage, DEM with colour coding and Visualisation of Image draped over DEM (Coulomb C Crater)

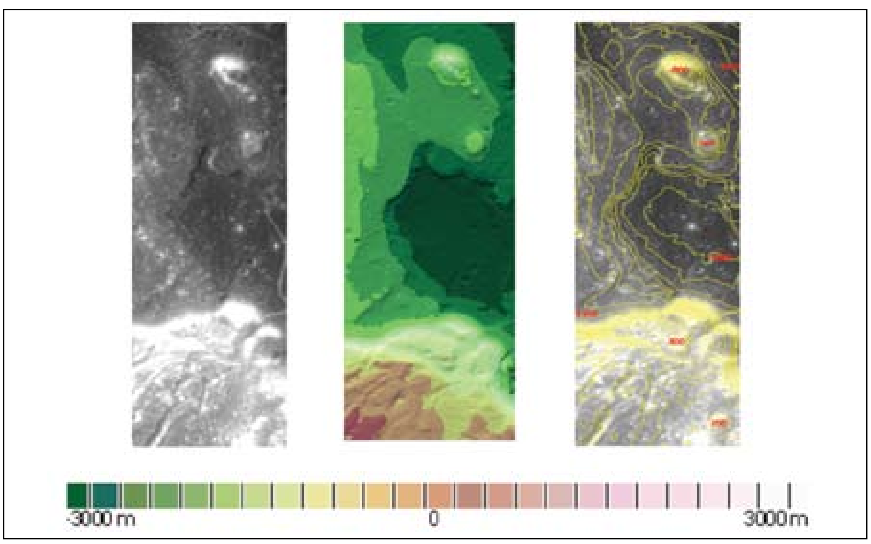

Figure-6: Part of Mare Orientale (a) Orthoimage (b) colour coded DEM (20 km x 65 km long) (c) Contour Image

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"Our motto: Right features, Right time, Right price"

An interview with François Erceau, Vice President and General Manager, Magellan Professional on Magellan's products and technologies

François Erceau
Vice President and General Manager
Magellan

Magellan has had a strong product development history and there are a number of 'firsts' in hand held GPS associated with the brand, in the current economic scenario how does the company view its product development strategy?

Magellan Professional is a value leader in the GNSS positioning industry. The current economic conditions confirm our approach. Our product development strategy is driven by a simple and efficient motto: Right features, Right time, Right price. Today Magellan's innovative spirit clearly shows in our hardware design, ease of use and the technology benefits of our products. In difficult times people look for more value, and that is exactly what Magellan provides.

Magellan has established itself as a GPS/GLONASS product, what about compatibility with other up coming GNSS systems like Galileo?

Magellan Professional has always sought to provide technology when it's of value to the user and not before. We don't play a marketing game that pressures the user to pay for a technology that is not valuable today. By 2013 when Galileo becomes fully operational, many of today's GNSS receivers, given their average life span of 5 years, will be obsolete. We will market Galileo receivers only when this capability can provide real benefit, not just promised benefit.

Magellan has global locations to serve its global customers, but which region has seen the maximum growth for your products in the last one year and which region do you think will lead the growth in the use of this technology in the coming year?

Last year we saw growth in all regions, but more growth in the developing countries. In 2009, given the current economic scenario, we anticipate flat sales in the US and Europe and increasing sales in the developing countries where our value proposition is especially interesting.

Recently the concerns for having a 'backup' to GPS have gained momentum, what are your views on this?

This is not a new concern; it has been an issue since the beginning of satellite navigation. It is the reason that Receiver Autonomous Integrity Monitoring (RAIM) was invented and is used in aeronautical applications, and the reason why the coastal authorities install differential GPS systems with integrity monitoring. Our BLADE™ technology is constantly monitoring each individual satellite measurement and can tell when any measurement has become degraded and is unusable. Of course the entire system can be jammed, in which case it is unusable, but this is not expected to happen except during acts of war or terror.

A rethink in strategy has been required by almost everybody in 2009, has Magellan also needed this rethink?

The current economic conditions mean that our competitors, who have a large infrastructure to support, are having a very difficult time, leading to store closings and lay offs. Our organisation is already shaped for tough times, with its effective operations, a strong dealer network, a culture of resource optimisation and a driving spirit that accepts challenge. Our motto remains the same for 2009, Right features, Right time, Right price. Our price to performance ratio is more competitive than ever. This value strategy is essential for an emerging player like Magellan Professional, and it's perfect for rough economic times.

Robert Snow, Marketing Director Magellan Professional (left) and Randy Noland, VP, Marketing Carlson Software during the announcement of their partnership

Which application do you think will contribute most to the expansion in the use of GNSS technology in the coming years?

We limit ourselves to professional applications, so I will not speak about consumer applications. We see machine guidance and control as the fastest growing professional market, which is why we recently teamed with Carlson Software to more actively pursue this market.

Please elaborate on the how Magellan BLADE™ technology helps to set the Magellan products apart from other others?

BLADE encompasses all our techniques used for signal processing and Position Velocity Time calculations. It includes our patented technique for using GLONASS measurements to enhance the GPS-derived solution and the automatic GLONASS bias determinations we make. BLADE sets Magellan products apart from others in many ways. Here are three of the key differentiators:

- It makes all the checks and preparations needed to mitigate any negative effects of GLONASS signal instabilities. The result is more reliable measurement processing and usage than with competing boards or GNSS receiver offerings.
- It can work with the GLONASS measurements from any manufacturer's base station. This is often not the case with other brands.
- It also uses the ranging measurements from SBAS satellites (as opposed to the Ionospheric model data that is transmitted by these satellites), allowing us to perform RTK with an L1 GPS+SBAS receiver, such as our ProMark™ 3 or DG14.

ProMark 500 + ProFlex 500

MAXIMUM FLEXIBILITY

Competitive Advantage:

- BLADE™ GNSS technology
- Enhanced RTK accuracy
- Wide range of communications
- Rugged base & rover solution
- Multi-application field terminal

Multi-constellation RTK Surveying by Magellan

Designed by our GNSS experts, ProMark 500 survey solution delivers state-of-the art RTK features in a light, rugged cable-free rover that gives you maximum mobility and flexibility in the field. Its unique GNSS engine insures fast initialization, long-range accuracy, robust signal tracking, and secures future constellation evolutions.

ProMark 500 and now the new ProFlex 500 for backpack and remote antenna applications bring the best Magellan technologies for the survey market. These receivers include all the features that users expect for productive and reliable RTK GNSS positioning.

Embedded BLADE technology provides the best possible measurements from three constellations GPS+GLONASS+SBAS and full interoperability with any vendor's reference station transmitting GPS+GLONASS L1/L2.

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A sensor architecture for high precision UAS navigation

This paper presents the CIRA's flying test facility for autonomous mid-air flight and landing on runways instrumented by Differential Global Positioning System (DGPS) base station. We present this paper in two parts. The first part focuses on system architecture and navigation algorithm. We would publish the second part of the paper in May 09 issue of Coordinates. The second part will detail the algorithm validation procedure and results.

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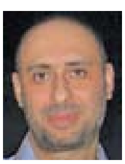

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The effort for realizing fully autonomous and operative Unmanned Aerial Systems (UAS) induced the need of developing innovative techniques for integrating measurements derived from different aircraft navigation systems. Since no human aid is available onboard UAVs, navigation hardware must attain larger capabilities than the ones of manned platforms. In particular, the most important features that shall be considered are autonomy, safety, compatibility with previously developed flight standards, and whole mission coverage [1]. This latter feature means that adequate and reliable navigation must be accomplished even during critical phases such as takeoff and landing, during which the required positioning should be always available with a high accuracy [2].

Several research activities have been developed in last years in order to increase the autonomy features in UAVs [3], in order to expand the flight envelope [4] and to improve security levels of modern aircrafts, both manned and unmanned. In particular, a very great research effort has been devoted to the achievement of high automation in the landing phase, so as to allow the landing of an aircraft without human intervention, also in presence of environmental disturbances.

Currently, no single sensor is capable of reliably realizing the required performance without relying on some ground measurement, hence UAS navigation requirements can be fulfilled only by integration of measurements from multiple sensors. In particular, configurations that integrate inertial sensor measurements with GPS, altimeters, air data sensors, and magnetometers are very frequent ([5]-[7]), and resulting performance and reliability depends on both sensors accuracy and adopted integration techniques.

In this context, CIRA developed a complete autonomous mid-air flight [8], collision avoidance [9], take-off and landing ([10], [11]) system for fixed wing aircrafts. This overall system has been worked out in the national founded project TECVOL (Technologies for Autonomous Flight), which continues and extends the previous CIRA project ATOL (Automatic Take-Off and Landing), successfully completed in 2004 [12]. Autonomous mid-air flight and autonomous landing capabilities of this system have been completely tested, up to the experimental in flight validation by means of a prototypal flight test bed, while at present autonomous collision avoidance and autonomous take off systems have been tested up to the real time stage and are ready for the real world in flight validation.

To work with high performances, the autonomous flight algorithms developed in the TECVOL project need of a good set of navigation measures, so suitable sensors fusion algorithm has been developed in the same project, as described in the next.

System Architecture

The technologies developed in the TECVOL project are validated in real world by means of a flying test bed, consisting of a piloted aircraft equipped with on-board avionic system and on-ground control station, both designed and integrated by CIRA. The flying platform is an experimental ultra light aircraft with a max take off weight of 450 Kg, a max speed s/l about 218 km/h, a cruising speed about 190 km/h, wing area of 13.2 m^2, wing span of 9.6 m and maximum engine power of 100 hp.

On board avionic system includes all devices, selected among the Commercial-Off-The-Shelf (COTS) ones, needed to perform the in flight experimental validation of advanced guidance, navigation and control functionalities. These devices are the ones described in the next.

- A Flight Control Computer (FCC), which is an embedded real-time computer based on a PowerPC processor, provided by the supplier with a tool based on the most advanced control system rapid prototyping methodologies. This software environment enables the automatic coding of the real-time SW directly from Matlab/Simulink™ diagrams.

- A navigation sensor suite including: (a) two GPS, one in differential mode and the other in Real Time Kinematic (RTK) L1/L2 mode, capable to provide position measurements with few centimetres accuracy; (b) a solid state Attitude Heading Reference System (AHRS); (c) a laser altimeter; (d) an Air Data Computer (ADC) with a dedicated air data probe capable to provide IAS, TAS, barometric pressure and aerodynamic angles measurements. For what concerns the two GPS installed on board, it is worth to emphasize that only the one in DGPS mode is used in the sensor fusion algorithm described in the next, while the other, in RTK mode, is used as reference to verify the sensor fusion algorithm accuracy.

- Digital electromechanical servos, to command both aerodynamic surfaces and throttle, driven by the FCC.

- A digital bidirectional data link system able to exchange data between on board FCC and the ground control station, with a maximum bit-rate of 9.600 bit/sec in uplink and 115.200 bit/sec in downlink, up to about 6 Km of operative range.

- Angles of attack and sideslip sensors.

- Surfaces position sensors.

As already said, two GPS are installed on board and configured in different ways, to have a comparison between the aircraft position and velocity measures obtained by the sensors fusion algorithm implemented in the FCC and the ones obtained by the GPS configured in RTK mode. The radio-modem output is connected to both GPS, in such a way as each sensor receives and selects the Real Time Correction Messages (RTCM) required by the RTK and DGPS algorithms. The ground control station (GCS) is installed in a big shelter fixed on the ground near the runway. It is designed to show telemetry data to flight test engineers through dedicated Human Machine Interfaces (HMI) and to allow the on board avionic system remote reconfiguration. The GCS architecture is based on the interconnection of the elements listed in the next:

- Ground Control Computer (GCC),
- downlink radio-modem,
- uplink radio-modem,
- engineering workstation computer,
- virtual cockpit computer,
- autonomous flight management computer,
- GPS base station,
- GPS differential correction radio-modem.

The GCC, based on PC-104 form-factor, is the core of the whole ground segment. It is connected, by an Ethernet field bus, with all the computers in the GCS and, by dedicated point-to-point RS232 connection, with the uplink and downlink radio-modem. Considering reliability constraints, both GCC and FCC use a hard real-time operating system.

