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

No: DL(E)-01/5079/14-16
Licensed to post without pre-payment U(E) 28/2014-16
Rs.100

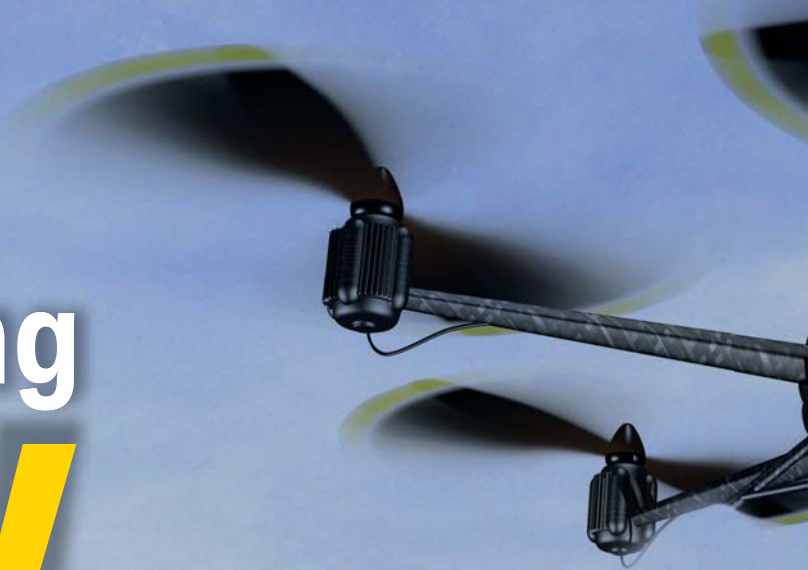
ISSN 0973-2136

www.mycoordinates.org

Coordinates

Volume XI, Issue 01, January 2015

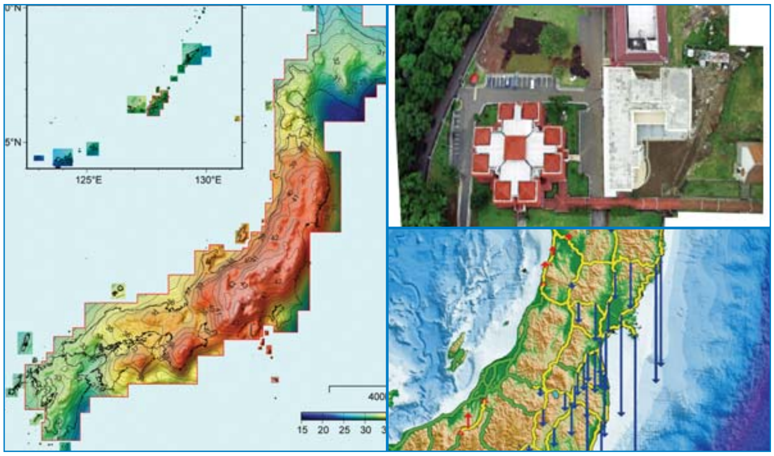
THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND



Integrating UAV in airspace challenges & efforts

‘Future Indian Space - Renewing Policy Dimensions’


Gain perspective in real-world GNSS simulation
The GNSS simulator in the R&S®SMBV100A vector signal generator
Expensive, inflexible simulation of GNSS scenarios is a thing of the past. Now you can easily and cost-effectively test your satellite receivers under realistic conditions.
Comes with a variety of predefined environment models such as “rural area”, “urban canyon”, “bridge” and “highway”
Allows flexible configuration of realistic user environments including atmospheric modeling, obscuration, multipath, antenna characteristics and vehicle attitude
The R&S®SMBV100A generates all relevant communications and broadcasting standards such as LTE, HSPA+, WLAN, HD Radio™ and FM stereo.
To find out more, go to
www.rohde-schwarz.com/ad/smbv-gnss
R&S®SMBV-GNSS
ROHDE&SCHWARZ
© airpano.com



In this issue

Coordinates Volume 11, Issue 01, January 2015

Articles

Columns

This issue has been made possible by the support and good wishes of the following individuals and companies Andri Hernandi, Asep Yusup Saptari, Basara Miyahara, Eric Mwaikambo, Hendriatiningsih Sadikin, Kensuke Kokado, Leslie Cary, Martin Hagai, Masaki Murakami, Mukund Kadursrinivas Rao, Rizki Abdulharis, Sridhara Murthi K R, Tetsuro Imakiire, Tokuro Kodama, Tomoaki Furuya, Toshihiro YahagI, and V S Ramamurthy; Antcom, EOS Positioning, HiTarget, iFEN, Javad, Linertec, Microsurvey, Navcom, NovAtel, Pentax, Riegl, Rohde & Schwarz, Spectra, Trace Me, Trimble, and many others.

Mailing Address
A 002, Mansara Apartments
C 9, Vasundhara Enclave
Delhi 110 096, India.
Phones +91 11 22632607, 98102 33422, 98107 24567
Fax +91 11 22632607

Email
[information] talktous@mycoordinates.org
[editorial] bal@mycoordinates.org
[advertising] sam@mycoordinates.org
[subscriptions] iwant@mycoordinates.org

Web www.mycoordinates.org

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

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

Editor Bal Krishna

Owner Centre for Geoinformation Technologies

Designed at Spring Design (ajay@springdesign.in)

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

This issue of Coordinates is of 64 pages, including cover.

Je suis Charlie

"I disapprove of what you say, but I will defend to the death your right to say it"

- S. G. Tallentyre

Bal Krishna, Editor
bal@mycoordinates.org

The new application of GEONET for multi-GNSS observation and height determination

The immensely-high performance in defining, maintaining and providing geodetic reference frame and position information has made GEONET an essential infrastructure

Basara MIYAHARA
Director, Physical Geodesy Division, Geospatial Information Authority of Japan, Ministry of Land, Infrastructure, Transport and Tourism, Tsukuba City, Ibaraki Pref, Japan

Toshihiro YAHAGI
Geospatial Information Authority of Japan, Ministry of Land, Infrastructure, Transport and Tourism, Tsukuba City, Ibaraki Pref, Japan

Tomoaki FURUYA
Geospatial Information Authority of Japan, Ministry of Land, Infrastructure, Transport and Tourism, Tsukuba City, Ibaraki Pref, Japan

Masaki MURAKAMI
Geospatial Information Authority of Japan, Ministry of Land, Infrastructure, Transport and Tourism, Tsukuba City, Ibaraki Pref, Japan

Tokuro KODAMA
Geospatial Information Authority of Japan, Ministry of Land, Infrastructure, Transport and Tourism, Tsukuba City, Ibaraki Pref, Japan

Tetsuro IMAKIIRE
Geospatial Information Authority of Japan, Ministry of Land, Infrastructure, Transport and Tourism, Tsukuba City, Ibaraki Pref, Japan

Kensuke KOKADO
Geospatial Information Authority of Japan, Ministry of Land, Infrastructure, Transport and Tourism, Tsukuba City, Ibaraki Pref, Japan

Geospatial Information Authority of Japan (GSI) has developed and operated nationwide GNSS continuous observation network, GEONET, since 1996. The GSI has gradually updated system of GEONET and the upgrade has enabled GEONET to receive more and more signals. GNSS observation data of GEONET, including GPS, QZSS and GLONASS, has been publicly opened to users since July 2012. The immensely-high performance in defining, maintaining and providing geodetic reference frame and position information has made GEONET an essential infrastructure not only for land surveys, but also for geospatial information management and crustal deformation monitoring in Japan. The system showed great performance in maintenance of geodetic reference frame in Japan through prompt revision of survey results at the 2011 off the Pacific coast of Tohoku Earthquake. GSI is still facing the challenge to enhance the system performance in order to enable real-time monitoring of crustal movements and earthquake magnitudes in case of huge earthquakes.

GSI also utilized GEONET stations for developing a new hybrid geoid model of Japan, GSIGEO2011. The new model was created by fitting high-resolution gravimetric geoid model of Japan to GNSS/leveling geoid undulations at GEONET stations, and has been publicly available since April 1, 2014. By utilizing the new model for GNSS surveying, orthometric height determination by GNSS surveying has become possible as the same precision-level as third-order leveling surveys. The height determination has been available for public surveys in Japan since April 1, 2013. Orthometric heights of almost all of the triangulation control points in Japan were also re-calculated and revised by applying geoid heights of the model. The revision improved consistency in orthometric heights between triangulation control points and GEONET stations.

Introduction

GSI has been developing and operating nationwide GNSS continuous observation network, GEONET, since 1996 (Hatanaka et al., 2003). GNSS observation data of GEONET, including GPS, QZSS and GLONASS, has been publicly opened to users, and GEONET has become essential infrastructure not only for land surveys, but also for geospatial information management and crustal deformation monitoring in Japan. The system showed great performance in maintenance of geodetic reference frame in Japan through prompt revision of survey results Tohoku Earthquake that took place off the Pacific coast in 2011.

The GEONET stations are also utilized for development of a hybrid geoid model of Japan, GSIGEO2011. The GSI created the new hybrid geoid model by fitting high-resolution gravimetric geoid model of Japan to GNSS/leveling geoid undulation at GEONET stations. Orthometric height determination by GNSS surveying has become possible anywhere in Japan by utilizing the model. And the orthometric height determination has also been applicable in public surveys as alternative to third-order leveling in Japan since April 1, 2013.

GEONET

Overview of GEONET

Currently, the GSI is operating continuous GNSS observation stations at approximately 1,300 locations. The stations are covering all Japanese islands in order to realize and maintain the geodetic reference frame in Japan as well as to monitor crustal deformation in Japan. The entire system, which is comprised of these observation stations and the central station in Tsukuba for collecting, analyzing and distributing these data, is called GNSS Earth Observation Network System, GEONET.

Significant crustal deformation was caused by the 2011 off the Pacific coast of Tohoku Earthquake and GEONET detected the deformation just after the earthquake. Figure 1 shows the horizontal movements and Figure 2 the vertical movements of GEONET stations in northeastern Japan (GSI, 2011). The maximum displacement is recorded at the Oshika site in Ishinomaki City, Miyagi Prefecture, and comprises about 5.3 m horizontal displacement toward the east to south-east and up to 1.2 m vertical subsidence.

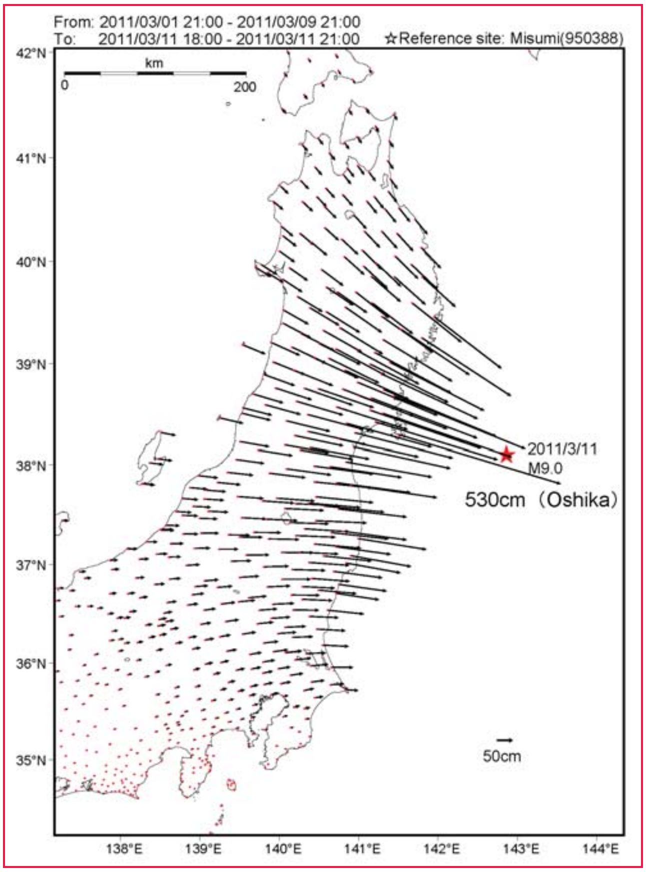


Figure 1: Crustal movement (horizontal) with the 2011 off the Pacific coast of Tohoku Earthquake on March 11, 2011.