Navigation Algorithm

The most common integrated navigation techniques make use of Kalman filtering ([13]-[15]). The main drawback of these techniques is the necessity of an

	Pros	*Cons*
GPS (low frequency)	High accuracy in differential mode Long-term accuracy Deterministic solution to the fix position problem	Satellites visibility Jamming and/or cycle-slip Fast dynamics not captured Slow output data rate to determine a trajectory No attitude information Higher noise than INS
INS (high frequency)	No jamming High output data rate Works in every environment Fast dynamics captured Lower noise than GPS	No long-term accuracy Start-up calibration required

Table 1 – Main features of GPS and INS equipments

accurate sensor error model, so as when poor information are available about the sensors used it is very difficult to obtain an appropriate adjustment of the Kalman Filter. With the aim to develop a low cost navigation sensor suite, our choice has been to use a simpler sensor fusion algorithm based on the concept of Complementary Filtering that will be described in the next.

For what concerns, generally, a sensor fusion algorithm design, in a navigation system based only on GPS measures, typical error sources are:

- excessive noise,
- low updating frequency (generally up to 10 Hz), therefore for dynamics the faster measures turn out little reliable,
- satellite "loss".

To overcome these limitations, a good solution consists in the integration of the GPS position and speed measures with the ones coming from other sensors: the auxiliary system most commonly used to such aim is an INS sensor.

In Table 1, main features of both GPS and INS are shown and compared.

In general, from the Table 1 analysis, it can be derived that the advantages arising by the INS/GPS integration are:

- advanced accuracy on position and speed,
- limitation of the INS errors by means of the GPS measures,
- possibility of using INS when the GPS is unusable,
- the velocity measure from the INS can help to eliminate GPS jamming problems,
- the position measure from the INS can help to reduce the acquisition time of the satellites (time to hot fix),
- the high INS short-term accuracy can eliminate the cycle-slip problem,
- thanks to GPS, INS can be economic and more compact.

The complementary filter here proposed, described in the next, is a further method which contributes to integrate position and speed measures, coming from GPS, with accelerations, attitude and orientation measures, coming from an AHRS (Attitude and Heading Reference Systems). In this case, it is not necessary the use of a sophisticated INS with its algorithms for estimating, independently from the GPS, position and speed of the vehicle. This filter aims to determine in the best way the aircraft position and speed, in the NEU reference system, by using both the raw measures from the inertial sensors and the measures supplied by the GPS.

The general concept of the complementary filter is the integration of acceleration measures supplied by the AHRS, in order to obtain position and speed measures affected by lower noise and with a larger band in comparison with GPS measures. However, even if the AHRS measures are little noisy, they are affected from remarkable bias errors, so speed and position calculated only by integration of the accelerations can quickly diverge from the real values. In order to limit the effects due to the bias, therefore, it can be thought to integrate the accelerations and to process them through a high-pass filter, obtaining the medium-high frequency component of the considered signals. The low frequency components can be obtained by a filtering stage of the GPS measures through a low-pass filter. The final estimate of position and speed is equal to the sum of the two components above mentioned.

The resulting architecture of the complementary filter we developed is, therefore, the one shown in the schematic representation of Figure 1.

It is important to emphasize that, in both velocity and position measures estimation, the high-pass filter applied to AHRS measures and the low-pass filter applied to GPS measures must be "complementary", in the sense that the sum of the transfer functions of the two filters must be equal to one. This is the reason why the navigation measures integration method here proposed is defined "complementary filter".

The specific cut-off frequencies used in the filters shown in Figure 1 have to be chosen to reach the following two contrasting aims: minimizing the noise power due to the GPS and avoiding the error arising from the integration of the AHRS accelerometers bias.

The method above described applies in normal no-failure conditions, where INS and GPS sensors correctly work. However, also in the case of GPS failure it is necessary obtain estimation, even if not optimal, of vehicle navigation data. The strategy adopted in this situation is described in the next.

In the case of GPS failure, the basic idea is to replace the GPS measures with the ones provided by a sensor characterized by the same characteristics, even if with lower precisions: in this case ADS, with an appropriate offset adjustment, represents a good solution. Pressure altitude (PALT) is used regarding the vertical position measure, while for the vertical speed is used the PALT RATE measure. Regarding position and velocity in the horizontal plane, instead, ADS does not directly supply such measures, but they can be opportunely obtained. In particular, for the velocity in the horizontal plane estimation the procedure described in the next is used. As long as GPS correctly works, it is continuously performed wind estimation, based on the relation:

$$W = V_{in} - TAS$$

where W, Vin and TAS represent respectively wind, inertial velocity and true air speed vectors, in the inertial reference frame. When a GPS failure is detected, this wind estimation is frozen and constant wind is considered, so from the TAS measure derived from ADS it is possible to approximately estimate the inertial speed as:

$$V_{in} = W_{frozen} + TAS$$

In this way it is possible, in case of GPS failure, approximately estimate the inertial speed components in the horizontal plan.

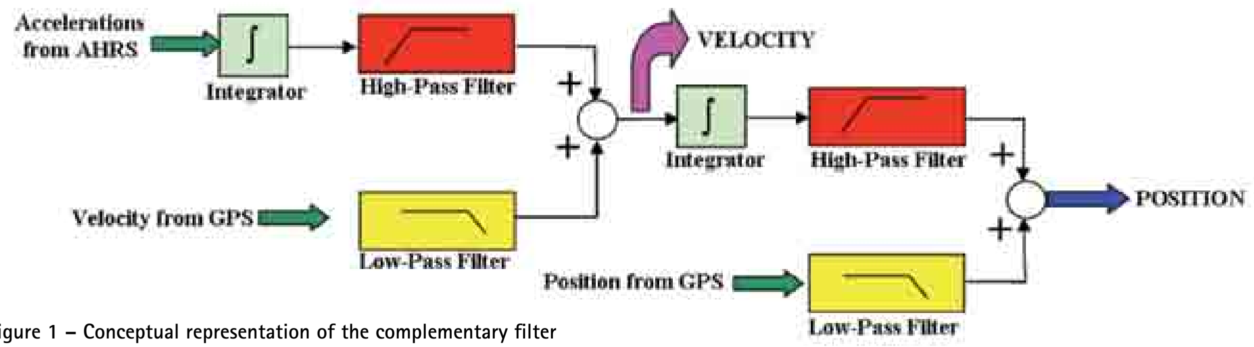

Figure 1 – Conceptual representation of the complementary filter

Such components are used in place of GPS velocity measures as inputs in the complementary filter, which supplies in output velocity and position estimation.

This idea correctly works when the aircraft is following a trajectory in a mid-air flight mission. In the case of GPS failure during landing, to obtain a better estimation of the measures of interest, it is also possible to use laser altimeter measures. During landing phase, therefore, PALT and PALT RATE ADS measures are replaced by altitude and vertical speed estimations derived from laser altimeter measures. In this case too, of course, the cut-off filtering frequencies applied on the laser are specifically optimized.

For what concerns the use of the navigation measures integration method here proposed in the future Global Navigation Satellite Systems (GNSS) framework, furthermore, it is very relevant to emphasize that the described sensor fusion algorithm can be used in this framework too, by simply replacing the GPS receiver with one able to receive EGNOS (European Geostationary Navigation Overlay Service) and GALILEO signals.

Moreover, in the future GNSS framework it will be possible to improve the proposed algorithm, by including new safety features. In particular, the basic idea consists in using the EGNOS performance information (in terms of accuracy, integrity, continuity and availability) to improve the sensor fusion algorithm efficiency and to add an integrated diagnostic function for detecting system failures. Based on this integrated diagnostic function, it will be possible to switch, in case of failure, in an appropriate degraded navigation mode. This will constitute a very relevant enhancement of the proposed navigation system, considering that integrity issues, important in general for many applications, are particularly critical in the aviation field, where vehicles can travel at high speed and can quickly deviate from the flight path.

To be concluded in May-09

Calibration method of IMU based only accelerometers

In this paper, the static and dynamic calibration methods are investigated based on the general output equation of an accelerometer.

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Because of the MEMS inertial sensors being more and cheaper, most studies focus on their applications. It is known that the simple principle and construction of the MEMS accelerometer make it is possible to improve the performance of MEMS accelerometers faster than that of gyros, so most efforts are done to use only the linear accelerometers forming the IMU called IMU-BA which has the potential market in the land and air navigation system, such as the car, air and missile navigation by integrated with the satellite navigation information, and so on, though it can not be used in practice at present. It is obvious that the errors of an IMU-BA will be brought by the accelerometer outputs deviating from its correct value. The installation errors and accelerometer errors are the most important two kinds of error sources causing the accelerometer output errors. In order to improve the performance of a IMU-BA, it is necessary to identify and calibrate all of the errors just mentioned above either on-line or off-line as accurately as possible. The accelero-meter errors include scale factor error, bias and noise. The installation errors include both the location and orientation error which means the actual sensor location and sensing direction of an accelerometer have uncertainty associated with the ideal and a significant effect upon the velocity estimates. Some one has reported that the uncertainty in the accelerometer locations is on the order of a few mils. These uncertainties can be calibrated by putting the IMU-BA on the rate table in different appropriate attitudes and other means. Single and multiple accelerometers can be calibrated simultaneously. Part of this work involves building an error compensation scheme employing a parameter estimator for the accelerometer locations and directions. In this paper, one scheme of IMU-BA in which all of the nine accelerometers directions are parallel to the frame axis, are introduced to investigate the calibration of the installation errors of IMU-BA. In this scheme, six of accelerometers are respectively placed at points located on the three axes and from the frame original, and used to calculate the angular velocity and specific force, the other three located at the original point of the frame and taken as the observation of specific force to bound the angular rate estimate errors. The performance of motion parameters detected depends directly on the sensor and the installation errors in the inertial measurement unit based only accelerometers. In this paper, the static and dynamic calibration methods are investigated based on the general output equation of an accelerometer. Taking the local level or gravity as the reference, the static calibration methods on the sensor error and the installation direction error are given by the multi-position measuring the IMU-BA; driving the IMU-BA in a constant angular speed, the dynamic calibration method is presented also by the multi-position measuring IMU-BA.

Typical configuration of IMU-BA

In principle, any IMU-BA formed by six or more accelerometers located in “non-zero” is effective to meet the need of measuring the motion parameters. The typical configurations of IMU-BA are as Fig 1.