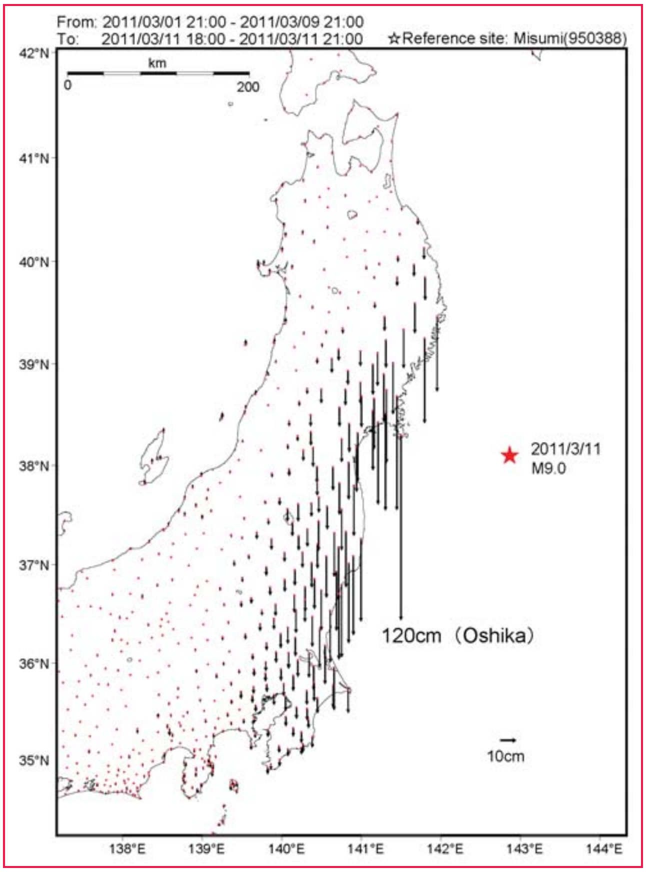


Figure 2: Crustal deformation (vertical) with the 2011 off the Pacific coast of Tohoku Earthquake on March 11, 2011.

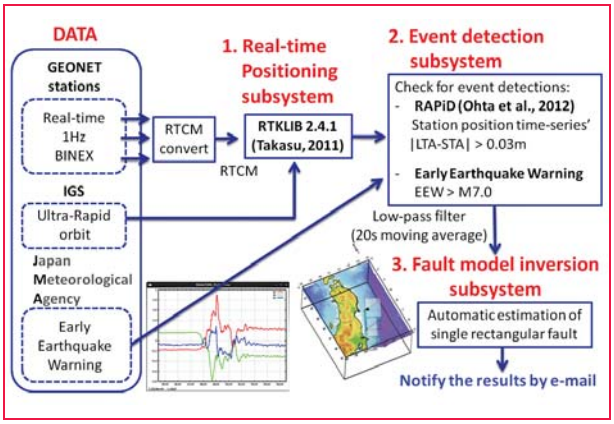


Figure 3: Flow diagram of processing of REGARD.

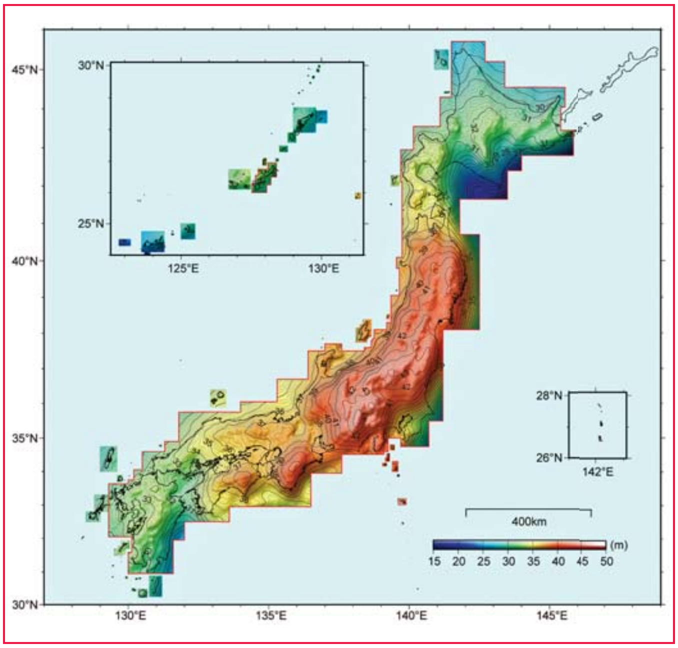


Figure 4: New hybrid geoid model of Japan, GSIGEO2011 ver.1. Counter interval is 20cm and numerals in meters. Areas enclosed with the red lines indicate the effective areas of the model.

Data distribution

GNSS observation data and GNSS solutions of GEONET are freely available from the GSI website (http://terras.gsi.go.jp). These observation data contain pseudo range and carrier phase data per 30 seconds and broadcast ephemerides in RINEX format. On July 13, 2012, at 15 % of GEONET stations, GSI started providing the observation data received from the Quasi-Zenith Satellites System (QZSS) and GLONASS in addition to the existing GPS. On May 10, 2013, this was extended to almost all GEONET stations.

The QZSS is a regional satellite-based positioning system operated by Japan. The system covers regions from East Asia to Oceania centering on Japan and is designed to enable users in the coverage area to receive QZS signals from high elevation angles at all times. The first satellite of QZSS was launched in September 2010, and four satellites constellation is planned to start its operation in 2018 by adding three satellites into the orbits. Recently, RINEX ver. 3.02 that officially supports QZSS was released, and the GSI will provide the data in the format from 2015.

The GSI collects real-time data from 1,257 stations with sampling intervals of 1 second. These data are provided to three private enterprises via a non-profit distributor, and utilized for generating correction data for network-based RTK.

Analysis strategies of GEONET data

GEONET has three different routine analysis strategies; Quick, Rapid and Final. Quick analysis is executed every three hours with 6 hour data and utilized especially for promptly monitoring crustal movements. Rapid analysis is done every day with 24 hour data. Final analysis is the most robust analysis and executed with IGS final orbits. These analyses are routinely performed with BERNESE ver.5.0.

By utilizing spatially dense coverage of GEONET stations and robust real-time streaming data, the GSI has been developing a new GEONET real-time analysis system, named REGARD (Real-time GEONET Analysis System for Rapid Deformation Monitoring). The system is designed for estimating permanent displacement fields and Mw of giant earthquakes immediately after the earthquakes. The system also notifies the results in real-time. Figure 3 shows processing flow diagram of the estimation by REGARD. The GSI verified that the system successfully could estimate appropriate Mw values just after a couple of minutes in cases of large events (e.g. Mw8.9 in the 2011 Tohoku earthquake). It is planned to focus on exploiting to prompt estimation of tsunami scale and prompt tsunami warning.

New hybrid geoid model of Japan and its application for land survey

New hybrid geoid model of Japan, "GSIGEO2011"

The GSI has developed a new hybrid geoid model of Japan, GSIGEO2011 (Figure 4), which covers almost all areas of Japanese islands. The model is created in such a way that a high-resolution gravimetric geoid of Japan, "JGEOID2008" (Kuroishi, 2009) was fitted to GNSS/leveling geoid undulations at 971 sites by a Least Squares Collocation method. The sites are composed of 786 GEONET stations, 29 tide gauge stations and 156 benchmarks. The model reproduces geoid heights at the GNSS/leveling sites with the consistency of a standard deviation of 1.8 cm (Figure 5). The errors range from -6.2 cm to 8.2 cm with average of 0.0 cm, indicating that the model is consistent with GNSS/leveling geoid heights to 2 cm in magnitude at one-sigma level of confidence. The model was made publicly available on April 1, 2014.

In the areas affected by crustal deformation of the 2011 off the Pacific coast of Tohoku Earthquake, the GSI re-surveyed orthmetric heights of benchmarks through almost all the leveling routes and also at 55% of GEONET stations (Figure 6). The GSI immediately conducted network adjustment calculation with the re-surveyed data and made the results publicly available as revised survey results of the benchmarks. The revised orthometric heights were also utilized for development of GEIGEO2011, and the model is consistent with the orthometric heights even in the areas greatly affected by the crustal movements of the Tohoku earthquake.

Orthometric height determination by GNSS survey utilizing GSIGEO2011

By utilizing the model to convert GNSS-derived three-dimensional positions to orthmemetirc heights, GNSS survey can determine orthometric heights at the same precision-level as third order leveling surveys. The orthometric height determination by GNSS surveying has been applicable in public surveys as alternative to third-order leveling in Japan since April 1, 2014. The GSI also newly established a survey procedure for the height determination. The procedure defines a work flow to determine orthometric

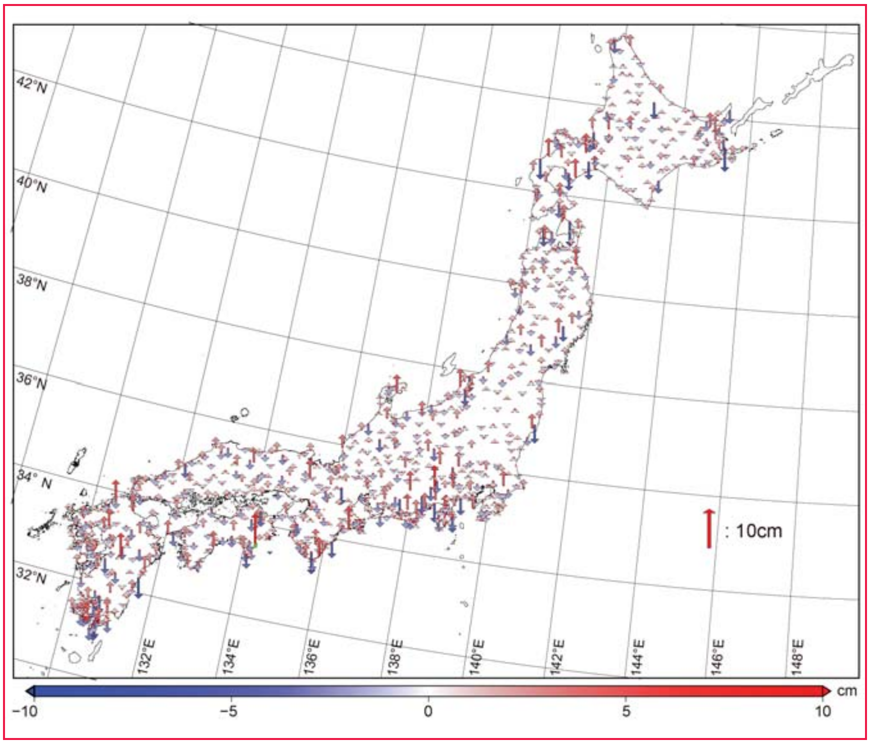


Figure 5: Reproduction errors of GSIGEO2011 from Hokkaido to Kyushu at GNSS/leveling geoid undulation points used as input data in modeling. Numerals are in centimeters.

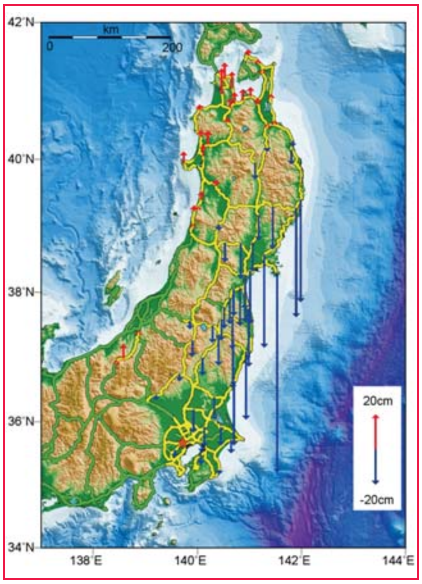


Figure 6: First order leveling routes and differences in heights between original and re-calculated survey results of first order benchmarks. Yellow line indicates leveling routes re-surveyed after the Tohoku Earthquake. Allows show the differences in heights.

heights through GNSS observation by utilizing the model and has also been publicly available since April 1, 2014.