The output equation of an accelerometer

Denoting the point in body-frame as P, the location of P in body-frame (b-frame) and inertial-frame

TRIUMPH-1

TRACY versatile and
JUSTIN comprehensive
GIODIS survey systems

Tracy in focus

Better than 30 cm GIS... instantly or 5 cm static

Actual size

GISmore stand-alone or inside the hat

Bluetooth wireless connection to GISmore

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

Many ways to use

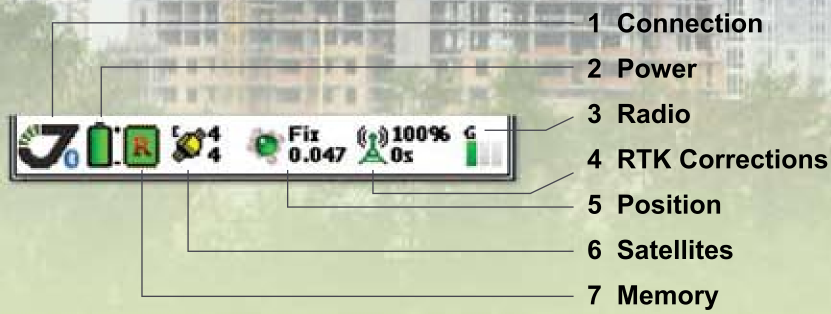
Tracy – as easy as 1-2-3

1 CONNECT - 2 CONFIGURE - 3 SURVEY

- All complex GNSS survey with Tracy by just 3 buttons on one screen

- Constantly monitor all hardware status – green color means ok, red indicates on a problem

CONSTANT MONITORING ALL SURVEY INFORMATION



A comprehensive field software

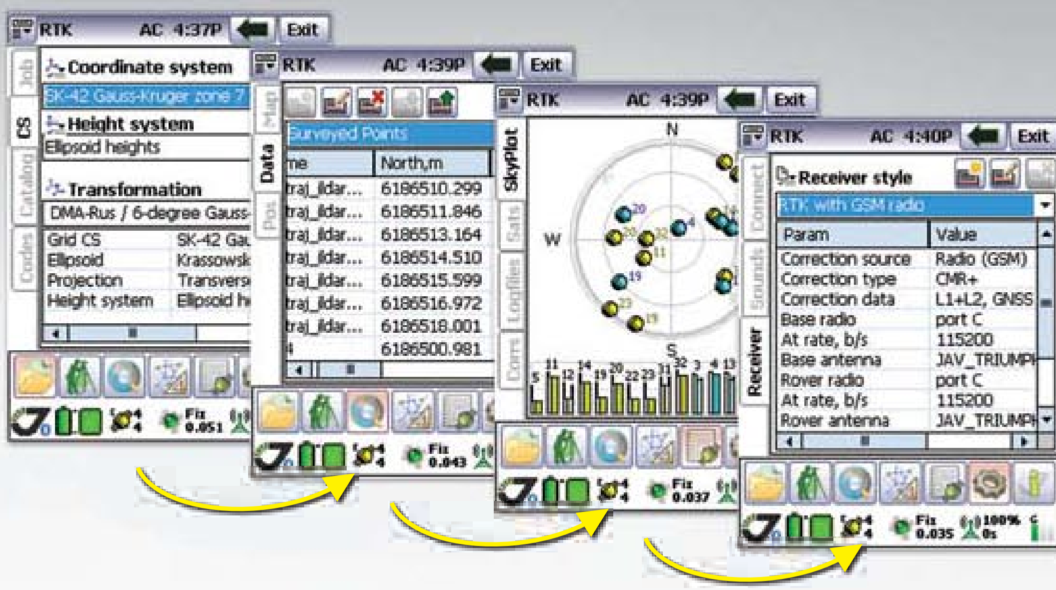
Two modes:

- **Lite**

  for novice user and main survey works

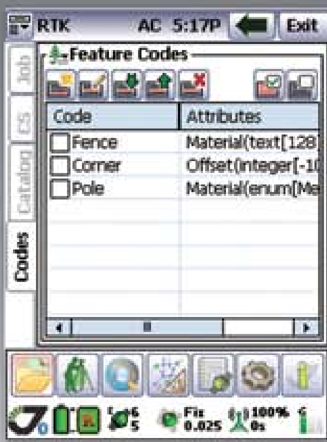
- **Extended**

  for complex tasks and configurations

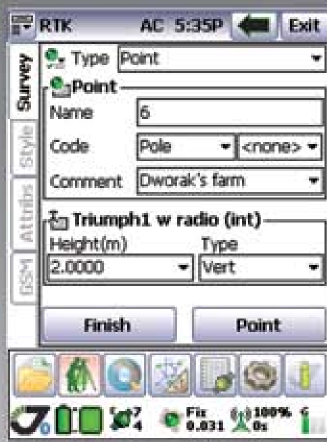


Instantly switch from one window to any other by just one or two click due to tabs and pages window organization

Suitable for all kinds of work

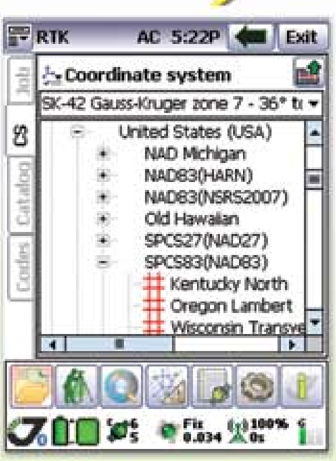


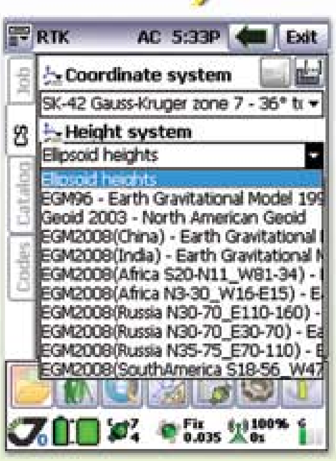
Feature codes and data acquisition with attributes



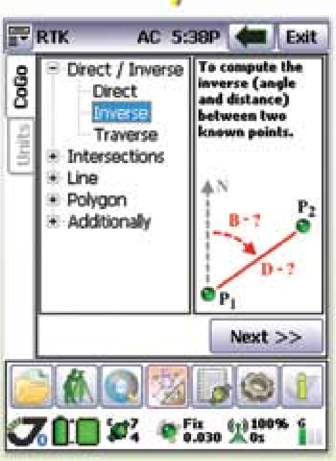
All main surveying task – point survey, trajectory survey, stakeout, data acquisition etc

- **Data acquisition with feature codes**
- **National and local coordinate system and geoid support**
  Horizontal and vertical localizations
- **Increased productivity and reliability**
- **Built in COGO routines**





Wide set of coordinate system including local and user defined. Ability to use global, regional and user defined (with Tracy Tools) geoids



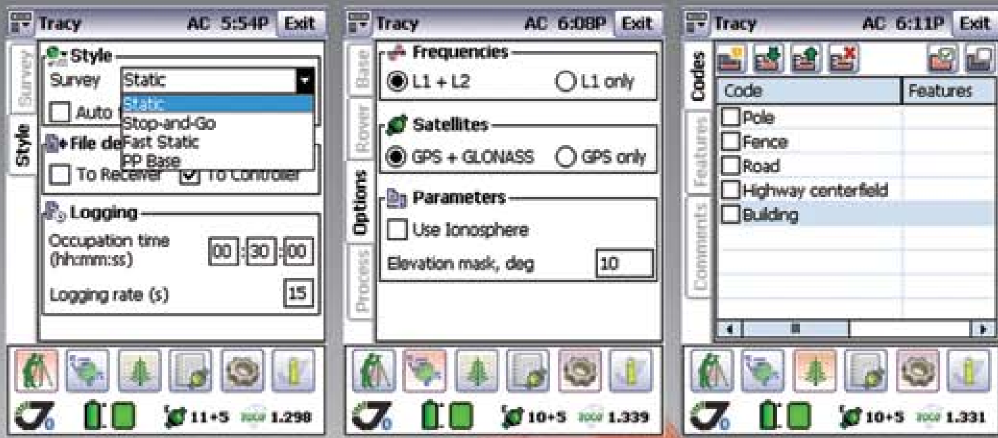
Set of CoGo (Coordinate Geometry) tasks

Full internationalization, including on-screen keyboard

Special modules for special tasks

PPK MODULE

DATA COLLECTION FOR POST-PROCESSING



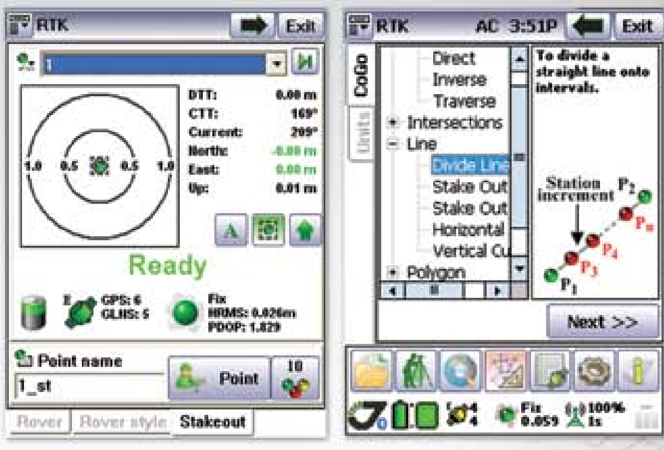
Static, Fast Static and Stop&Go surveying

In-field data analysis

Data acquisition in post-processing survey with attributes

TRACY

RTK (Real Time Kinematics) SURVEY AND STAKEOUT

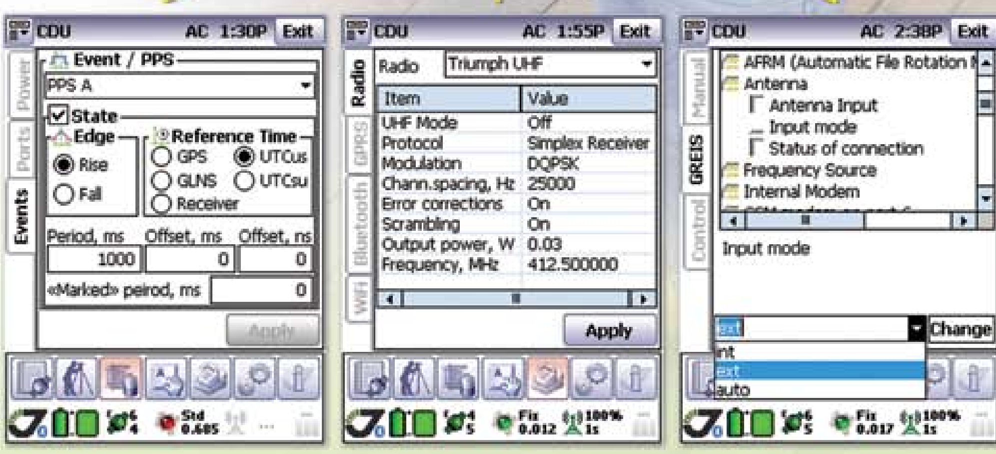


Support for survey and stakeout projects

CDU MODULE

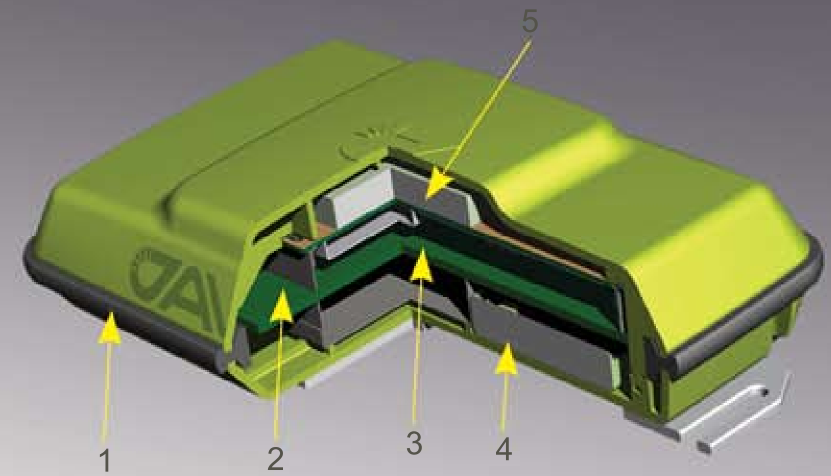
CONTROL DEVICE UNIT

Advanced configuration and trouble-shooting directly in field



Configuration of all hardware, including internal UHF/GSM/GPRS radios, Bluetooth module, WiFi module, etc

Full control of receiver with GREIS commands in terminal or by settings



1. Guard Bumper

2. Bluetooth/GSM Antenna

3. GNSS Receiver, Power Board, GSM/Bluetooth and Memory

4. Rechargeable li-Ion Battery

5. GNSS Antenna Connectors

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

Using its internal Bluetooth® and GSM/GPRS connection the receiver can access local GNSS Reference Station Network. As standard future the GISmore receiver provides access to the SBAS correction services. In addition to post-processed DGPS capabilities, the GISmore utilizes external correction services for real-time DGPS mapping and navigation applications.