Re-calculation of orthometric heights of triangulation control points

The GSI also re-calculated and revised orthometric heights of almost all of the triangulation control points in Japan by applying geoid heights of the new model. The results were publicly announced on April 1, 2014. The differences between the original and the re-calculated heights range from -94cm to 78cm with average of 15cm (Figure 7). The GSI started triangulation surveys of the triangulation control points in 1880's and had conducted the surveys over a hundred years. Therefore, these differences in the heights are derived from not only the model improvement, but also vertical crustal deformation caused by cumulative crustal deformation in Japan islands from 1880's. The revised results are available in the GSI website and users can access more accurate and credible heights information of Japan.

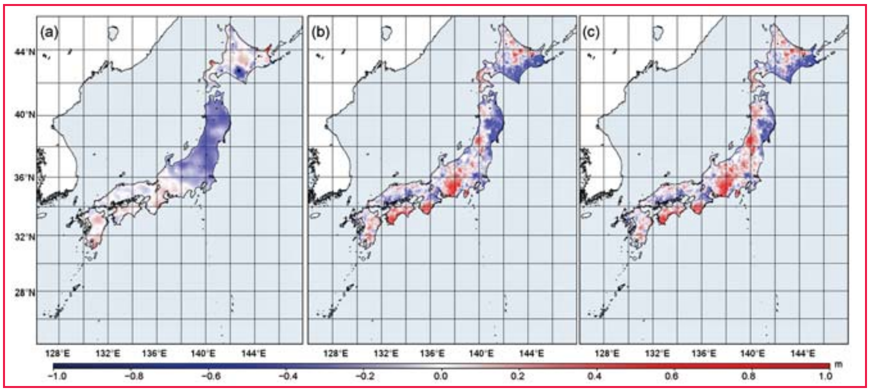


Figure 7: Differences between original and re-calculated orthometric heights of triangulation control points. (a): Differences by geoid model improvement. (b): By cumulative crustal deformation since 1880's. (c): Total differences i.e. (a) + (b).

References

Geospatial Information Authority of Japan (2011): Crustal deformation associated with the 2011 off the Pacific coast of Tohoku Earthquake on March 11, 2011, http://www.gsi.go.jp/chibankansi/chikakukansi40005.html (accessed 5 Dec., 2014). (in Japanese)

Hatanaka, Y., T. Iizuka, M. Sawada, A. Yamagiwa, Y. Kikuta, J.M. Johnson and C. Rocken (2003): Improvement of the Analy sis Strategy of GEONET, Bulletin of the Geospatial Information Authority of Japan, Vol.49 March, 2003, 11-37.

Imakiire, T. and T. Kobayashi (2011): The Crustal Deformation and Fault Model of the 2011 off the Pacific Coast of Tohoku Earthquake, Bulletin of the Geospatial Information Authority of Japan, Vol.59 December, 2011, 21-30.

Japan Aerospace Exploration Agency (2013): Interface Specifications for QZSS (IS-QZSS), http://qz-vision.jaxa.jp/USE/is-qzss/index_e.html (accessed 5 Dec., 2014).

Japan Association of Surveyors: http://www.jsurvey.jp/eng.htm (accessed 5 Dec., 2014).

JENOBA CO., LTD: http://www.jenoba.jp (accessed 5 Dec., 2014). (in Japanese)

Kuroishi, Y. (2009): Improved geoid model determination for Japan from GRACE and a regional gravity field model, Earth Planets Space, 61, 807-813.

Murai, Y. (2013): Project Overview Quasi-Zenith Satellite System, Abstract of 5th Asia Oceania Regional Workshop on GNSS.

Nippon GPS Data Service Corporation: https://www.gpsdata.co.jp/index.html (accessed 5 Dec., 2014). (in Japanese)

Ohta, Y., T. Kobayashi, H. Tsushima, S. Miura, R. Hino, T. Takasu, H. Fujimoto, T. Iinuma, K. Tachibana, T. Demachi, T. Sato, M. Ohzono, and N. Umino (2012): Quasi real-time fault model estimation for near-field tsunami forecasting based on RTK-GPS analysis: Application to the 2011 Tohoku-Oki earthquake (Mw 9.0) Journal of Geophysical Research., 117, B02311, doi:10.1029/2011JB008750.

Takasu, T. (2011): RTKLIB ver. 2.4.1 Manual, http://www.rtklib.com/prog/manual_2.4.1.pdf (accessed 5 Dec., 2014)

Toyofuku, T., B. Miyahara, H. Nakagawa, K. Nitta, T. Saito, H. Amemiya, Y. Kimura and M. Yamanaka (2008): GEONET -GPS Earth Observation System-, Abstract of International Symposium on GPS/GNSS 2008 in Tokyo, 147.

Tsuji, H., K. Miyagawa, K. Yamaguchi, T. Yahagi, K. Oshima, H. Yamao and T. Furuya (2013): Modernization of GEONET from GPS to GNSS, Bulletin of the Geospatial Information Authority of Japan, Vol.61 December, 2013, 9-20.

Yahagi, T., K. Miyagawa, S. Kawamoto, K. Oshima, K. Yamaguchi, H. Muramatsu, Y. Ohta, T. Demachi, S. Miura, R. Hino, Y. Saida and Y. Douke (2014): Enhancement of GEONET Real-time Analysis System for Covering over Japan, Abstract of Japan Geoscience Union Meeting 2014.

"ICAO develops the global regulatory framework for UAS"

Says Leslie Cary, Programme Manager, Remotely Piloted Aircraft Systems (RPAS), International Civil Aviation Organization in an interview with Coordinates

For the benefit of our readers, can you explain the evolution of the terms UAV, UAS and RPAS?

In 2005, ICAO became involved with unmanned aerial vehicles (UAV) when our Air Navigation Commission (ANC) requested the Secretary General to consult selected States and international organizations with respect to: present and foreseen international civil UAV activities in civil airspace; procedures to obviate danger to civil aircraft posed by UAVs operated as State aircraft; and procedures that might be in place for the issuance of special operating authorizations for international civil UAV operations.

One result of this consultation was an agreement by the ANC that the subject should be referred to as 'unmanned aircraft systems' (UAS), in-line with RTCA and EUROCAE agreements. This change of terminology was also appropriate given that the vehicles are aircraft by definition and should therefore be referred to as such, while also acknowledging that said aircraft operate as part of a system.

The terms 'remotely piloted aircraft' (RPA) and 'remotely piloted aircraft system' (RPAS) were adopted by ICAO as subsets of unmanned aircraft (UA) and UAS, respectively. Not all UA are RPA, however all RPA are UA. The distinction lies with the ability of a person, i.e. a remote pilot, to actively manage the flight in real time, as does the pilot of a manned aircraft.

As ICAO develops the global regulatory framework for UAS, it is focusing on the integration of manned and unmanned aircraft operating in non-segregated airspace and at aerodromes. The *Convention on International Civil Aviation*, signed at Chicago on 7 December 1944 and amended by the ICAO Assembly (Doc 7300) stipulates that *"pilotless aircraft… shall be so controlled as to obviate danger to civil aircraft."* In this context, pilotless and unmanned are synonymous. In order to ensure the safety of manned aircraft as required by the Convention, it is considered essential that any unmanned aircraft operating in non-segregated airspace in the vicinity of manned flights have a licensed individual with appropriate knowledge, skills and training at the controls.

> ICAO has recently completed drafting the Manual on RPAS

In summary, UAVs are unmanned aircraft. Unmanned aircraft that are remotely piloted are the focus of ICAO's work.

What is the mandate and the role of ICAO in the context of RPAS for civil applications?

ICAO has tasked several of its expert groups with work associated with RPAS.

The **Remotely Piloted Aircraft Systems Panel (RPASP)** coordinates and develops ICAO Standards and Recommended Practices (SARPs), procedures and guidance material for RPAS to facilitate a safe, secure and efficient integration of RPA into non-segregated airspace and aerodromes.

The **RPASP** will, in collaboration with other ICAO expert groups, undertake specific studies and subsequently develop provisions to facilitate the safe, secure and efficient integration of RPA into non-segregated airspace and aerodromes while maintaining the existing level of safety for manned aviation. The RPASP will:

1. Serve as the focal point and coordinator of all ICAO RPAS related work, with the aim of ensuring global interoperability and harmonization;
2. Develop an RPAS regulatory concept and associated guidance material to support and guide the regulatory process;
3. Review ICAO SARPs, propose amendments and coordinate the development of RPAS SARPs with other ICAO expert groups;
4. Assess impacts of proposed provisions on existing manned aviation; and
5. Coordinate, as needed, to support development of a common position on bandwidth and frequency spectrum requirements for command and control of RPAS for the International Telecommunications Union (ITU) World Radio Conference (WRC) negotiations.

The ICAO Legal Committee is undertaking a study on liability issues related to RPAS. The Aviation Security Panel and the Committee on Aviation Environmental Protection are likewise engaged.

Does ICAO have any role in formulating guidelines for military drones also?

ICAO does not provide standards for military aircraft; however States have a strong interest in ensuring their military and civil aviation systems can co-exist efficiently. Furthermore, there are many lessons that have been learned by military authorities regarding design, manufacture and operation of UAS that can be shared with their civil counterparts. As such, ICAO serves as a forum where States can develop guidelines that may prove useful for both civil and military purposes.

Would you please explain the importance of the international regulatory framework for RPAS?

Whether aircraft are manned or unmanned, the international regulatory framework provided by ICAO allows aviation to advance in a safe, orderly and sustainable manner. The international regulatory framework provides harmonization so that manufacturers, operators, service providers, regulators, other stakeholders and the public have common expectations and understandings of the aviation system.

Determining airworthiness, operator responsibilities, training, safety management, airspace access requirements, phraseology, separation standards, security, facilitation and frequency spectrum are all topics for which global harmonization is essential. Cross-border operations, global marketing and national operations in the vicinity of international aircraft/aerodromes each warrant the need for globally standardized aviation provisions.

ICAO has recently completed drafting the *Manual on Remotely Piloted Aircraft Systems (RPAS)* (Doc 10019) which is undergoing editorial review prior to publication. This document provides readers with analyses of how the existing regulatory framework developed for manned aviation applies to unmanned aircraft and provides insight into the changes that will be coming. It serves as an educational tool for States and stakeholders, it supports the development of SARPs and guidance material by ICAO and it gives a basis for other standards-making organizations to harmonize their activities.

ICAO is hosting the first global RPAS Symposium ***Remotely Piloted or Piloted: Sharing One Aerospace System*** that will be held at ICAO Headquarters from 23 to 25 March 2015. Material from the new RPAS Manual will be presented along with Industry's vision of future operations, regulatory and oversight challenges faced by States and airspace and aerodrome integration issues. Information on the symposium and exhibition can be obtained at: *http://www.icao.int/meetings/rpas*

What are the main regulatory challenges faced by the States in the use of RPAS?

States face many challenges when it comes to UAS and their use. For complex UAS employed for professional purposes, the difficulties revolve around adapting regulations developed to address issues encountered in manned aviation to finding effective solutions for the scenarios presented by unmanned aviation. Finding effective solutions requires a deep understanding of the issues and the underlying 'what, how and why' answers that led to the existing manned aviation regulations. Complicating this is the very rapid development of technologies that far outpace the ability of States, ICAO and the standards-making organizations to develop regulations.

States face an entirely different set of challenges for simple UAS that are readily available for purchase online and in hobby or toy stores. These UAS possess capabilities that allow them to be operated relatively easily by untrained individuals, yet they can have catastrophic consequences on the safety of persons, property or other aircraft when used inappropriately. Educating the public on the safe use of these UAS is an urgent challenge.

What is ICAO proposing for the safe, secure and efficient integration of RPAS into non-segregated airspace alongside manned aviation?

RPAS are entering into a transportation system that prides itself as the safest mode of travel and transit. The safety level has been achieved through rigorous review of

> Educating the public on the safe use of UAS is an urgent challenge

accidents, incidents and errors. Regulations have evolved as knowledge and experience were gained and oversight of operators and service providers has assured compliance with the changing requirements.