Victor

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

- **Lightweight (17 ounces; 482 grams)**
  magnesium case with easy-to-grip over-molding

- **Operating temperature**
  -22°F to 122°F (-30°C to 50°C)

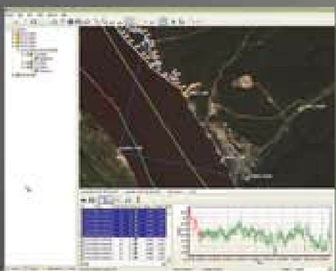
- **Connectivity via built in Bluetooth, USB Host and Client, plus 9-pin RS-232 and optional WiFi and Modems**

- **Rechargeable, field replaceable, Li-Ion battery**
  It operates for more than 20 hours on one charge (3 to 5 hours of charging time)

Software

- **Justin**

  A comprehensive Survey and GIS software

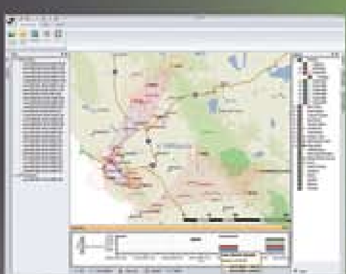


- **Tracy**

  A versatile and powerful field software

- **Giodis**

  Full-featured office post-processing software



JAVAD

WWW.JAVAD.COM

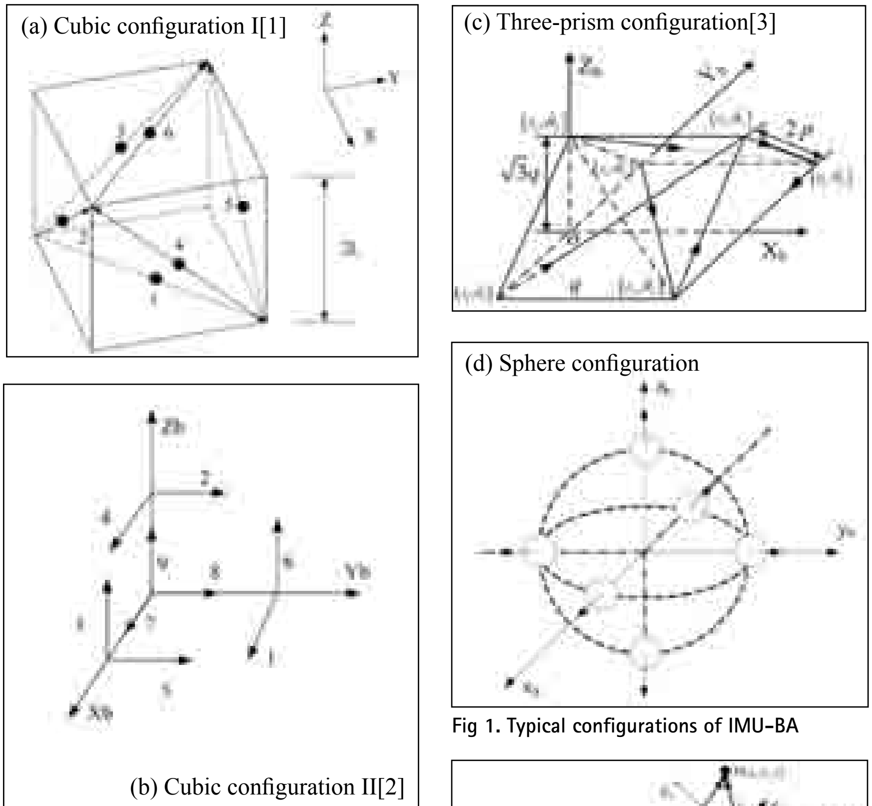


Fig 1. Typical configurations of IMU-BA

(i-frame) is showing as Fig.2.

It is known from Fig 2

$$\mathbf{R}_i = \mathbf{R}_o + \mathbf{r}_b \quad (1)$$

$$\left.\frac{d^2\mathbf{R}_i}{dt^2}\right|_i = \left.\frac{d^2\mathbf{R}_o}{dt^2}\right|_i + \left.\frac{d^2\mathbf{r}_b}{dt^2}\right|_b + 2\omega\times\left.\frac{d\mathbf{r}_b}{dt}\right|_b + \omega\times(\omega\times\mathbf{r}_b) + \frac{d\omega}{dt}\times\mathbf{r}_b \quad (2)$$

Denotion $\mathbf{A} \triangleq \left.\frac{d^2\mathbf{R}_i}{dt^2}\right|_i$, then the acceleration of point P is

$$\mathbf{A} = \ddot{\mathbf{R}}_o + \ddot{\mathbf{r}}_b + \dot{\omega}\times\mathbf{r}_b + 2\omega\times\dot{\mathbf{r}}_b + \omega\times(\omega\times\mathbf{r}_b) \quad (3)$$

In the case of P fixing in b-frame, there is the simple one

$$\mathbf{A} = \ddot{\mathbf{R}}_o + \dot{\omega}\times\mathbf{r}_b + \omega\times(\omega\times\mathbf{r}_b) \quad (4)$$

When an accelerometer is located on the position of $\mathbf{r}_j^b$ and in the sensing direction of θ_j, the output of accelerometer A_j is

$$A_j = [\ddot{\mathbf{R}}_o + \dot{\Omega}\mathbf{r}_j + \Omega\Omega\mathbf{r}_j]\bullet\theta_j \quad (j=1,2,\cdots,N) \quad (5)$$

Where:

Ω is the screw matrix of ω; the dot "•" means the "dot product".

The formula (5) may be denoting as[4]

$$A_j = \theta_j^T\ddot{\mathbf{R}}_o + (\mathbf{r}_j\times\theta_j)^T\dot{\omega} + \theta_j^T\Omega^2\mathbf{r}_j = \left[(\mathbf{r}_j\times\theta_j)^T \;\; \theta_j^T\right]\begin{bmatrix}\dot{\omega}\\ \ddot{\mathbf{R}}_o\end{bmatrix} + \theta_j^T\Omega^2\mathbf{r}_j \quad (6)$$

A_j is the ideal output of an accelerometer, in fact, there are the scale factor error S_j, bias b_j and noise W_{aj} in the practical one which may be written as follow

$$\hat{A}_j = (1+s_j)A_j + b_j + w_{aj} \quad (7)$$

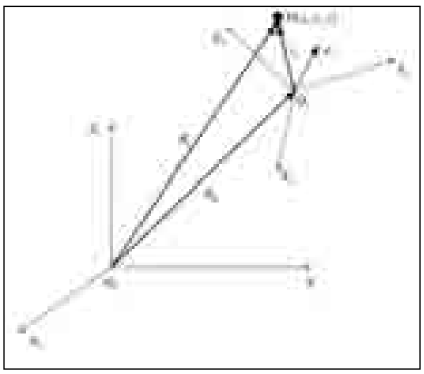


Fig 2. The location of P in b-frame and i-frame

The static calibration on IMU-BA

Putting the IMU-BA in six different positions and collecting all of the accelerometer-outputs. The six positions of IMU-BA placed correspond to: axis along with the direction, axis against the direction, axis along with the **g** direction, X_b axis against the **g** direction, z_b axis along with the **g** direction, y_b axis against the **g** direction. The outputs of accelerometer j in the six different positions just mentioned are as follow:

$$\begin{aligned}
\hat{A}_j^{(1)} &= g_0(1+s_j)\theta_j^T[1\ \ 0\ \ 0]^T + b_j\\
\hat{A}_j^{(2)} &= g_0(1+s_j)\theta_j^T[-1\ \ 0\ \ 0]^T + b_j\\
\hat{A}_j^{(3)} &= g_0(1+s_j)\theta_j^T[0\ \ 1\ \ 0]^T + b_j\\
\hat{A}_j^{(4)} &= g_0(1+s_j)\theta_j^T[0\ \ -1\ \ 0]^T + b_j\\
\hat{A}_j^{(5)} &= g_0(1+s_j)\theta_j^T[0\ \ 0\ \ 1]^T + b_j\\
\hat{A}_j^{(6)} &= g_0(1+s_j)\theta_j^T[0\ \ 0\ \ -1]^T + b_j
\end{aligned} \quad (8)$$

From formula (8) there is

$$\hat{b}_j = \frac{1}{6}\sum_{k=1}^{6}\hat{A}_j^{(k)} \quad (9)$$

Introducing the new vectors

$$\hat{A}_j^{(1-2)} = \hat{A}_j^{(1)} - \hat{A}_j^{(2)}$$

$$\hat{A}_j^{(3-4)} = \hat{A}_j^{(3)} - \hat{A}_j^{(4)}$$

$$\hat{A}_j^{(5-6)} = \hat{A}_j^{(5)} - \hat{A}_j^{(6)}$$

$$[\hat{A}_j] = [\hat{A}_j^{(1-2)}\ \ \hat{A}_j^{(3-4)}\ \ \hat{A}_j^{(5-6)}]^T$$

then

$$\hat{\theta}_j = \frac{1}{2g_0(1+s_j)}[\hat{A}_j] = \frac{[\hat{A}_j]}{\sqrt{[\hat{A}_j]^T[\hat{A}_j]}} \quad (10)$$

Taking θ_{0j} as the normal installation direction of the accelerometer j, then the relevant installation error is

$$\Delta\theta_j = \hat{\theta}_j - \theta_{0j}.$$

Multiplying $[\hat{A}_j]$ by a left coefficient W_j ($W_j^T\theta_j \neq 0$) and making the sum of it

$$W_j^T[\hat{A}_j] = 2g_0(1+s_j)W_j^T\hat{\theta}_j \quad (11)$$

$$\hat{s}_j = \frac{1}{2g_0W_j^T\hat{\theta}_j}W_j^T[\hat{A}_j] - 1 \quad (12)$$

The normal scale factor of the accelerometer j and the relevant error is respectively s_{0j} and $\Delta s_j = \hat{s}_j - s_{0j}$.

The dynamic calibration on IMU-BA

The dynamic calibration is used for calibrating the installation position error of an accelerometer in IMU-BA which needed rotation relative the inertial frame. Driving respectively the IMU-BA in a constant angular speed in there different installation direction in which the rotation axis parallels to the gravity direction, i.e. the rotation axis is respectively in the planes x-z, y-z and x-y. The output of the accelerometer j is[4]

$$\tilde{A}_j^{(n)} = \theta_j^T R_{ib}^{(n)} + \theta_j^T \left[\omega_{ib}^{(n)}\times\right]^2 r_j,\quad n=1,2,3$$

The six different positions just mentioned are as follow

$$\tilde{A}_j^{(1)} = \theta_j^T R_{ib}^{(1)} + \theta_j^T \left[\omega_{ib}^{(1)}\times\right]^2 r_j$$
$$\tilde{A}_j^{(2)} = \theta_j^T R_{ib}^{(2)} + \theta_j^T \left[\omega_{ib}^{(2)}\times\right]^2 r_j$$
$$\tilde{A}_j^{(3)} = \theta_j^T R_{ib}^{(3)} + \theta_j^T \left[\omega_{ib}^{(3)}\times\right]^2 r_j$$

$$\hat{r}_j = \begin{bmatrix} \theta_j^T \left[\omega_{ib}^{(1)}\times\right]^2 \\ \theta_j^T \left[\omega_{ib}^{(2)}\times\right]^2 \\ \theta_j^T \left[\omega_{ib}^{(3)}\times\right]^2 \end{bmatrix}^{-1} \begin{bmatrix} \tilde{A}_j^{(1)} - \theta_j^T R_{ib}^{(1)} \\ \tilde{A}_j^{(2)} - \theta_j^T R_{ib}^{(2)} \\ \tilde{A}_j^{(3)} - \theta_j^T R_{ib}^{(3)} \end{bmatrix} \qquad (13)$$

Denotion

$$M = \begin{bmatrix} \theta_j^T \left[\omega_{ib}^{(1)}\times\right]^2 \\ \theta_j^T \left[\omega_{ib}^{(2)}\times\right]^2 \\ \theta_j^T \left[\omega_{ib}^{(3)}\times\right]^2 \end{bmatrix}$$

There is

$$\hat{r}_j = M^{-1} \begin{bmatrix} \tilde{A}_j^{(1)} - \theta_j^T R_{ib}^{(1)} \\ \tilde{A}_j^{(2)} - \theta_j^T R_{ib}^{(2)} \\ \tilde{A}_j^{(3)} - \theta_j^T R_{ib}^{(3)} \end{bmatrix}$$

The actual installation position of the jth accelerometer may be estimated by formula (13) in the case of the inverse matrix in it exists, and then the installation error is $\Delta r_j = \hat{r}_j - r_{0j}$ ($\mathbf{r}_{0j}$ is the normal one).

It should be emphasized that the IMU-BA needs to be droved in a constant angular speed in order to avoid the $\mathbf{\Omega}_{ib}^{b}$ too small to make M singularity, otherwise M^{-1} may not exists.

Conclusion

The static and dynamic calibration methods may be used for calibrating the sensor and installation errors of an accelerometer in IMU-BA. The local level or gravity may be taken as the reference to calibrate the sensor and installation direction errors in the static condition; the IMU-BA is needed to rotate in a constant angular speed to calibrate the installation position error, i.e. the IMU-BA calibrated must be in a dynamic condition. The direction of the IMU-BA placed is needed select properly both for the static and dynamic methods.

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Taking geomatics to greater heights in India

Thoughts on land information system, polices and reorganization

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Till almost early seventies, Survey of India was synonymous with the surveying profession in India. That situation does not exist any more. The reason is not far to find out… Many new organizations, have carved out their own niche in the domain of the surveying and mapping. These new entities have been generally propelled either by the new technology eg satellite imagery or due to unmet demand of a particular type of information – example, Forest Survey of India.

The surveying and mapping (called Geomatics in this paper) have embraced many new disciplines and spread over a much wider span and taken a bigger and focussed name of Land Information Technologies – refer to Box-1. Many find it convenient to call these by one word-Geoinformatics or Geomatics.

A judicious combination of these technologies is designed for a given Geomatics project.

This paper looks into the present technologies and policies to present a different view or suggestion for improvement. The views are not limited to only the technical and production process regarding Geomatics products and services in Indian environment but go beyond and touch the structure of the organizations in Geomatics sector. In order to do justice for the new thinking a model for change is first evolved. The suggested changes are then discussed.

The paper also recognizes the presence of government organizations, namely, Survey of India (SOI), Naval Hydrography Office of Navy, MO-GSGS (Army Survey Directorate), National Remote Sensing Centre (NRSC), Indian Space Research Organization (ISRO) and many other members of the National Spatial Data Infrastructure (NSDI), IIT (RK) and many private organizations. The State Cadastral Surveys Organizations are very much affected by the survey policies; hence, their requirements should have a place in the new thinking.

Model for change

Management of change in any organization should be governed by the `body of knowledge' which has been accumulated over the years. The main

Box-1: Land Information Technologies

- Field Surveying, Control By Total Station, Type of Equipment
- Global Positioning System (GPS)-for field control
- Aerial Photography and Photogrammetry
- Satellite Imagery and Remote Sensing
- Geographic Information System (GIS)

Some New Technologies:

- Air Borne Laser Terrain Modelling (ALTM)
- Radar Interferometry
- Technology available for digital printing of maps instead of `offset' printing
- Transmitting graphic (map) information `on- line'
  Application of internet, compression of data

thrust of this knowledge comprises of recognizing the `Factors for Change' and most importantly, their `interaction / interface' with each other and outside-of-Geomatics-sector, policies in India (for example, Restriction Policy of Mapping in India). Based on these thoughts, a heuristic (based on experience) model for change is depicted below (Figure-1).

Let us discuss these factors, shown in Figure-1, in more detail. It follows from the figure that any suggested change in the policy is bound to impinge on the existing equilibrium reached between Technology, Organizational Structure and the Staff.

Technology

Products:

In business, especially in the marketing sense, the products are evolved and designed keeping in view the demand of the users. In other words, the market domain of products is `segmented' into different categories of users. For example, the type of maps required by a tourist is going to be quite different than, say, an engineer. While a tourist is mostly concerned with the terrain features and ease in their interpretation, an engineer requires the finer details and map should be accurate enough for his design and measurements. The same concept can be extended to other users of the maps and spatial data.

Users require different products:

In our case of Geomatics, the requirement of the various users can advantageously be converted to scales and main specifications of the product whether it is digital or analogue (paper map). Table-1 below provides details of these requirements and scales:

Further, some important characteristics of a map are described in Box-2 to establish a basis for making suggestions pertaining to the preparation and Updation of maps.

Suggestion one:

Ground Control to remain with Government Agencies

The geometry of the maps, namely, establishing accurate (geodetic accuracy) control stations should `continue' to remain with the Government Organization(s). This is the area of effort which should be motivated more by scientific / professional and national needs rather than the market-driven hasty procedures. The ultimate responsibility should rest with the government although the actual technical work can be outsourced to the capable organizations in India having the necessary know-how.

It is quite natural to believe that technically the job will be based on GPS technology.

Suggestion two:

Contents of the Map to be prepared by Public-Private-Participation (PPP)

The contents of the map ie topographical features will continue to be produced by the aerial photography / photogrammetry. But once the accurate contents are produced, its updating etc can depend on the satellite imagery the resolution of which will be commensurate with the accuracy of mapping.

The contents of the map could be prepared by the combined efforts of government and the private organizations. This policy will not only provide a quantum jump to the productivity of mapping organizations but will open the market for a large number of private organizations and consequent job opportunities.

Suggestion three:

Updating of Maps to go to private sector

Professionally there is no difficulty of updating the existing maps by the private sector. Not much equipment is needed towards this activity and this phase of work can be undertaken at a very low cost. In many cases the user-department can also undertake the revision.

At the initial stages this activity can be confined to the non-restricted areas and large scale Town Guide Maps of SOI and other area like cadastral (revenue) maps.

Some other suggestions pertaining to the improvement of maps and services have been mentioned in Box 3.

Structure: Linkages of existing surveying organizations

SOI is very much central to the overall network of the survey organizations in India. As mentioned earlier, there are presently many new organizations, which have carved out a niche as important members of the Geomatics community. It has also been suggested earlier (Suggestion One) that ground control stations and BM's should remain with the Government.

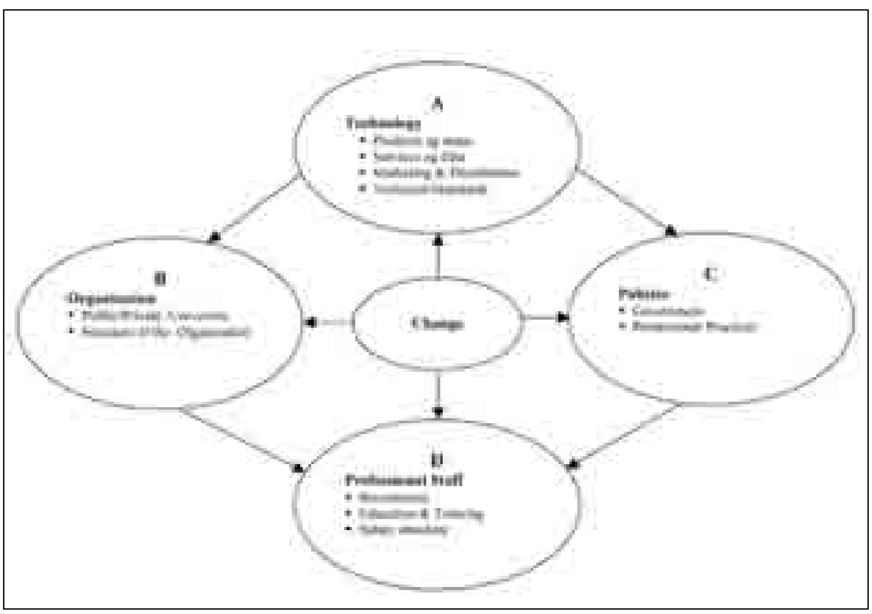

Figure-1: Model for Change-Management

The following suggestions are being made further as an extension of the same theme. The prevalence of Restriction Policy is also very much kept in mind while making these suggestions.

Suggestion four:

Reorganization; Survey of India; Area of responsibility

All non-restricted areas of India should be the responsibility of SOI for all the mapping activities. This division of responsibility will be done on the basis of 1:250000 sheets (sixteen 1:50000 sheets). All GPS control activities, aerial photography, photogrammetry and mapping on 1:50000, 1:25000, other large scale up to 1:10000 scale e.g. urban mapping and support to cadastral mapping will, in concept, be the responsibility of SOI.

Surveying and mapping of scales larger than 1:10000 should be left to the private sector or Public-Private-Participation (PPP) as mentioned earlier.

In addition, SOI will manage Geodetic & Research Branch. Survey Training Institute will also support the other sister organizations, namely Army Surveys and Naval Hydrographic Office.

Restriction Policy is mainly concerned with the northern borders and coastal belt. It is, therefore, suggested that all restricted mapping at the border areas be made the responsibility of Army Directorate of Surveys. In this, they will look after the production of maps on scales 1:50000, 1:25000 and 1:10000 (town maps). This will include establishment of control (upkeep also), aerial photography, photogrammetry and map printing.

Geodetic & Research Branch, Survey Training Institute (under SOI) will provide full support to the Army, Directorate of Survey and Naval Hydrographic surveys.

Similarly, Naval Hydrographic Office will look after the coastal belt (restricted areas) with all the responsibilities of mapping as mentioned above for the Directorate of Army Surveys.

Because of the restriction policy, the mapping activities involving scales larger than 1:10000 will be done under the variant of the formula for Public-Private-Participation.

Role of the Ministry of Science & Technology

Ministry of Science & Technology should continue the policy embracing all the surveying and mapping

Box-2: Characteristics of a map

A Map will have the following characteristics in general:

- Geometry (Accuracy of Position and Height)
  The geometry of a map is achieved through a set of ground control points, called stations and levelling Bench Marks (BM's). These stations may have the utmost accuracy of a geodetic station. BM's are, presently, being provided by the SOI. The position of these stations is given in the form of coordinates expressed in terms of Latitude and Longitude.

In most of the cases, accurate information about the stations and the BM's is restricted.

- Contents of a Map
  The earlier technology of the ground based methods (plane-tabling etc) has been replaced by the aerial photography (photogrammetry) and satellite imagery. The resolution of the modern day satellites has reached a level of one metre. This enables contents of the map to be based on high-resolution satellite imagery on most of the scales of mapping.
- Updateness of a Map
  It is a natural desire of a map user that the map, which he is using, is reasonably updated. Here also the satellite imagery is of great utility because satellite visits the same spot at a regular interval of say, one month or so. Therefore, technologically the problem of updating the maps, to a large extent, can be solved.

Box-3:

Benefits that would accrue to Map Users through small changes in Land Information Policies in Indial:

- Suggestions made earlier
  Let the control/geometry be with the government and contents in the private sector.
- Bench-Marks should become Control Station for X, Y also
  The above argument can be easily extended to the provision of X, Y coordinates to all the precision levelling BM's (top accuracy BM's of SOI). This suggestion is being facilitated and motivated by the evolution of the technologies which are harnessed to provide X, Y precision coordinates. Differential Global Positioning (DGPS) can determine the high accuracy first order points at the existing BM, avoiding the difficulty of line-of-sight condition and vagaries of weather.
- Maintenance of Old Great Trigonometric Survey (GTS) Geodetic Stations
  The Great Arc was a great scientific achievement and there should be a policy on maintenance of these spatial temples of SOI.

  The maintenance should be taken over by SOI from the local officials who do not appreciate the tremendous value of the GT stations which are a great historical legacy and are in a very bad state of upkeep. NRSC, Hyderabad should also similarly start thinking of maintenance of their Ground Control Points (GCPs) for the same reasons.
- Image Library of the Control Points
  It is the technical requirement of the photogrammetry technology that all the GCP's must be very accurately transferred to the aerial photograph or satellite imagery for further processing. The concerned departments may consider developing an Image-Library of their control points. The Image Library will be a very useful input to the photogrammetry (or image-grammetry) firms and they may pay for this valuable service.

activities in India through the modified structure of the National Spatial Data Infrastructure (NSDI).

The Surveyor General and his staff-support should be a part of the Ministry of Science & Technology. In fact, it is visualized that NSDI with little change in its constitution can act as an Advisory Council on technical, administrative and strategic matters pertaining to Geomatics. Also, there should be an Advisory Council to assist the Ministry. Some private professionals and NGOs could also be invited to become members of the Advisory Council. The advisory Council will be so structured that it is able to provide continuity and improvement of the policies. The transfer and change in bureaucracy and government organizations will then have a minimum effect on the major policy issues.

Summary of the suggestion four:

The purport of the above suggestion is that three government organizations, which are quite capable of delivering the results based on the latest technologies, will be responsible for the surveying and mapping. The coordination of the policies will be carried out by the Ministry of Science & Technology.