RPA, in order to be integrated with manned aircraft, must be able to act as equal members of the air navigation system. This includes maintaining aircraft in an airworthy state and assuring the components of the RPAS interoperate as intended. The RPAS must have the communication, navigation and surveillance systems appropriate for the airspace or operation. They must additionally operate in a manner that is predictable to other aircraft and air traffic control and comply with the rules and regulations in place. The RPA must be able to detect and avoid hazards and not act in a manner that is hazardous to persons, property or other aircraft. Neither the existing technology nor regulations currently support full integration.

What are the key security issues related to RPAS, the remote pilot station and the command and control link?

RPAS, including the command and control link, must be protected from both intentional and unintentional interference. This is consistent with all aspects of aviation security.

What are the main legal and liability concerns in the use of RPAS?

There are many (too many to address here) new legal issues that will be the subject of SARPs. Liability issues are being studied, however most are likely to be common to those of manned aviation.

Integrating UAV in airspace: challenges and efforts

In this article, we piece together the main issues involved in formulating a policy for RPAS

There is a reason for the fuss about formulating a policy for the use of Unmanned Aerial Vehicles (UAV)/ Unmanned Aircraft Systems (UAS) or as they are called today, Remotely Piloted Aircraft Systems (RPAS). In this article, we piece together the main issues involved in formulating a policy for RPAS by sifting through the **material available on various civil aviation authority websites**[1]. We also present a compilation of how some countries have addressed/ are addressing the use of RPAS in their airspace jurisdiction.

The Evolution of RPASs

The Convention on International Civil Aviation[2] (also known as the Chicago Convention) was signed on December 7, 1944. The **Global Air Traffic Management Operational Concept**[3] states that, '*An unmanned aerial vehicle is a pilotless aircraft, in the sense of Article 8 of the Convention on International Civil Aviation, which is flown without a pilot-in-command on-board and is either remotely and fully controlled from another place (ground, another aircraft, space) or programmed and fully autonomous.*' This understanding of UAVs was endorsed by the 35th Session of the International Civil Aviation Organization (ICAO) Assembly in Montreal in 2004.

The **ICAO Circular 328**[4] of 2011 says in Chapter 2, Section 5 (2.5): […] 'Whether the aircraft is manned or unmanned does not affect its status as an aircraft. Each category of aircraft will potentially have unmanned versions in the future. This point is central to all further issues pertaining to UA and provides the basis for addressing airworthiness, personnel licensing, separation standards, etc.' […]

[…] 2.7: 'Another fundamental of the assessment undertaken by ICAO is that a UA will not, for the foreseeable future, have passengers on board for remuneration.' […]

[…] 2.12: 'To date, most flights conducted by UAS have taken place in segregated airspace to obviate danger to other aircraft. Current UA are unable to integrate safely and seamlessly with other airspace users, the reasons for which are twofold - the inability to comply with critical rules of the air, and the lack of Standards and Recommended Practices (SARPs) specific to UA and their supporting systems.' […]

[…] 3.2: 'To better reflect the status of these aircraft as being piloted, the term 'Remotely-Piloted Aircraft' (RPA) is being introduced into the lexicon. An RPA is an aircraft piloted by a licensed 'remote pilot' situated at a 'remote pilot station' located external to the aircraft (i.e. ground, ship, another aircraft, space) who monitors the aircraft at all times and can respond to instructions issued by Air Traffic Control (ATC), communicates via voice or data link as appropriate to the airspace or operation, and has direct responsibility for the safe conduct of the aircraft throughout its flight. An RPA may possess various types of auto-pilot technology but at any time the remote pilot can intervene in the management of the flight. This equates to the ability of the pilot of a manned aircraft being flown by its auto flight system to take prompt control of the aircraft.' […]

[…] 3.8: 'The RPAS comprises a set of configurable elements including an RPA, its associated remote pilot station(s), the required command and control (C2) links and any other system elements as may be required, at any point during flight operation.'

And finally according to the **Joint Authorities for Rulemaking on Unmanned Systems (JARUS)**[5] - '*RPAS are a new type of aircraft which have to interact with the current airspace users. […] It is expected that RPAS are compatible with the way 'manned aviation' operations are carried out, while interacting with Air Traffic Services (ATS) and with other aircraft, and maintain the current and foreseen safety levels in aviation.*'

The Crux of the Matter

If RPAS are to use the same airspace as other aircraft, a space that is governed by the ATS then it automatically follows that they would also have to adhere to guidelines and governing principles similar to those followed by other aircraft. Therefore the challenge is to formulate guidelines for RPAS within the framework that guides other aircraft. In the ICAO presentation, **WRC-15 Agenda Item 1.5, Fixed Satellite Service spectrum to support the safe operation of Unmanned Aircraft Systems**[6], the essential requirements for integration of RPAS into civil airspace have been clearly listed as:

- Certification: RPA, operator, remote pilot
- Approval: RPAS as a complete system
- Collision and hazard avoidance
- Interact with ATC and other aircraft
- Security: data links, RPA, remote pilot station
- Predictable actions (not autonomous!)
- Contingency procedures

The Stop-gap Arrangement – Certification

ICAO Circular 328, 6.1 states: 'RPA are integrating into a well-established certification system and are subject to demonstrating compliance in a manner similar to that of manned aircraft. The fact that these aircraft cannot operate without supporting system elements (RPS, C2 data links, etc.) brings new complexities to the subject of certification.' […]

[…] 6.5: 'The first option envisaged is that the certification of the RPAS is documented with the Type Certificate issued to the RPA. The configuration of the RPAS as a whole would be included in the Type Certificate of the RPA, under the responsibility of one unique Type Certificate holder. […] The configuration of RPA and RPS would be certified in conjunction with the RPA by the State of Design of the aircraft and documented in the Type Certificate data sheet. […] The State of Registry would have responsibility for determining continuing airworthiness of the RPAS in relation to the appropriate airworthiness requirements.' […]

6.6: 'The second option envisaged would require not only new SARPs, but also new certificates comparable to the existing Type Certificate and Certificate of Airworthiness (COA) to be developed.' […]

The Long Term Plan

It is mentioned in ICAO's **Capacity and Efficiency Standardization Flyer on RPAS**[7] that, '[…] one of the operational needs noted in ICAO's Aviation System Block Upgrade (ASBU) strategy is the introduction of RPAS. A key component of successful RPAS integration will be ensuring that their potential economic and social benefits are not realized at the expense of general system safety or efficiency.' […]

[…] 'ICAO is well into the exhaustive process of reviewing every Annex to the Chicago Convention in order to discern how the introduction of RPAS into the regulatory framework is going to impact existing Standards. The **2013-2028 Global Air Navigation Plan (GANP)**[8] recognizes RPA as a legitimate user of the airspace and the performance capability Modules required for safe, successful RPAS integration have been defined under the ASBU framework.'

ICAO 2013-2028 GANP, Performance Improvement Area 4:

All three apply to all RPA operating in non-segregated airspace and at aerodromes and require good synchronization of airborne and ground deployment to generate significant benefits, in particular to those who are able to meet minimum certification and equipment requirements.

Block 1-RPAS: Initial Integration of RPA Systems into non-segregated airspace

- Implementation of basic procedures for operating RPA in non-segregated airspace including detect and avoid.
- Limited access to airspace by a new category of users.
- Increased situational awareness; controlled use of aircraft. […]

Block 2-RPAS: RPA Integration in Traffic

- Continuing to improve the RPA access to non-segregated airspace; continuing to improve the RPAS approval/ certification process; continuing to define and refine the RPAS operational procedures; continuing to refine communication performance requirements; standardizing the C2 link failure procedures and agreeing on a unique squawk code for C2 link failure; and working on detect and avoid technologies, to include Automatic Dependent Surveillance - Broadcast (ADS-B) and algorithm development to integrate RPA into the airspace. […]

Block 3-RPAS: RPA Transparent Management

- Continuing to improve the certification process for RPA in all classes of airspace, working on developing a reliable C2 link, developing and certifying Airborne Detect and Avoid (ABDAA) algorithms for collision avoidance, and integration of RPA into aerodrome procedures. […]

ICAO continues to cooperate and consult with States and industry stakeholders on the adoption of RPAS operations into pertinent regulatory frameworks.

ICAO Standardized Acronyms

- **Remotely Piloted Aircraft (RPA)** - an unmanned aircraft which is piloted from a remote pilot station.
- **Remotely Piloted Aircraft System (RPAS)** - a remotely piloted aircraft, its associated remote pilot station(s), the required command and control links and any other components as specified in the type design.
- **Remote Pilot Station (RPS)** - the component of the RPAS containing the equipment used to pilot the RPA.
- **Remote pilot** - a person charged by the operator with duties essential to the operations of an RPA and who manipulates the flight controls, as appropriate during flight time.

Other Terminology

- **Command and Control Link (C2)** - the data link between the RPA and the RPS for the purposes of managing the flight.
- **Command, Control and ATC Communications (C3)** - the C2 plus ATC communications.
- **Detect and Avoid (D&A)** - the capability to see, sense or detect conflicting traffic or other hazards and take the appropriate action.

(WRC-15 Agenda Item 1.5, Fixed Satellite Service spectrum to support the safe operation of Unmanned Aircraft Systems)

Implementing the Framework

Despite the detailed framework given by ICAO, actually formulating the policies and guidelines for the use of RPAS has been a challenge that only few countries seem to be overcoming - most are still struggling with it. Here is a snapshot of the conditions under which RPAS are allowed to operate in some of the countries.

United States of America

As required by Section 332(a) [Integration of civil unmanned aircraft systems into national airspace system, (a) required planning for integration], of the **FAA Modernization and Reform Act (FMRA) of 201**[9], the **Unmanned Aircraft Systems (UAS) Comprehensive Plan**[10] was put together by representatives from the Next Generation Air Transportation System (NextGen) partner agencies – the Departments of Transportation (DOT), Defense (DoD), Commerce (DOC), and Homeland Security (DHS), the National Aeronautics and Space Administration (NASA), and the Federal Aviation Administration (FAA) – as well as industry representatives, provided through the FAA's UAS Aviation Rulemaking Committee (ARC) in September 2013. The Plan sets the overarching, interagency goals, objectives, and approach to integrating UAS into the NAS.

This was followed by FAA's **Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Roadmap**[11] in November 2013. The purpose of the roadmap is to outline, within a broad timeline, the tasks and considerations needed to enable UAS integration into the NAS for the planning purposes of the broader UAS community.

As per the UAS Roadmap, 'Integration of UAS into the NAS will require: review of current policies, regulations, environmental impact, privacy considerations, standards, and procedures; identification of gaps in current UAS technologies and regulations, standards, policies, or procedures; development of new technologies and new or revised regulations, standards, policies, and procedures; and the associated development of guidance material, training, and certification of aircraft systems, propulsion systems, and airmen.'

The FAA first authorized use of unmanned aircraft in the NAS in 1990 and identifies three types of unmanned aircraft system operations: civil, public and model aircraft.

Civil Operations (Non-Governmental)

For civil operation, applicants may obtain a Special Airworthiness Certificate, Experimental Category (operations for research and development, flight and sales demonstrations and crew training) by demonstrating that their unmanned aircraft system can operate safely within an assigned flight test area and cause no harm to the public.

Public Operations (Governmental)

For public operation, the FAA issues a COA that permits public agencies and organizations to operate a particular UA, for a particular purpose, in a particular area. COAs are usually issued for a specific period - up to two years in many cases and most require coordination with an appropriate air traffic control facility. There were 545 COAs active as of December 4, 2013.

Model Aircraft

Recreational use of airspace by model aircraft is covered by FAA Advisory Circular 91-57, which generally limits operations for hobby and recreation to below 400 feet, away from airports and air traffic, and within sight of the operator.

FMRA Section 333 – Giving Wings to Civil Operations

Recognizing the demand to expedite integration of UAS into the NAS, the FAA has leveraged the authority granted under **Section 333 of the FMRA - Special Rules for Certain Unmanned**

FAA UAS Test Sites

After a rigorous 10–month selection process, on December 30, 2013, the **FAA selected six unmanned aircraft systems test sites in accordance with FMRA 2012**[13] across the country. The research and relevant data from the sites will feed into the requirements being developed to support UAS integration including providing information to support development of certification procedures, airworthiness standards, operational requirements, maintenance procedures, and safety oversight activities for UAS civil applications and operations.