Scales larger than 1:10000 scales will wholly go to the private sector in non-restricted areas while in restricted are a PPP will be resorted to.

Following organizations will thus function as the main government organizations in Geomatics sector:

- Survey of India – in Non-Restricted Areas
- Army – Directorate of Surveys – in border areas
- Naval Hydrographic Office – in coastal areas

It may be noted that this division of responsibility will give a big fillip to the professionalism of Geomatics in India.

Incidentally, it may also reduce some of the organizational and cadre oriented problems of these organizations!

Role of National Spatial Data Infrastructure (NSDI)

The role of NSDI in building the greatness in the Geomatics profession is and will remain vital, indeed irreplaceable by any other contemporary organization in the government. Yet another factor which imminently goes in favour of NSDI is its dimension within the structure of the government. NSDI will be looked to by its constituent organizations (even if these are from different Ministries) for managerial guidance and its immediate interface with the professional factors. As a matter of ambitious thinking, NSDI will be an excellent `surrogate' advising forum for all its members. Such a forum is bound to play an important part in the growth of Geomatics in India.

Polices affecting Indian Geomatics

Einstein once said: "only the insane can expect radically different results by doing the same thing over and over again". In the realm of Geomatics there is no doubt in anybody's mind that if there is one policy, which has had a profound impact, it is the Restriction Policy. Historically, almost the same policy is in effect since independence. The details are not being given for the sake of brevity of paper. This Restriction Policy has to be made congruent to the growth of technologies like high-resolution satellite imagery and GPS.

Suggestion five:

Changes in Restriction Policy of India

Some workable changes are suggested for consideration. These are motivated because of:

- Tremendous improvement in resolution of satellite imagery. 1 metre – resolution imagery of any part of earth is commercially available.
- Global Positioning System (GPS) is able to provide x,y,z coordinates to

Table-1: Scales and accuracy of Maps desired by different users

Functions	**Scale**	**Height/Contour Interval (CI)**
Planning		
Planning Industrial Sites	1:4000 to 1: 5000	2 meters
Engineering Plans	1:2000 to 1: 5000	1 Meter CI + Bench Marks
Housing	1:2000 to 1:4000	1 Meter CI + Bench Marks
Transportation	1 5000	1 Meter CI + Bench Marks
Traffic	1:1000	Map of traffic intersection
Engineering	1:1000 to 1:2000	Levelling along the alignment
Water Supply & Sewerage, waste disposal	1:2000 to 1:5000	
Roads etc	1:1000 to 1:2000	1 Meter Contour Interval
Regulatory		
Revenue Authorities Land related subjects	1:2000 to 1:4000	Correlation with existing revenue map
Jhuggi Jhopri Clusters.	1:2000 to 1:4000	
Land Resources		
Ground Water	1:10000 to 1:15000	5 meters
Drainage, surface water	1:10000 to 1:15000	5 meters
Environment		
Inventory of vegetation, trees, parks etc	1:4000 to 1:10000	
Heritage sites, monuments	1:2000	1 meter CI


nrsc
इसरो isro
1m
Increase in resolution
Decrease in price
Doha viewed by
Cartosat-2
NRSC Data Centre
National Remote Sensing Centre
Indian Space Research Organisation
Balanagar, Hyderabad - 500 625
Phone: +91 40 2388 4422, 4423, 4425
Fax: +91 40 2387 8158, 8664
Email: sales@nrsc.gov.in
Website: http://www.nrsc.gov.in

- fairly good accuracy of a few metres. By using two GPS instruments in Differential mode, one is able to achieve survey level accuracy.
- Some private firms abroad have started supplying large-scale maps to any user.

The above mentioned factors lead the Geomatics professional to suggest the following:

- Make all satellite imagery as Un-Restricted. Cartosat of India will give a big fillip to the mapping business in India.
- All aerial photography on scale 1:50000 falling in non-restricted map area of India to be declassified (from SECRET category).

Photogrammetric processing based on 1:50000 scale aerial photography will be able to strengthen the geometry of mapping up to 1:10000 mapping.

The author, in a separate paper, has been able to conclude that a market of about 100 crores per year is waiting to be tapped in case Restriction Policy is diluted to some extent. The suggested relaxation of the policy will generate business and consequent jobs for the geographers and other persons in the Geomatics profession.

Public Private Participation (PPP)

A model of photogrammetric production employing private photogrammetric firms working in the premises of NRSC is very commendable indeed.

The other government organizations, namely, RITES, NIC, WAPCOS etc can replicate `NRSC-Model' to generate survey data. Suggestion Four endorses the practice of PPP for larger scales i.e. 1:10000 by involving private sector in a big way. This in fact has become necessary as almost all GIS projects need digital database and density of data, which is provided by scales larger than 1:10000.

Professional Staff (People Factor)

The staff is the most valuable human capital, which alone will support the profession by way of vision, values and absorbing new technologies. Their education, therefore, becomes very important as well as urgent.

Unified Education in Geomatics at Manager Level

At present, a Geomatics specialist, especially at the manager level is being trained and educated from a narrow point of view of the organization with whom he is serving. For example, a manager of Survey of India will know more about surveying. The other subjects e.g. satellite remote sensing and GIS etc may be picked only by his own effort. The reverse is true in case the manager belongs to the GIS community, he may not know about a total station or photogrammetric model. This state of education and training, calls for a unified approach in education of a Geomatics-Manager.

Suggestion six:

A Course for Professional Geomatics Managers

A manager in Geomatics profession should have an in-depth exposure to whole gamut of Land Information Technologies, as mentioned in Box-1. Presently two major training institutes namely, Survey Training Institute of Survey of India and Indian Institute of Remote Sensing are the key players in training and education of officers. In addition some universities are also in the Geomatics field in a small way.

It will be a synergistically strong move, if both these institutions jointly create / evolve an integrated program for the Geomatics Professional Manager. Such a program will have `takers' coming from the private organizations (and abroad) because the activities and projects embrace all the disciplines of Geomatics.

It is a wish that, eventually, the model suggested above may bloom into full fledged Geomatics University of India with two campuses, one at Dehra Dun and other at Hyderabad.

Conclusion and summary

This paper primarily concentrates on a few, yet important, changes which should be brought out sooner than later. The advantages of the suggested policies have been shown with the help of a `model for change'. Let it be emphasized that greatest impetus to the whole gamut of Geomatics will take place in Restriction Policy. It is almost certain that without the change in the Restriction Policy the recipe of the NSDI will remain salt-less. The other change in the products and services are well within the ambit of the decision-makers who should definitely present the sweet face of the Geomatics to the users.

There is a great possibility that potential private market which is bottled up presently may open up. Any small or big company can contribute to generate `contents' and updateness of the map. Thanks to orbiting satellites and their available (!) imagery.

The changes suggested in the organizational structure will hopefully bring better production, healthy competition and ease of cadre problems. The coordinating role of the Ministry of Science &Technology consequently will increase for the betterment of the profession and cannot be under estimated.

It is through these measures that we, belonging to the Geomatics profession, feel that greatness will be bestowed on the profession of Geomatics.

Indian NSDI publishes Metadata Standards ver 2.0

The National Spatial Data Infrastructure (NSDI), under Department of Science & Technology of Government of India, has released Metadata Standard 2.0. It is prepared by the working group on 'Metadata Standards' chaired by Dr. S K Pathan, from Space Applications Centre (SAC), ISRO, Ahmadabad. The National Natural Resources Management System (NNRMS) Metadata Standards defines the schema and design for the NSDI Metadata. It also contains a set of relational tables that standardise the layer metadata, the geographic search metadata, the access metadata etc.

Metadata is the first element of the NSDI, which enables a user to find spatial data that is available in different NSDI Agency servers. It serves two major purposes – both for the spatial data generator and for the spatial data user. For the generator, it provides a framework to document the spatial data and declare its content for users. For the user, it serves many important purposes, including finding the spatial data as per need; browsing spatial data; deciding on whether the spatial data will meet the application need and finding how the spatial data can be accessed.

ISRO, with the involvement of Survey of India, National Informatics Centre, Geological Survey of India, Forest Survey of India, National Bureau of Soil Survey and Land Use Planning, National Atlas and Thematic Mapping Organisation, Central Ground Water Board, Central Water Commission and the private sector, has led the effort of defining a 'National Metadata Standards'. *http://gisserver.nic.in*

India's NLRMP to use Torrens Title

The Indian government has launched a National Land Records Modernisation Program (NLRMP) that will eventually enable it to use the Torrens title system to protect land titles throughout the country. Recently, Ms. Rita Sinha, Secretary, Department of Land Resources in the Ministry of Rural Development, told a conference in Washington DC that the decision to move the whole country towards the new titling system was made in August last year.

Torrens title is a system of land title where a register of land holdings maintained by the state guarantees an indefensible title to those included in the register. Four fundamental principles underpin Torrens title in most jurisdictions. They are, single, mirror, curtain and insurance –all problematic in India. The program will use computerised records, aerial photography surveys, satellite imagery and ground surveys to create the cadastral fabric. It is expected to last 8 years and cost Rs56 billion (US$2 billion). One of the biggest problems facing the government will be creating a cadre of skilled manpower. The plan will require about 50,000 survey staff and 200,000 administrative staff.

ESRI to safeguard land rights in China

ESRI Canada partnered with ESRI China Beijing, Trimble China, Chreod Group Inc., International Land Systems Inc. (ILS), USA and Landstar Digital Technology, China to help demonstrate the feasibility of applying state-of-the-art GIS and surveying technologies to solve land policy challenges facing China today. Results of the recently completed pilot project may ultimately serve as the foundation for a nationwide GIS-based rural land registration and certification program. *www.esricanada.com*

Scientists to create global soil map

University of Sydney scientists are behind a technology to map most of the ice-free land surface of the globe over the next five years in order to create something like"Google Earth" for soil quality. According to Professor Alex McBratney, Director of the University's Australian Centre for Precision Agriculture the maps will provide information about the soil at about every 100 metres across the world. Current maps are at the scale of one to five million. *www.usyd.edu.au*

Kerala SDI soon

The Kerala State government, India has finalised plans for State Spatial Data Infrastructure, which will serve as a common centre for the storage, processing and dissemination of digital spatial data pertaining to Kerala. The setting up of the infrastructure was approved recently. Central funding has been sought for the project and its implementation will be completed in about a year or less. *www.hindu.com*

Manifold sets GIS record for Supercomputing Desktop

Manifold.net has set a new world record for the number of processors used in a personal computer for GIS processing. It demonstrated an upcoming new software product that simultaneously utilized over 1440 processor cores to perform a remote sensing image computation at supercomputer speed with over 3.5 teraflops of performance, on a desktop 64-bit Windows PC equipped with three NVIDIA GTX 295 GPU cards costing less than $500 each. *www.manifold.net*

ESRI expands Virtual Earth Access in GIS by teaming with Microsoft

A new agreement with Microsoft Corporation gives ArcGIS users fast access to Microsoft Virtual Earth. Now, ArcGIS Desktop and ArcGIS Server users will be able to connect directly to Virtual Earth and quickly start their GIS projects with ready-to-use content. *www.esri.com/agolwhatsnew*

China publishes map collection on May 12 quake, aftermath

China has released a collection of maps recording the 8.0-magnitude earthquake that hit southwestern Sichuan and neighbouring provinces on May 12 last year. With 228 maps, it offers a panoramic view of the disaster, including the geology of the region, disaster damage, response and reconstruction. *www.chinaview.cn*

Obama proposes terminating system that backs up GPS

In his fiscal 2010 budget, President Obama killed funding for a system that would back up the much relied on GPS if it failed, despite calls from the telecom industry and federal agencies that it is needed. The Homeland Security Department (DHS) endorsed Loran-C a year ago as a backup for the satellite-based GPS, but in its fiscal 2010 budget, the department zeroed out funding for the system. *www.nextgov.com*

Seventh Lockheed Martin GPS Satellite launched

A Lockheed Martin-built GPS Block IIR (GPS IIR-M) satellite was successfully launched from Cape Canaveral Air Force Station. The IIR-20(M) spacecraft includes a new demonstration payload that will transmit a third civil signal located on the L5 frequency (1176.45MHz). The signal will comply with international radio frequency spectrum requirements. *www.lockheed-martin.com*