FAA lets 4 companies fly commercial drones

Four companies won approval from FAA to fly commercial drones to conduct aerial surveys, monitor construction sites and inspect oil flare stacks – Trimble Navigation Limited (TRMB), VDOS Global, Clayco Inc. and Woolpert Inc. *www.usatoday.com*

Six companies can fly small UAS

US Transportation Secretary Anthony Foxx announced that FAA has granted regulatory exemptions to six aerial photo and video production companies – the first step to allowing the film and television industry the use of UAS in the NAS. FAA is considering 40 requests for exemptions from other commercial entities. *www.faa.gov*

Center of Excellence

The Congress directed the FAA to establish a **UAS Center of Excellence (COE)** [14] under the Consolidated Appropriations Act of 2014. The COE will be jointly managed by the FAA's NextGen and UAS Integration offices and will be a geographically disbursed consortium of the FAA, university partners and their affiliates selected by the FAA Administrator to conduct UAS related research, education and training while working jointly on issues of mutual interest and concern.

However, despite these efforts; the Audit Report number AV–2014–061 of the Office of Inspector General, issued on June 26, 2014 says it all in its title – **FAA Faces Significant Barriers to Safely Integrate Unmanned Aircraft Systems into the National Airspace System.**[15]

Aircraft Systems[12], to establish an interim policy that bridges the gap between the current state and NAS operations.

Section 333, provides flexibility for authorizing safe civil operations in the NAS by granting the Secretary of Transportation the authority to determine whether airworthiness certification is required for a UAS to operate in the NAS.

Australia

In his paper – **UAS Regulatory Developments**[16], James Coyne of Civil Aviation Safety Authority (CASA) says, […] 'CASA commenced the development of regulations pertaining to the operational use of UAS in 2000, which resulted in the publication of **Civil Aviation Safety Regulation (CASR) Part 101, Unmanned Aircraft and Rocket Operations in 2002**[17]. These regulations provide the framework under which all classes of UAS can be operated in Australian airspace. The regulations are supported by **Advisory Circular (AC) 101-1 - Unmanned Aerial Vehicle Operations, Design Specification, Maintenance and Training of Human Resources**[18].' […]

CASR Subpart 101.F – UAVs

Division 101.F.1- General
Subpart 101.F - UAVs

101.235 - (1) This Subpart applies to:
(a) the operation of a large UAV; and
(b) the operation of a small UAV for purposes other than sport or recreation.

101.240 Definitions in this Subpart:

Approved area means an area approved under regulation 101.030 as an area for the operation of UAVs

Certified UAV controller means a person certified under Division 101.F.3 as a controller of UAVs

Controller of a UAV means a person who performs a function that would be, if the UAV were a manned aircraft, a function of its flight crew

Large UAV means any of the following:
(a) an unmanned airship with an envelope capacity greater than 100 cubic meters
(b) an unmanned powered parachute with a launch mass greater than 150 kilograms
(c) an unmanned aeroplane with a launch mass greater than 150 kilograms
(d) an unmanned rotorcraft with a launch mass greater than 100 kilograms
(e) an unmanned powered lift device with a launch mass greater than 100 kilograms

Micro UAV means a UAV with a gross weight of 100 grams or less

Small UAV means a UAV that is neither a large UAV nor a micro UAV

UAV means unmanned aircraft, other than a balloon or a kite

Division 101.F.2 - Operation of UAVs generally

101.245 Operation near people - (1) Subject to subregulations (2) and (3), a person must not operate a UAV within 30 meters of a person who is not directly associated with the operation of the UAV. […]

101.250 Where small UAVs may be operated - (1) A person may operate a small UAV outside an approved area only if: (a) where the UAV is operated above 400 feet AGL, the operator has CASA's approval to do so; and (b) the UAV stays clear of populous areas. […]

101.255 Large UAVs - requirement for certificate - (1) A person may operate a large UAV only if either a special certificate of airworthiness (restricted category), or an experimental certificate, has been issued for it under Subpart 21.H of Part 21. […]

101.270 Requirement for UAV operator's certificate - (1) A person may operate a UAV for hire or reward only if the person holds a UAV operator's certificate that authorizes the person to operate the UAV. […]

101.275 Approval of operation of large UAVs - (1) A person may operate a large UAV only with CASA's approval. […]

101.280 UAVs not to be operated over populous areas - […] (2) A person must not operate a UAV that is not a certificated UAV (a UAV for which a certificate of airworthiness has been issued) over a populous area at a height less than the height from which, if

Drone 'near miss' with passenger plane close to Heathrow airport investigated

A near–miss report investigating how a drone was able to come within feet of a passenger jet as it prepared to land at Heathrow Airport, has concluded there had been "a serious risk of collision."

As the model helicopter was so small, it did not appear on the aircraft's radar, the pilot said. Luckily, the object did not strike the plane and the pilot was able to make a normal landing.

However, the report warned that the object had distracted the pilot during a critical phase of the flight.

Earlier this year the British Airline Pilots' Association (BALPA) demanded better protection for the public from the risks of drones. It wants drones, officially known as RPAS, which share airspace with passenger and freight airliners, to meet the same safety standards as piloted aircraft. It includes being flown only by operators with pilot–equivalent training.

In October, Birmingham University warned the use of drones in the UK would rise over the next 20 years, which in turn raised "significant safety, security, and privacy concerns".

www.theguardian.com and *www.independent.co.uk* any of its components fails, it would be able to clear the area. […]

Division 101.F.3 - Certification of UAV controllers

Division 101.F.4 - Certification of UAV operators

In his presentation, **Development of UAS in civil airspace and challenges for CASA**[19], in February 2013 the Director of Aviation Safety, John McCormick said, '[…] approximately 90 percent of the RPAs operating in Australia today are less than 7 Kgs […] due to increasing number and their varied capabilities, it is impossible for CASA to effectively regulate all of them. We have to address the current reality. There is no point in CASA writing regulations that can't be enforced. That's just bad law. […]'

'[…] The current CASR Part 101 deals with unmanned aircraft, model aircraft and rockets. As a result of rapid growth and technological advancements in this industry, this regulation has become somewhat ineffective and needs amendment. […] The principal objective of a fresh aviation regulatory framework is to achieve and maintain the highest possible uniform level of safety. […] Identifying the commonalities and differences between manned and unmanned aircraft is the first step toward developing a regulatory framework that will provide, at a minimum, an equivalent level of safety for the integration of RPA into non-segregated airspace and at aerodromes […].'

Canada

In Canada, unmanned aircraft are considered as aircraft under the **Aeronautics Act**[20] and are governed by the **Canadian Aviation Regulations (CARs)**[21], which require anyone conducting UAS operations to obtain and comply with the provisions of a **Special Flight Operations Certificate (SFOC)**[22].

In 2010, the **Canadian Aviation Regulation Advisory Council (CARAC)**[23] established the Unmanned Aircraft System Program Design Working Group. The purpose of the group is to make recommendations for amendments to current aviation regulations as well as introduce new regulations and standards for the safe integration of routine UAS operations in Canadian airspace in four phases. The group presented its **Phase 1 Final Report**[24] in March 2012.

Flying an Unmanned Aircraft in Canada

More and more people in Canada are using unmanned aircraft for work or pleasure and Transport Canada regulates their use to keep the public and airspace safe. **Do's and Don'ts of Flying an Unmanned Aircraft**[25]

Do

- Only fly your UAV during daylight and in good weather
- Always be able to see your UAV with your own eyes
- Make sure your UAV is safe for flight before take-off
- Know if you need permission to fly
- Respect the privacy of others

Don't fly:

- Closer than 9 km from any airport, heliport, or aerodrome
- Higher than 90 meters from above the ground
- Closer than 150 meters from people, animals, buildings, structures, or vehicles
- In populated areas or near large groups of people, including sporting events, concerts, festivals, and firework shows
- Near moving vehicles, avoid highways, bridges, busy streets or anywhere you could endanger or distract drivers
- Within restricted airspace, including near or over military bases, prisons, and forest fires
- Anywhere you may interfere with first responders

Permission and Safety Requirements[26]

To fly your unmanned aircraft legally, you may need to follow strict safety conditions outlined in an exemption or apply for permission from Transport Canada. It depends on the type of aircraft, its weight, as well as how and where you plan to use it.

If your aircraft:

- Weighs 35 kg or more, you need to apply for a SFOC before you can use it.
- Weighs less than 35 kg and is used for recreational purposes, you don't need permission to fly.

Unmanned aircraft that weigh less than 25 kg may qualify for an exemption to the rules, which will allow you to fly without permission.

If your aircraft:

- Weighs 2 kg or less and you can meet the safety conditions in the Transport Canada exemption for UAVs that weigh less than 2 kg or less, you don't need to request permission to fly.
- Weighs between 2.1 kg and 25 kg and you can meet the safety conditions in the Transport Canada exemption for UAVs that weigh between 2.1 kg and 25 kg; you don't need to request permission to fly. However, you must notify Transport Canada by completing the submission form.

Transport Canada simplifies rules for UAS

Transport Canada announced at the Unmanned Systems Canada conference in Montréal, two exemptions that simplify small UAV operations and safely integrate UAVs into Canadian airspace. Under the new exemptions, a Special Flight Operations Certificate will not be required for UAVs under 2 kilograms and certain operations involving UAVs under 25 kilograms. The new approach will apply to commercial operations and contribute to a strong safety regime for those on the ground and in the skies.

In October, Canada's national safety awareness campaign for UAVs, which aims to help Canadians better understand the risks and responsibilities of flying UAVs was launched.

www.uasvision.com

If you cannot or choose not to meet the safety conditions in the UAV exemptions, you must apply for a SFOC.

United Kingdom

Depending on the design and mass of an unmanned aircraft and the activity for which it will be used, it may be necessary to apply for permission from the Civil Aviation Authority (CAA) before commencing any flight.

Permission for a UAS

You must request permission from the CAA if you plan to fly the aircraft on a commercial basis or fly a camera/ surveillance fitted aircraft within congested areas or closer to people or properties that are not under your control

Permission is not required if the aircraft will not be flown close to people or properties, and you will not get 'valuable consideration' (i.e. payment) from the flight.

Permission is also not required for 'practice' or demonstration flights.

CAP 722, Unmanned Aircraft System Operations in UK Airspace – Guidance

Overall, the purpose of **CAP 722**[27] is to highlight the safety requirements that have to be met, in terms of airworthiness and operational standards, before a UAS is allowed to operate in the UK. It is a joint civil/military document, intended to draw together independent civil and military guidance so as to establish best practice for all UAS activities.

CAP 393, Air Navigation: The Order and the Regulations

The CAP 39328 amendment principally contains changes to the Air Navigation Order (ANO) arising from the European Aviation Safety Agency (EASA) Aircrew Regulation. In it, Article 166 includes specific regulations for small unmanned aircraft and Article 167 includes additional regulations for small unmanned aircraft that are 'equipped to undertake any form of surveillance or data acquisition'.

Unmanned aircraft with an operating mass of 20 kg or less are defined as 'Small Unmanned Aircraft' and according to Article 253 are exempt from the majority of the regulations that are normally applicable to manned aircraft.

Unmanned aircraft with an operating mass of more than 20 kg are subject to regulation as though they are manned aircraft.

India

Public Notice dated October 7, 2014 – Use of UAV/ UAS for Civil Applications[29]

[…] UAS has potential for large number of civil applications. However, its use besides being a safety issue, also poses security threat. The airspace over cities in India has high density of manned aircraft traffic. Due to lack of regulation, operating procedures/ standards and uncertainty of the technology, UAS poses threat for air collisions and accidents. The civil operation of UAS will require approval from the Air Navigation Service provider, defense, Ministry of Home Affairs, and other concerned security agencies, besides the Director General of Civil Aviation (DGCA).