GLONASS Changes Operating Frequencies on Four Satellites

On March 11 GLONASS authorities changed the operating frequency channels of two pairs of antipodal satellites. Modern GLONASS and GPS/GLONASS receivers should have handled the transition seamlessly. *www.glonass-ianc.rsa.ru*

European air agency launches new control system

A new air traffic-control system will use GPS to track planes using satellites. The new system will eliminate the reliance on the radio beacons which require planes to travel along "air lanes". Instead of placing a flight into an air lane, an air traffic controller can pick from a wide variety of routes between airports. The system is designed to double the number of planes over Europe while cutting flight times and airport congestion. *www.eurocontrol.be*

Honeywell supplies Satellite Precision Landing System for Qantas

Qantas Airlines has received approval by the Australian Civil Aviation Safety Authority to use the Honeywell SmartPathTM Ground-Based Augmentation System (GBAS) at Sydney International Airport for satellite-based landings on their A380 aircraft. *www.honeywell.com*

GOCE completes Early Orbit Phase

ESA's GOCE satellite was formally declared ready for work on 20th March. During the critical Launch and Early Orbit Phase beginning with separation from its booster on 17 March, GOCE was checked out to confirm that all of its control systems are operating normally. *www.esa.int/goce*

GPStogo – a novel scheme

GPStogo is a scheme for providing GPS receivers, for the purpose of contributing to OpenStreetMap, to people in developing countries where the cost is high. The OpenStreetMap Foundation is the operators of this scheme. *http://foundation.openstreetmap.org/gpstogo/*

Indian successfully tests GPS/GIS enabled tree census

Dr. Ramesh Madav, Chairman, Enbitech and CEO of Terracon Ecotech Pvt Ltd, successfully tested the most modern Tree Census Methods, using GPS and GIS. It was done in presence of various technocrats, Municipal Corporation and Government representatives. *http://hamaraphotos.com*

Garmin GPS device users can use MapmyIndia maps now

Garmin GPS devices users can now use MapmyIndia's India maps, and have access to maps of 202 cities, 130,000 towns and villages, 450,000 point of interests, and navigate to 640,000 unique reachable destinations across India. *www.mapmyindia.com*

Wireless Matrix In-Cab Navigation and Communication solution

Wireless Matrix in-cab Navigation and Messaging solution for FleetOutlook® will be available for subscription soon. The mini-applications connect drivers and dispatchers wherein Location-based data is transferred bi-directionally between the in-vehicle navigation platform and FleetOutlook. *www.wirelessmatrix.com.*

Fully integrated Hybrid WiFi-, Cell-ID+ and GPS Positioning Solution

Spotigo has launched its fully integrated positioning solution "HyPS", which can combine GPS and Spotigo's WiFi and Cell-ID positioning methods as inputs to calculate the position of devices. *www.spotigo.com*

Genasys signs commercial partnership with Creativity Software Ltd.

Creativity Software and Genasys have joined together to provide Location and Mobility solutions and Services to their existing customers and to the Telecoms industry. Genasys will contribute with its LBS middleware, SIMLocator and GMPB technology, whereas Creativity Software will provide various applications. *www.genasys.com*

TeleCommunication Systems, Inc. expands LBS into China

TCS has expanded its LBS offerings into China. Building on its customer base in Hong Kong, TCS will work closely with the Alliance

Development Group to enhance the global offering of LBS products and services. *www.telecomsys.com*

iPhone OS 3.0 to allow turn by turn navigation

Apple announced turn by turn navigation on the new iPhone OS 3.0 software. The beta software and SDK are available immediately for registered developers; iPhone customers will be able to download the software for free. *www.apple.com/iphone/preview-iphone-os/*

Fleet Routing Solution by TomTom and Advantage Integrated Solutions

TomTom has partnered with Advantage Integrated Solutions to optimize business fleet organization and itinerary planning on TomTom PRO Series navigation devices. *www.tomtom.com*

Google introduces Voice-Cum-Location-Based search to BlackBerry

Google introduced new features to its Google Mobile App, including its My Location application for BlackBerry handsets for voice control functions, enabling users to speak to the device when requesting information. *www.google.com*

DirectSat USA selects Trimble Mobile Resource Management Solution

DirectSat USA has selected Trimble as its Mobile Resource Management solutions provider, and will begin utilizing the Trimble GeoManager(sm) solution in approximately 1,100 of its service vehicles. www.trimble.com/mobile_resource_management

Galileo update

Galileo and China's Compass argue over frequencies

The Christian Science Monitor reports that China's insistence on using the same radio frequency as Galileo may render some features of the European system unusable in the event of a crisis. China's membership of "Galileo," has soured to the point where the two sides are locked in a dispute over radio frequencies, as China races ahead with its own network of satellites. Without an agreement, China would be able to frustrate European military forces' efforts to deny a future enemy crucial satnav capability. *http://survapedia.com/2009/03/galileo-china-argue/*

European court of auditors lambastes Galileo Satellite Navigation Program

Preliminary observations on "The management of the Galileo programme's development and validation phase," adopted by the European Court of Auditors (ECA) is a kind of post-mortem filled with ruefulness and might-have-beens. The Galileo program is five years behind schedule and facing a current overrun of €2.25 billion (US$3.06 billion) above the 2000 cost projection of €3.33 billion for the definition, development and validation, and deployment phases. The ECA is given powers under various European Union (EU) treaties to carry out independent audits of programs and their use of EU finances. Based on audit work was performed during 2007 and 2008, the preliminary observations will become a final published report to be made public within the coming months. Although the audit covers the program from its origins in the early 1990s up to the end of 2008, it focuses on the EU's satellite navigation programs — Galileo and the European Geostationary Navigation Overlay Service (EGNOS) — during the years 2003 to 2006.

And, through the eyes of the auditors, it's not a pretty sight. Section headings in the table of contents foreshadow the ultimately dreary conclusions: "Concession negotiations failed," "Technological development activities delayed and over budget," "Limited usefulness of RTD [research and technological development] activities," "EGNOS integration only partially successful," "Poor public-sector governance."

Particular attention (and opprobrium) is reserved for the effort to form a Public-Private Partnership (PPP) that sought to derive two-thirds of the cost of deploying the system from a private concessionaire that would operate the system at a profit. The PPP effort fell apart in mid-2006, when the program sponsors — the European Commission (EC) on behalf of the EU and the European Space Agency (ESA) — decided to transform the program into a more traditional public procurement.

The auditors point out that, despite recommendations in two studies prepared by PriceWaterhouseCoopers, the EC did not investigate traditional public procurement. Moreover, neither the EC nor the GJU constructed a public sector comparator, that is, an estimate for comparative purposes of what the project would cost if traditional procurement methods were used. Instead, the ECA concludes (as was widely assumed at the time), "The Commission proposed, and the [EU] Council adopted, a PPP for the deployment and operational phases of Galileo in order to obtain a political consensus."

GeoEye sign reseller contracts. Beijing Earth Observation reseller in China

GeoEye, Inc. has signed agreements with several international resellers to provide high-resolution, satellite imagery and value-added products from its new GeoEye-1 Earth-imaging satellite to customers in China, Middle East, Turkey and Russia. Beijing Earth Observation, China has signed a new agreement with GeoEye to receive data from the GeoEye-1. *www.geoeye.com*

LPS supports Acropolis Laser-Scanning project

ERDAS has reported use of LPS software to create 3D models of the Acropolis in Greece. LPS is an integrated suite of photogrammetry software tools for generating terrain models, producing orthophotos, and extracting 3D features. *www.erdas.com*

RazakSAT to be launched on April 21

The images from RazakSAT, Malaysia's first home-grown remote sensing satellite can be purchased from the Malaysian Remote Sensing Agency from middle of this year. RazakSAT will be launched from Kwajalein Island in the Republic of Marshall Islands, on April 21. *www.remotesensing.gov.my*

India's own Google Earth causes security worries

India is launching its own version of Google Earth called Bhuvan for urban planning, officials said, amid worries that it could be misused after the Mumbai attacks probe showed militants had studied Google images of targets. It is a web-based service developed by India's National Remote Sensing Centre (NRSC). It will help viewers gauge the soil type and ground water potential across the mainland with high resolution images and data from satellites. "We are working with the government for a 2.5 metre (7 feet) resolution," NRSC director V. Jayaraman. But there are security concerns that Bhuvan could be misused because usage would be free. "Giving satellite images to everyone will obviously have some kind of a security impact," said Ajai Sahni of New Delhi's Institute for Conflict Management. Security analyst Uday Bhaskar said there needs to be a global consensus on availability of such technology. *http://in.reuters.com*

India to launch Israel-backed Radar Imaging Satellite

India has acquired a radar imaging satellite (RISAT) built with inputs from Israel that will be launched early next month, the officials said. RISAT has an all-weather viewing capability. *Press Trust of India*

Satellite Imagery over fire affected areas in Victoria, Australia

A screen shot of the fire damage from AAMHatch's RapidEye Web Browser. In this colour infrared image, the red areas show healthy vegetation and the black areas show the fire damage.

Iwave launches SiRF III based GPS module in India

Iwave Systems Technologies Private Ltd has unveiled iw-GPS receiver module based on SiRF III, a low power, miniature module for Personal Navigation, fleet management, asset tracking, personal tracking, surveying, security and other navigation devices. *www.iwavesystems.com*

CARIS delivers advanced Bathymetric Data Management Solution

CARIS announced the release of Bathy DataBASE 2.2, implementing the very latest technology available to address the obstacles of storing and managing large volumes of multi-dimensional data. *www.caris.com*

Hale Capital Partners and Autodesk announcement

Hale Capital Partners and Autodesk announced completion of the transaction to transfer Autodesk's Location Services business unit to LocationLogic, a new entity owned and operated by Hale Capital Partners, with Autodesk and other minority investors. *www.autodesk.com/gis*

First Real-Time Passenger Information System for Gdansk by GMV

GMV has won, in collaboration with the Energy and Mining Technical Assistance Loan, a contract to supply a new passenger information system for the Polish city of Gdansk. *www.gmv.com*

EC selects SES ASTRA for EGNOS

SES ASTRA has been selected by the European Commission (EC) to provide services to the European navigation service EGNOS. It will supply the EU with a tailor-made payload as well as the related necessary ground infrastructure. The payload will operate in L-band and be located on SES ASTRA's new SIRIUS 5 satellite. *www.ses-astra.com*

"In India, we can leverage the huge talent pool of resources"

Willy Govender: Promoter, Director and Group CEO, Data World on launch of operation in India

"Data World has extensive experience and domain expertise in the public sector and local government". Please elaborate

Data World is a major solution provider to Municipalities, Provincial and Central governments in South Africa. The scope of its services varies from Property Taxation Management systems for municipalties to Census Systems at the National Level. We have extensive domain knowledge in the Municiapl Revenue, Public Transportation, Environemntal Management and Licensing, Land Registers, Municipal/Ward/Election boundary delimitation etc. In the Municipal Property taxation domain our product 'Value Assist' has a 30% market share. E-Governance solutions developed using our ADF, which has integrated Workflow, Document Management, Content Management and Discovery components are being used extensively by various govt entities to streamline their business process, enhance service delivery and improve accountability.

An IT company or a Geo-Spatial service provider – how does your company see its positioning in India?

Data World came to India with two broad vision - to leverage the huge talent pool of resources and to find a new market. India is still one of the few growing economies. We would position ourselves as an IT company with substantial capabilities to provide geo-spatial solutions. We have vast experience in providing enterprise geospatial solutions across various industries, however we do not limit to just GIS solutions. We have a team of people providing IT solutions that are not geo-spatial like Digital pen and Paper, Property Valuation solutions etc.

Please elaborate on your "geo-spatial industry standard products that can be used for out of box spatial data delivery and analysis".

Data World has a geo-spatial product suite called as "Buffalo". It is primarily built on top of Map Server and provides elaborate capabilities for geo-spatial data consumption, visualization and analysis. In spite of being built on various open source technology it offers an easy to use system which is robust, scalable and can be used for various application domains. Buffalo comprises set of a desktop tools and enterprise components that can easily be integrated with other systems and extend geo-spatial capabilities at a reasonable cost. It also has elaborate mechanism for service delivery that includes and enterprise deployment and even as an appliance that can be plugged into the data centre and literally be used out of box.