DGCA is in the process of formulating the regulations (and globally harmonize those) for certification & operation for use of UAS in the Indian Civil Airspace. Till such regulations are issued, no non government agency, organization, or an individual will launch a UAS in Indian Civil Airspace for any purpose whatsoever.

The above is for strict compliance.

Some Other Countries

Excerpts from the National Aeronautics and Space Administration's (NASA) article, **Perspectives on Unmanned Aircraft Classification for Civil Airworthiness Standards**.[30]

'In the pursuit of enabling UAS to routinely access the NAS, much attention is being devoted worldwide to challenges of developing certification processes, regulation, and standards for UAS,

European Commission satisfied with current drone regulations

The European Commission (EU Commission) has released the results of two studies it had conducted which address key social impacts of the commercial use of drones.

The European market for civil drones (RPAS), the Commission's first study on privacy, data protection and ethical risks in civil RPAS operations, found the current European and member state regulatory frameworks are largely adequate to address the privacy, data protection and ethical impacts of RPAS. It further added that the problem lies in educating the RPAS industry about its obligations and enforcing the regulatory mechanisms that are in place.

The second study, which was on third–party liability and insurance requirements, investigated the current regulatory framework and insurance market, in order to assess whether they could ensure effective compensation of victims in case of an accident.

EU Commission concluded that there is no immediate need to adapt national liability regimes or the EU insurance regulation applying to professional use of RPAS. *www.europa.eu*

including those related to airworthiness. Many organizations have developed or are currently debating classification approaches for UAS airworthiness standards. Most notably, though, there is an absence of consensus on what those airworthiness standards should be and how they might apply across the diverse spectrum of UAS types.

This paper is not intended to propose answers to those questions, but instead to facilitate ongoing deliberations by providing insight into some of the relevant factors underlying classification of Conventionally Piloted Aircraft (CPA), and observations based on current approaches about the applicability of the current aircraft classification system and corresponding airworthiness standards to UAS.'

B.6. Israel

The Civil Aviation Authority of Israel (CAAI) is the regulator for the civil aviation sector, as part of Israel's Ministry of Transportation. […] The CAAI defines three - top level categories that should constitute the driving factor in defining the extent and level of requirements to be applied when granting approval to conduct UAV operations:

Category I: UAV operations that do not belong to either of the other two categories, i.e., conducted within confined airspace portions and above confined area (usually unpopulated).

Category II: UAV operations may be allowed with some operational restrictions with two practical subdivisions - Category IIa: Airspace restrictions but no specific restrictions in term of overflown areas and Category IIb: Airspace restrictions and flight above sparsely populated areas only.

Category III: UAV operations may be allowed with no specific operational restrictions (i.e., in non-segregated airspace and over populated areas).

B.7. France

[…] In April 2012, the Directorate General for Civil Aviation (DGAC) issued regulations concerning the design, use, and operators of UAS in France, which include a UAS classification approach that is related to airworthiness. In the regulations, UAS are primarily separated between model aircraft and RPA, and they are then further subdivided by weight, operation, and in the case of model aircraft, by propulsion system. The DGAC defines model aircraft to include the requirement that it remain permanently within direct visual range of the remote pilot. […] France is also a member of EASA and aircraft greater than 150 kg fall under the purview of EASA.

B.8. Japan

Use of UAS for civil applications is governed by two different organizations in Japan: the Japan Agricultural Aviation Association (JAAA) and the Japan UAV Association (JUAV). The JAAA, which is part of the Ministry of Agriculture, Forestry and Fisheries, addresses the safe construction and operation of UAS for agricultural applications, since the bulk of UAS operations in Japan are for agricultural purposes, which entail flying over uninhabited fields with line-of-site operations. The JUAV Association is a private industry consortium of sixteen companies and was set up to expand Japan's UAS industry and to develop standards for the safe use of UAS in non-agricultural applications. The Japanese Civil Aviation Bureau, which is a part of the Ministry of Land, Infrastructure, Transport and Tourism, does not address UAS issues.

B.10. Malaysia

The Malaysian Department of Civil Aviation (DCA) issued an Aeronautical Information Circular (AIC) titled, 'Unmanned Aerial Vehicle Operations in Malaysian Airspace', to provide guidance to civil-use UAS operators in the form of Civil Aviation Regulations. In particular, this AIC version states that civil-use UAS above 20 kg shall be required to have a certificate of airworthiness.

B.16. Switzerland

Switzerland integrated its civil and military airspace in 2001. The Swiss regulatory efforts on UAS appear to largely involve a few key organizations, both private and public. The most prominent organizations include the Swiss Federal Office of Civil Aviation (FOCA), Skyguide, and Aerosuisse. Currently, the Swiss regulations address UAS operational certification on a weight basis, with a 30 kg breakpoint. In particular, UAS above 30 kg must seek specific approval for operation in the Swiss national airspace, and UAS below 30 kg do not require authorization to operate.

International Effort

The **Unmanned Aircraft Systems Study Group (UASSG)**[31] was established by the Air Navigation Commission (ANC) in November 2007 with the following terms of reference – 'In light of rapid technological advances, to assist the Secretariat in coordinating a framework for regulatory development as well as in guiding the SARPs development process within ICAO, for civil UAS, and to support a safe, secure and efficient integration of UAS into non-segregated airspace and aerodromes.'

It's members are: Australia, Austria, Brazil, Canada, China, Czech Republic, France, Germany, Italy, Netherlands, New Zealand, Norway, Russian Federation, Singapore, South Africa, Sweden, UK, US, Civil Air Navigation Services Organization (CANSO), EASA, European Organization for Civil Aviation Equipment (EUROCAE), EUROCONTROL, International Council of Aircraft Owner and Pilot Associations (IAOPA), International Coordinating Council of Aerospace Industries Associations (ICCAIA), International Federation of Air Line Pilots' Associations (IFALPA), International Federation of Air Traffic Controllers' Associations (IFATCA), North Atlantic Treaty Organization (NATO), Radio Technical Commission for Aeronautics (RTCA), UVS International.

Endnotes

1 Note: Some material has been taken verbatim.
2 http://www.icao.int/publications/Documents/7300_orig.pdf
3 http://www.icao.int/Meetings/anconf12/Document%20Archive/9854_cons_en%5B1%5D.pdf
4 http://www.icao.int/Meetings/UAS/Documents/Circular%20328_en.pdf
5 http://jarus-rpas.org/phocadownloadpap/6_Official-Publications/JARUS-C2-link-RCP-concept-Ed-1-00.pdf
6 http://www.icao.int/APAC/Meetings/2014%20RPGWRC15/SP03_NLD-G.%20Osinga_FSS%20allocations%20for%20unnamed%20aircraft.pdf
7 http://www.icao.int/NACC/Documents/eDOCS/FS/FS-ATM-Flyer_US-Letter_ANB-RPAS_2013-08-26.pdf
8 www.icao.int/sustainability/pages/GANP.aspx
9 http://www.gpo.gov/fdsys/pkg/CRPT-112hrpt381/pdf/CRPT-112hrpt381.pdf
10 http://www.faa.gov/about/office_org/headquarters_offices/agi/reports/media/uas_comprehensive_plan.pdf
11 http://www.faa.gov/uas/media/uas_roadmap_2013.pdf
12 http://www.faa.gov/uas/legislative_programs/section_333/how_to_file_a_petition/media/section333_public_guidance.pdf
13 http://www.faa.gov/uas/media/Order_Selecting_Six_UAS_Test_Sites.pdf
14 http://www.faa.gov/about/office_org/headquarters_offices/ang/offices/management/coe/media/pdf/CoE_UAS_safety.pdf
15 https://www.oig.dot.gov/sites/default/files/FAA%20Oversight%20of%20Unmanned%20Aircraft%20Systems%5E6-26-14.pdf
16 http://www.icao.int/Meetings/UAS/Documents/Coyne-James_CASA_Australia_WP.pdf
17 http://www.comlaw.gov.au/Details/F2014C01095/Html/Volume_3#_Toc399250893
18 http://www.casa.gov.au/wcmswr/_assets/main/rules/1998casr/101/101c01.pdf
19 http://www.casa.gov.au/Scripts/nc.dll?WCMS:STANDARD::pc=PC_101374
20 http://www.tc.gc.ca/eng/acts-regulations/acts-1985ca-2.htm
21 http://www.tc.gc.ca/eng/acts-regulations/regulations-sor96-433.htm
22 https://www.tc.gc.ca/eng/civilaviation/regserv/cars/part6-standards-623d2-2450.htm
23 https://www.tc.gc.ca/eng/civilaviation/regserv/affairs-carac-menu-755.htm
24 http://www.h-a-c.ca/UAV_REPORT.pdf
25 http://www.tc.gc.ca/media/documents/ca-standards/Infographic_UAV_safety_tips_English.pdf
26 http://www.tc.gc.ca/media/documents/ca-standards/Infographic_Permission_to_fly_a_UAV_Print_English.pdf
27 http://www.caa.co.uk/docs/33/CAP722.pdf
28 http://www.caa.co.uk/docs/33/CAP%20393%20June%202014.pdf
29 http://dgca.nic.in/public_notice/PN_UAS.pdf
30 http://shemesh.larc.nasa.gov/people/jmm/NASA-TM-2013-217969.pdf
31 http://www.icao.int/ESAF/Documents/APIRG/APIRG16/Docs/apirg16ip15_en.pdf

- Compiled by Shubhra Kingdang

UAV system with terrestrial geo-referencing for small area mapping

This paper describes the first stage of our research to develop small land parcels mapping distributed evenly by combining an Unmanned Vehicle Aerial Mapping using UAV and terrestrial method, where the terrestrial method is used to geo-reference photograph directly

Hendriatiningsih SADIKIN
Associate Professor, Institute of Technology of Bandung and Head of Surveying and Cadastre Research Division, Faculty of Earth Sciences and Technology, Institute of Technology of Bandung, Indonesia

Asep Yusup SAPTARI
Academic Assistant, Surveying and Cadastre Research Division, Faculty of Earth Sciences and Technology, Institute Technology of Bandung, Indonesia

Rizki ABDULHARIS
Ph.D candidate on Spatial Planning in Developing Countries at Technische Universität Dortmund

Andri HERNANDI
Academic Assistant, Surveying and Cadastre Research Division, Faculty of Earth Sciences and Technology, Institute of Technology of Bandung, Indonesia

UAVs in this study is a system which is divided into two sub-systems that are attached to the vehicle itself consisting of a camera, navigation instruments, etc. The second sub-system is a system on land that is composed of digital terrestrial measuring devices. To support the implementation of the study, one should design an instrument/vehicle appropriate to the research requirement. Thus, it allows modification in the design of an instrument in accordance with the required specifications.

In the mapping technology, the UAV has provided several options to meet the need for the provision of data, especially the data on parcels. Tendency to derive data from all environmental conditions in 'economical', 'up to date', manner and accuracy that meets the mapping standards is the base of this research. This tendency can be used for accurate, complete observation and control over of land ownership status or plots in rural areas and small parcels in the area that lie scattered. Development of UAV technology design aims to make the technology more adaptive with low cost and use of the instrument as a carrier vehicle for the camera in aerial photography by combining traditional photogrammetric technology. So far, the massive land parcels mapping are common with high-resolution satellite imagery (Quickbird, Geoeye, World View) and in certain areas, aerial photography is utilized. But the method is constrained by the high price of the image (if it is related to the size of the area mapped). The time for ordering images is constrained by several factors - one of the most common obstacles is cloud cover conditions, followed by regulations on the purchase of the image.

The UAV capabilities in overcoming deficiencies of imaging using the satellite imagery are an excess of UAV technology in mapping parcels. However, the main disadvantage in the use of UAVs is lying in the resultant geometric precision of photograph/image, as it is associated with unstable camera carrying vehicle/aircraft.

Modification of existing method will be carried out to solve these problems, which is an objective in this research generally.

Background

The rapid growth of population led to the requirement for land for developing more residences or parcels, resulting in the change in data on land use, both spatial and attribute, in the land administrative system. The phenomenon suggests the importance of the information on dynamic land ownership along with changes in the population in relation to treatment of land/parcels. Relationship with these changes spawned the need for a system that can record data in an accurate manner in defining land status. Such changes lead to transformations of land spatial and textual database, including data on control, ownership, use, and land utilization. To address these problems, one of the measures is to take fast, modern, systematic and complete construction of base map and thematic map covering basic geographic element data, facility/important places and governance possession, use and utilization of land on a large scale.

In his research, Cunningham, K. (2011) found that the quality of the cadastral survey is directly related to population density and variety for each village, so often found in some of the villages with no cadastral maps that meet the standards of cadastral maps. The existence of the cadastral map for each village with diverse characteristics of population and topography is a challenge to seek a method in the provision of cadastral maps in every village in the region of NKRI. Another problem is the challenge to be able to map the parcels accurately in a small area, and between the parcel and the others is not adjacent/distant/ within a single stretch of one another.

The main problem in spatial land database updating is the availability of a map with a resolution and accuracy that meets the specifications of land maps. Regulation of the State Minister of Agrarian Affairs/Head of National Land Agency Number 3/1997 on the Implementation of the Provisions of Government Regulation No. 24/1997 on Land Registration in Article 13 stipulates that the basic map of registration is made on scale 1:1,000 or greater for residential areas, 1:2.500 or greater for agricultural areas and 1:10.000 for large plantation areas. Thus, the necessary imagery with a resolution greater than 0.5 meters for residential areas, for agriculture is greater than 1.25 meters and 5 meters for plantations, or it can be concluded that to map the parcels that have high-resolution imagery.

To obtain high-resolution images that are costly (if it is related to the mapped area of parcels), the time for procurement is over 2 months (if not more) and are often constrained by cloud cover. So the approach of photogrammetry (using manned aircraft) can be an option, but expensive aircraft lease and the requirements to fly a plane as a vehicle carrying the camera is an economically ineffective method, especially when the area coverage will be mapped is small (<1,000 ha) and when the parcels being mapped lie scattered far apart from one another.

Another problem commonly encountered with regard to the topographic characteristics is that in several regions of Indonesia there are distinctive challenges in terms of both topographic mapping accessibility and implementation of mapping. The mapping by terrestrial or direct observation in the field has been recognized for precision that meets the technical mapping specifications. However, constraints of accessibility, weather and the extent of the area surveyed by such methods are rarely used in areas with characteristics of undulated topography and difficult accessibility. These situations led us to modify some surveying techniques to meet the necessity of land parcels map.

Objective

Based on the description in the background section, the objective of this research is ‘Improving Land Parcels Mapping Method by Integrating UAV System with Terrestrial Direct Georeference System’.

To achieve the objective, innovative methods were used to provide spatial data by combining the low cost photogrammetric method using Unmanned Aerial Vehicle (UAV), with a terrestrial method that has high accuracy as control point on the ground. Given the research, innovation will result in the method of mapping parcels with the following advantages:

1. Can be used on topography with high risk and hard accessibility.
2. Can be used to map small parcels and some scattered parcels located far apart from each other.
3. Have high temporal and spatial accuracy.
4. At low cost.

Table 1. Pro and cons of the different type of UAVs (0: Lowest value; +: Middle value; ++: Best) (Eisenbeiss, 2010)

Types of Vehicle	Range	Endurance	Weather Wind Dependency	Manuver ability	Payload Capaciti
Balloon	0	++	0	0	+
Airship	++	++	0	+	++
Gliders/Kites	+	0	0	0	0
Fixed Wing Glider	++	+	+	+	+
Propeller & Jet Engines	++	++	+	+	++
Rotor-Kite	++	+	0	+	+
Single Rotor (Heli)	+	+	+	++	+
Coaxial	+	++	+	++	++
Quadrotors	0	0	0	++	0
Multi-Copters	+	+	+	++	+

Methodology

In general, the availability of an aerial photo map for the purpose of making a land parcels map in Indonesia is still far from completion. Satellite imagery is often used to identify parcels boundary with level of resolution, and the accuracy is not as it is expected. In addition to not meeting the resolution for the creation of land maps, the parcels to be mapped often are found in areas that are difficult to map even by remote sensing methods as a result of cloud cover or the degree of openness of the land which makes it difficult to be mapped directly in the field. Photogrammetric methods in either large, medium or small formats are generally plagued with problems of availability of aircraft, licensing in photography, dense cloud cover that requires the aircraft to fly quite low, cost in photography, etc. Thus for small acreage, this method assessed is not effective. We therefore need a method to map parcels that can overcome these problems, and one of the methods that will be used in this research is the method of unmanned aerial mapping, also known as Unmanned Aerial Vehicle (UAV).

UAV Vehicle Design

There are several unmanned vehicle designs to be considered in the mapping of plots, as shown in Table 1. At the beginning of this study, we plan to use fixed-wing aircraft. However, after the examination of the signal response capability on the total station instrument was complete, we then used quadrotors.

We planned to use fixed wing gliders UAV with consideration to overcome the problems of payload capacity limitation and wind factor, that are becoming a major problem in maintaining vehicle stability when aerial photographs are taken, as shown in Table 1. However, to find out more definitely

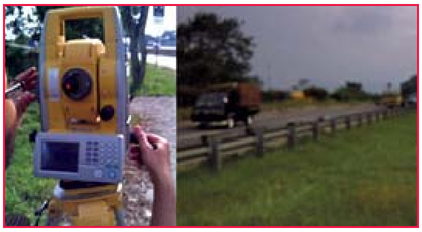


Figure 1: Measure TS capacity in determining the position of moving objects.

Figure 2: a) quadrotor type X650 b) type X450 c) Q 800

the type of aircraft that is appropriate to this research, we first conducted a study of aircraft designs to determine which vehicle type was adaptable with the total station (TS) instrument capabilities that will be used to determine the position of the camera. This study used non-reflector total station's top con GPT 3500 and GPT 7500.

To understand the tracking rate of total station instrument in determining moving objects, we make a simulation measurement with moving cars with different speeds as the targets. In order to obtain position data/ coordinates of target of various speed, we carried observation around the freeway which allow cars to move with speed until 100 km/hr. From the observation, we found that for a car with speed of about 40 km/ hr with a distance of 112 meters to the car, TS need 11 seconds to process the signal; meanwhile for cars at faster speeds, a longer processing time is necessary. The most suitable vehicle for this research is the vehicle with the ability to fly at speeds below 40 km/h and yet be stable. This specification cannot be achieved using fixed-wing aircraft/fixed wing. As a solution, we have to consider an alternate design and UAV of quadrator type equipped with navigation system and auto pilot. To design this type of aircraft, the team collaborates with PT. Terrascan. There were three quadrotor designs prepared in this study: type X650, X450 and type Q800.

The vehicle should be designed in such a way that makes it able to support time synchronization process between the time for photo capturing by onboard camera with the distance and direction angle measurement time by total station on the ground. Three options offered in order time synchronization:

1. Set the time/timer on camera for the initial photo taken and interval of photo taken.
2. Equipe UAV with LED lights system that will flash on when the camera take the picture.
3. The aircraft can support the aerial photography in 'Stop and Go'.

The third option cannot be realized by fixed wing UAV. The main advantage of quadrotor design makes it possible to fly and take photos at very slow speeds <40 km/hour, even stop over an area of interest as required or photograph when motionless and continue flying, in contrast with fixed winged aircraft. Nevertheless, beside those advantages, quadrotor type has some major drawbacks in payload and endurance, specially in battery capacity. For this case, we have to be more careful in monitoring the battery capacity and load. In this study, we use Lippo 2200 mAh 3 cellular battery with the respective lifetime of 5 minutes each.

The quadrotor type X650 body design consists of a metal frame the makes it more easy to reflect waves emitted by a total station, making it faster to get the vehicle position than type X450 whose vehicle body is made of melamine. Having a melamine material body, longer time is necessary to get the vehicle position data when type X450 is used. But in terms of flight stability, X450 is more stable than X650. UAV operator can maintain X450 position in a point for some minutes to help surveyor on the ground track it easily and take its coordinates. For those reasons, we redesigned aircraft type X450 body

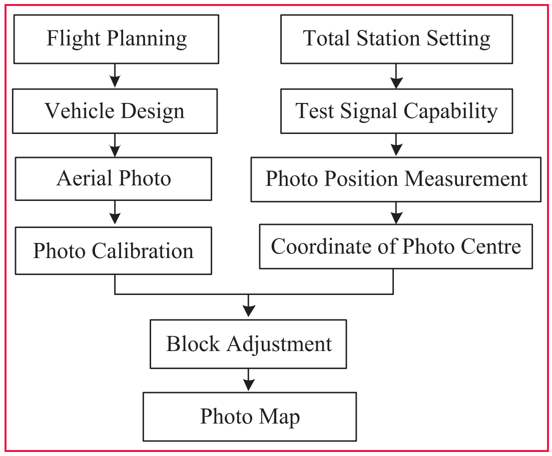


Figure 3: The methodology of research

with aluminum foil coated to reflect total stations wave better in the next research.

Measurement of Photograph Position

In general, the methodology to be used in this study is illustrated in Figure 3.

The measurement begins with study on vehicle construction design to be used for photography and the digital camera used is a regular digital pocket camera, such as canon 100s onboard in vehicle body. The UAV is also equiped with GPS navigation to monitor UAV system status and its position during flight, specially to direct the vehicle to some interest target/ land parcel. Camera position was measured using a non-reflector total station instrument GPT 7500 or GPT 3500, installed just above the ground control points of known coordinates as reference, so that by knowing the distance and angle to the camera, the camera's coordinates can be determined using polar coordinate and trigonometric system.

Basically, the land parcel photography using UAV is photogrammetric method where the photography is carried out using digital camera attached to the vehicle, but the vehicle used is a small unmanned aircraft managed by a remote control. The relationship between the aircraft and the total station is depicted in figure 4. The combination of polar and trigonometric method in photo coordinates determination are the key in this method.

As illustrated in figure 4, α is the measured horizontal angle of UAV/ camera from

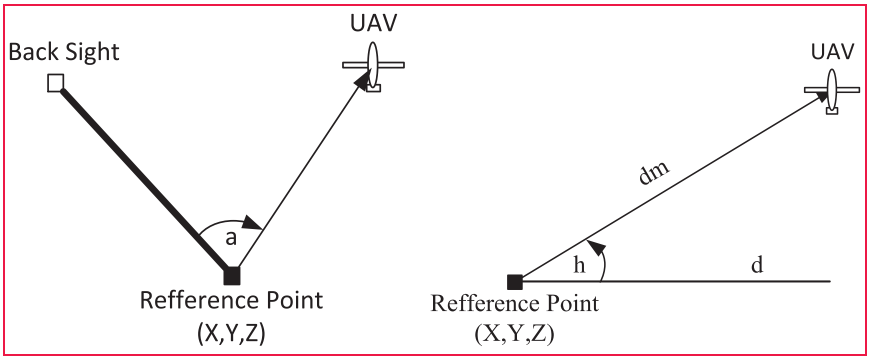


Figure 4: Measurement of UAV Position

Figure 5: Measurement of vehicle position using Total Station

Figure 6: The reference point

back sight point. In the same time, total station performs trigonometric method with measuring vertical angle (h), slope distance (dm) and horizontal distance (d), and process all simultaneously to produce coordinates (x, y and z) of the photograph.

Although the UAV can be managed up to the range > 20 km, the length of strip in one photo session is limited by the range of total station. For example, the maximum range of the total station Topcon of GPT 3500 Type to its target is ± 2000 m, so UAV can't be further than 2.000 m from the total station. The limitation of total station range is a major consideration in the photography flight planning, so this method is only suitable for a small area and plane topography (up to this research).

The UAV is an unmanned aircraft controlled remotely by using a remote control in crossing over the area to be mapped so that the entire area is covered. The camera used consists of many types and brands likes Canon S100 and GoPro; even almost all pocket cameras can be used as imaging sensors, while to obtain high-resolution level can be offset by vehicles flying high. Problems that commonly persist in using the camera mounted on a UAV is regarded to geometric accuracy of images produced. This is due to the slant position of the camera at the time of photography caused by wind; stronger the wind the bigger slant angle, so that when the resulting image is directly used to develop a mosaic photo, it will not meet the accuracy standards of map scale of 1:1,000. To reduce the effects of these problems, the camera was equipped with a gyro system to compensate tolerable slant angle.