Topcon Announces GRS-1

Topcon Positioning System's new GRS-1 is a fully integrated dual-constellation, network-enabled RTK rover system. It is an all-in-one handheld GNSS receiver and field controller with high-speed processor, increased memory, built-in camera, compass and bar code reading function. *www.topconpositioning.com*

Spatial Law and Policy Committee

The Board of Directors of the Open Geospatial Consortium (OGC®) has chartered a committee of the Board to specifically address the "spatial law and policy issues" which will influence development requirements of the Consortium's technology process. Both public sector and private sector users and providers of geospatial data and technologies face a wide range of legal issues associated with growth in consumer and business applications for spatial technology. All applications using spatial technology raise issues that involve intellectual property rights, liability, privacy, and national security. *www.opengeospatial.org*

Software for bridge design

Bentley Systems has acquired LEAP Software, a provider of analysis and design products for concrete bridges. The flagship product, LEAP Bridge, is an analysis, design, and load-rating application that integrates all bridge design components into one application with a single user interface. *www.bentley.com*

ILRIS-HD High Density Scanner

Optech Inc has launched the ILRIS-HD High Density scanner which offers four times the speed for data collection, high-accuracy survey modes, rapid survey modes, and unsurpassed angular resolution. *www.optech.ca*

Trimble to provide reference stations in China

Trimble has been selected by the National Development and Reform Commission, which is led by the China Earthquake Administration (CEA), to supply GNSS Continuous Operating Reference Station (CORS) receivers for the Crustal Movement Observation Network of China (CMONOC). Trimble will supply 295 NetR8 GNSS CORS receivers and GNSS Choke Ring antennas for the project. *www.trimble.com*

Leica GeoMoS Web Evaluation License

Leica Geosystems announced a 30 day free trial of Leica GeoMoS Web. Available to all existing and new users, GeoMoS Web is a web-based service for visualization and analysis of monitoring via internet. Each authorized user can access the monitoring project anywhere and anytime.

Trimble 2009 DIMENSIONS

Trimble opened its Dimensions 2009 conference with more than 2,400 registered attendees from 67 countries around the world. The conference theme-*Positioning for Success Today. And Tomorrow*-provided insight into how surveying, engineering, construction, mapping, GIS, geospatial and mobile resource management professionals worldwide can harness the power of today' s technology to help face tomorrow's challenges. It was held on February 23-25 at the Mirage Hotel in Las Vegas, USA.

"We are extremely pleased with the strong interest demonstrated in Trimble Dimensions," said Bryn Fosburgh, Trimble vice president. Attendees had the opportunity to network with key industry leaders, develop new contacts, build partnerships, discuss opportunities and discover how to overcome obstacles in today's competitive business environment.

With more than 300 sessions across multiple specialty tracks, the conference focused on increasing productivity in the field and the office to transform the way work is done. The conference included an off-site demonstration and training area and a Partners Pavilion that showcased the complete suite of Trimble construction, survey, engineering, aerial and mobile mapping, GIS and infrastructure solutions, including products from Applanix, Crain, Geo 3D, INPHO, Meridian Systems, Pacific Crest, Quantm, RolleiMetric, SECO, Tripod Data Systems (TDS), TopoSys and XYZ Solutions. Highlighted solutions and technologies included GPS; total stations; field computing and data collection; 3D scanning; pre-design construction planning; 3D visualization; construction project management; aerial mapping; wireless communications; data transfer; and field and office software applications. Other technology providers who are Trimble partners also participated to extend the conference's range of products and applications.

Leica has also released RCD100, an integrated medium-format mapping camera on the market. It is a mapping solution for converting from analog to digital airborne imaging and for those who want productivity and efficiency for smaller to medium-sized photogrammetric mapping and orthophoto projects. *www.leica-geosystems.com*

Hemisphere GPS Reaches Record Revenues

In a global economic situation where many companies are cutting back, Hemisphere GPS has leaned forward. It has reported a 35% increase in 2008 revenues. The company's record revenue total of $72.7 million can be attributed to a strong agriculture market and growing marine, geographical information system and original equipment manufacture sales.

NAVCOM Partners With Astrium Services

Astrium Services will become the sole European supplier of NavCom Technology's GNSS product and positioning solutions, including the StarFireTM Network, global decimeter-accurate satellite-based augmentation system (GSBAS).

"By providing the stand-alone accuracy of the global StarFire™ Network along with precise positioning solutions, our new partnership with Astrium Services has the potential to bring GSBAS to new and important market sectors including defense, civil security and aerospace," said Michael Lindsay, COO for NavCom Technology.

Own rockets in satellite launches from 2010

Europe will use its own lightweight rockets in the launching of small satellites instead of Russia's Dnepr and Rokot from 2010, said Jean-Jacques Dordain, director general of the European Space Agency's.

At a Glance

- ►SPOT Satellite GPS Messenger now available at Fry's Electronics in USA
- ►ERDAS Image Web Server released with Optimized Tile Delivery serving more than 4000 tiles in a second.
- ►Leica Geosystems achieves Singapore Quality Class certification
- ►RMSI wins CII Corporate Wellness Award 2009
- ►ESRI (UK) secures £1.35m GIS contract for Scottish police service
- ►DALSA receives contracts for CAD $17.3m for RS and Photogrammetry
- ►Rockwell Collins wins $450m contract to provide Defence Advanced GPS Receivers to U.S. Air Force GPS Wing.
- ►Microsoft, TomTom settle patent dispute
- ►Garmin lays off 141 employees in US
- ►PND maker Mio cuts jobs in the UK
- ►u-blox increased net profit by 60.9% in 2008. It acquires Geotate B.V.
- ►Navteq reports continued growth for In-Vehicle Navigation in 2008
- ►Top Image Systems reports 39% increase in full year revenues
- ►The worldwide value of GPS networks and services to rise from US $263m in 2009 to US $504m by 2013, according to a report by Position One Consulting.
- ►Navteq reports continued growth for In-Vehicle Navigation in 2008
- ► Cadcorp SIS 7.0 released
- ►RMSI wins CII Corporate Wellness Award 2009
- ►Alliant Energy Corporation has signed a 3 year enterprise license agreement with ESRI
- ►PND maker Mio cuts jobs in the UK

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3-6 May
Naples, Italy
www.enc.gnss09.it

International Conference on Integrated Navigation Systems
25 -27 May
Saint Petersburg, Russia
www.elektropribor.spb.ru

Defence Geospatial Intelligence Middle East
10 - 13 May
Dubai
enquiry@iqpc.ae
www.geospatialdefence.com

3rd UN sponsored PCGIAP Land Administration Forum for the Asia and Pacific Region
24-26 May 2009
Tehran, Iran
www.csdila.unimelb.edu.au

June 2009

GSDI 11 World Conference
15-19 June
Rotterdam, The Netherlands
http://gsdi.org/gsdi11/

TRANS-NAV 2009
8th International Navigational Symposium
June 17-19
Gdynia, Poland
http://transnav.am.gdynia.pl

July 2009

ESRI International User Conference
13–17 July
San Diego, USA
www.esri.com

August 2009

SEASC 2009,
4-7 August
Bali, Indonesia
www.bakosurtanal.go.id/seasc2009/04

2009 IMTA Asia Pacific Conference & Trade Show
7-8, August
Darwin, Australia
imtaaspac@chariot.net.au
http://www.maptrade.org/events/upcoming.php

September 2009

ISDE 2009
9-12 September
Beijing, China
www.digitalearth-isde.org

ION GNSS 2009
22-25 September
Savannah, Georgia, USA
www.ion.org

INTERGEO 2009
22-24 September
Karlsruhe, Germany
www.intergeo.de

2nd GNSS Vulnerabilities and Solutions Conference
2- 5 September
Baska, Krk Island, Croatia
http://twitter.com/BaskaGNSS2009

October 2009

ACRS 2009
19-23 October
Beijing, China
http://www.aars-acrs.org/acrs

November 2009

WALIS International Forum 2009
11-13 November
Perth Convention Exhibition Centre, Australia
www.walis.wa.gov.au

December 2009

IGNSS Society 2009
1- 3 December
Holiday Inn Gold Coast, Queensland, Australia
www.ignss.org

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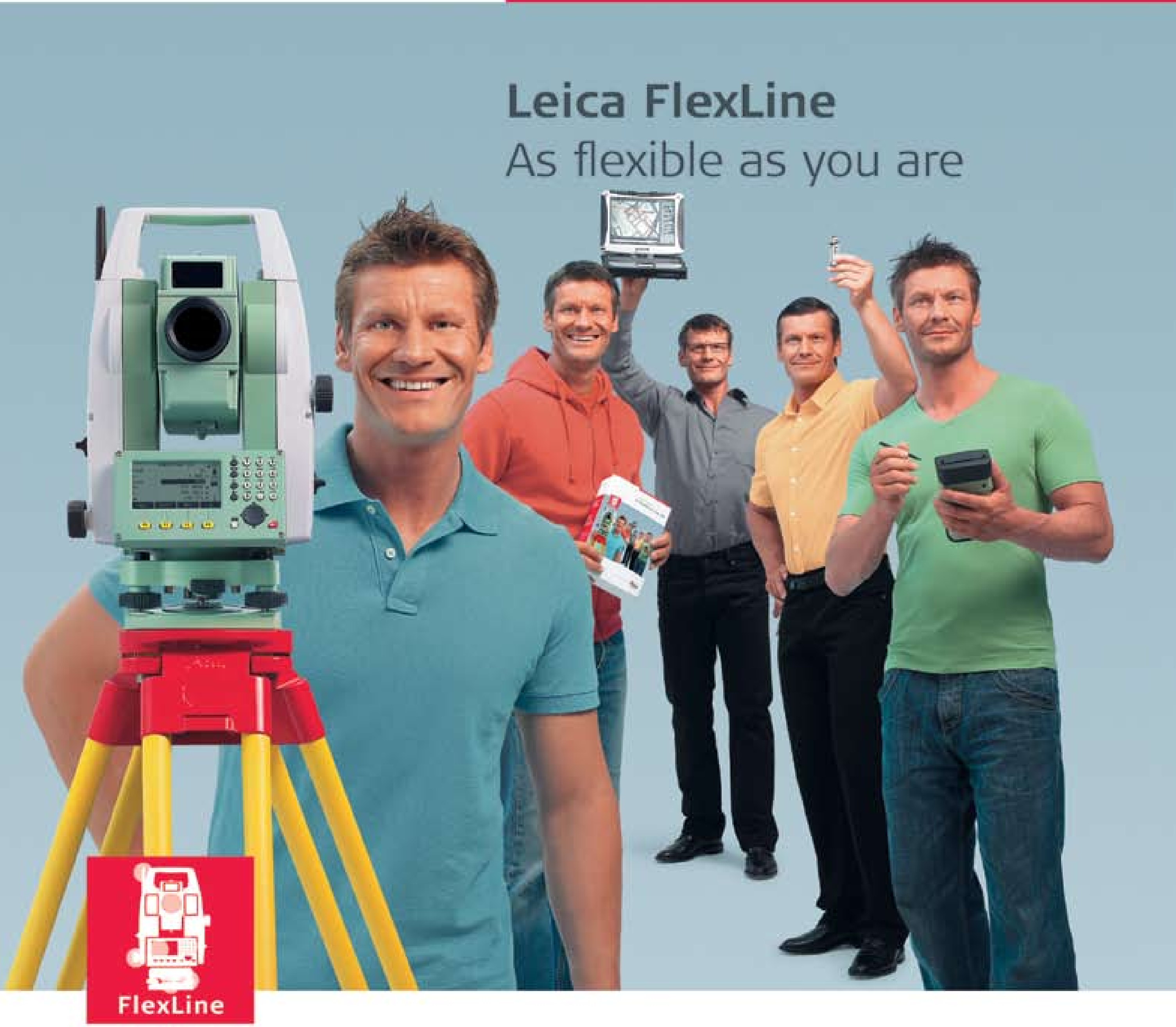
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