Position of camera/vehicle is tied to the known ground control points/ reference points around the location of the research. The reference points named P1 with coordinate (0806171; 9233373) in UTM systems and backsight point P2 (0806196; 9233391) selected as control points and conjugate backsight or in other case, local coordinate system are applicable too.

Another issue of this research is related to the measured target. The UAV is designed in various lengths according to the requirement or observation objective; the question is which part of the vehicle should be targeted from the ground to be considered as camera centre, since it is difficult to exactly center the target to the

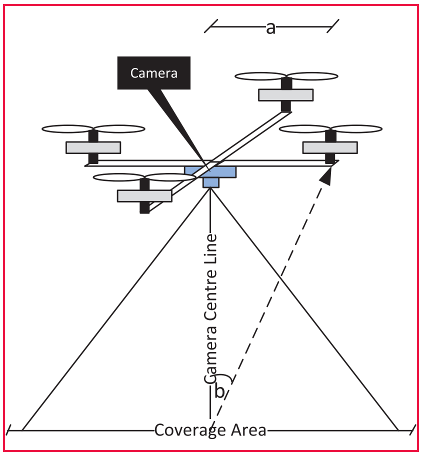


Figure 7: Direction of the shot at the target

camera. Should it be in the right position of camera or anywhere across the vehicle body assuming that target deviation from camera center can be tolerated. This situation can be described as in figure 7.

When total station shots slip from the camera central with deviation angle (β), where the picture scale lies in comparison between focus camera (f) with flying height (h) and the magnitude of the error due to slipping of the photograph by the total station in photo image is (b), then relation between target deviation (a) and (b), can be described as:

$$b = \frac{f}{h} x\ a$$

From the above equation it can be concluded that the target in the area of the vehicle body can be assumed to coincide with the center of camera, if we consider airframe size <2 m (l m to the left and right sides), the deviation from the camera center on the image can be considered coincident, so the surveyor can shoot any location on the body of the UAV to measure camera position.

The problems that may arise in the determination of the distance and angle of each photo image is synchronization between photo taken occurrence/ exposure with distance and angle data retrieval by total station. So it is necessary to consider the UAV design and planning specifically related to the implementation of the photo shoot time by arranging the photographic interval timer in the camera and use a beam signaling LED (Light-emitting diode Emitting) as a cue for surveyors to retrieve the distance and angle data of the

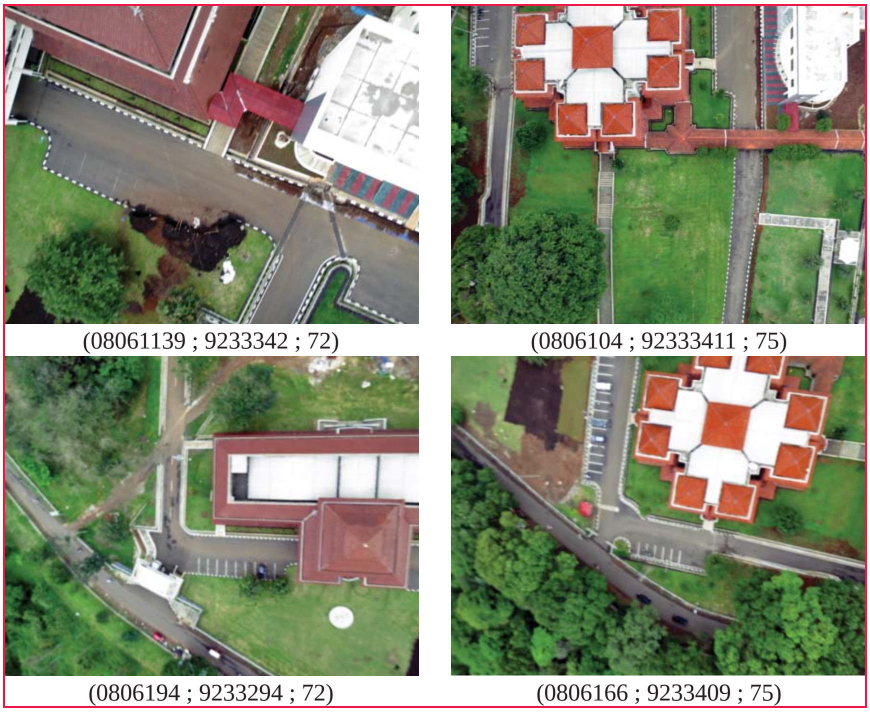


Figure 8: Coordinates of photo centre

Figure 9: Land parcels image

camera position on the ground. Similarly, the design of control point distribution must accommodate the relationship among land parcels to be mapped, total station capability and design and nature of UAV. Some examples of aerial photos with its x, y coordinate and z (flying height + instrument height) are listed in figure 8.

Pictures recorded still contain distortions in which the circular-shaped pictures/ arched as the effect of the lens. For photogrammetric processing stages, each photograph is calibrated beforehand so that the data has the flat form. The post process of each photograph is presented in the form of a mosaic image as in figure 9.

Control Point Design

Control points tied up photograph to coordinate system on Earth, so that the process of reconstruction of the photo of the vehicle UAV will greatly depend on the quality and the distribution of these control points. In this study, selected control points must be close to the parcels that must be mapped. In order to distribute it in the correct manner, control points location must cover parcel boundaries located in a stable place during measurement, total station range must be considered compared to UAV and for this research, we still avoid undulated topography. In addition to the small area being measured, it is possible to use the terrestrial method in ground control points position measurements.

Conclusion

The UAV technology can be used to map a small area economically, but the quality of the resulting map is always constrained by the geometric accuracy problems as a result of the instability of the vehicle while taking the photos, so aerial photography mapping method using the usual UAV cannot be used to create an accurate map. To overcome these problems, we try to modify mapping methodology, which in this research, is done by integrating vehicle UAV systems photogrammetry with terrestrial systems.

The initial phase should be done is to conduct a study about vehicle design which accomodates the characteristic of total station to determine camera position accurately, a vehicle must be able to stop during a flight, and continue flying smoothly, be stable against wind thrust and the outer body material should be made from perfect reflectors like metal. These specifications facilitate observers on land to get the reflection waves perfectly which is then converted onto slope distance, vertical angle, and the coordinates x, y, z of camera at the end.

The deviation between camera centre and shooting target on UAV body can be ignored, so we can assume that coordinate resulted coincide with coordinate of the photo centre.

Refference

Akhtman, Y. dkk. 2011, MAV-Based Real Time Localization Of Terrestrial targets With Cm Level Accuracy, *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vol. XXXVIII-1/C22.

Blaha, M. dkk. 2011, Direct Georefferencing Of UAVS, *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vol. XXXVIII-1/C22.

Cunningham, K. dkk. 2011, Cadastral Audit and Assesments Using Unmanned Aerial Systems, *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vol. XXXVIII-1/C22.

Eisenbeis, H. 2011, The Potential Of Unmaned Aero Vehicle For Mapping.

Stoter, J. dan Oosterom P.V. (2006), 3D Cadastre In An International

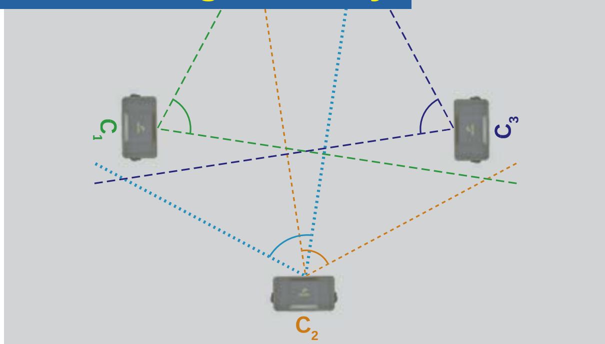
The paper was presented at FIG Congress 2014, Kuala Lumpur, Malaysia, 16-21 June 2014.

In the Issue:

BLM Report

*See BLM test report on TRIUMPH-LS at **www.javad.com***

New Photogrammetry



Get about 2 cm accuracy with TRIUMPH-LS internal camera in offset survey.

Angle Measurement

Quickly measure angles with TRIUMPH-LS internal camera by pixel processing to about 10 angular minutes.

VB-RTK

BREAKING NEWS

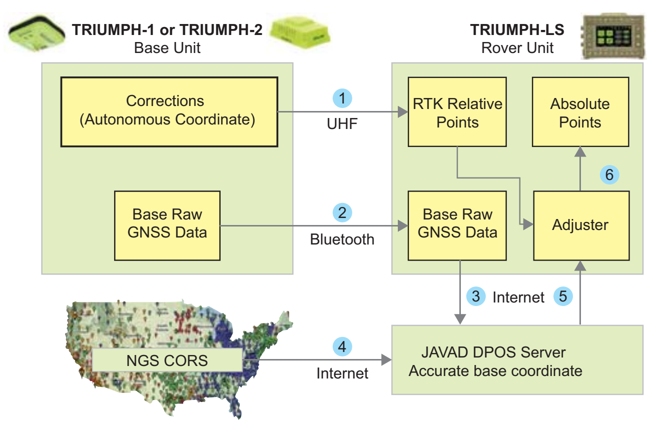
RTK productivity improves when the base station is close to the rover. In technical terms, searching for “integer ambiguity” and having a correct “fixed solution” becomes much more reliable, faster and more accurate, especially in more difficult areas with foliage, multipath, and obstructed satellites.

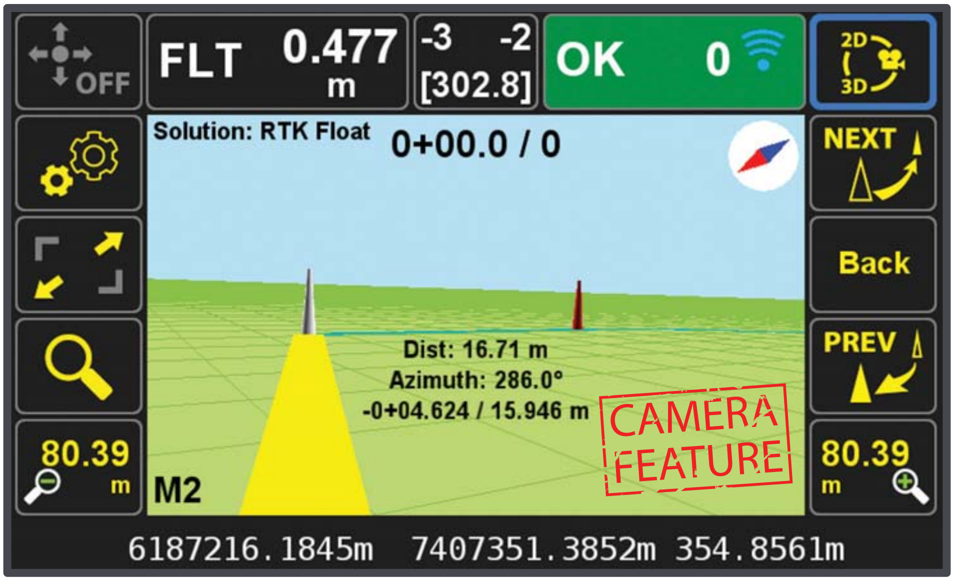
RTN and VRS systems provide a “virtual” base station near you, but this does not mean that the “virtual” base station is a “real” base station that eliminates the integer ambiguity problem. The difficulties of obtaining a fixed solution is still related to the nearest actual base station to your location.

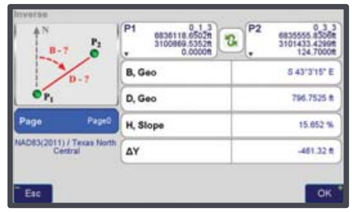
There are two problems with depending on your own base station near your rover working area. The following are explanations of both and solutions:

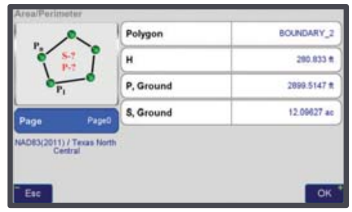
First is the financial investment in an additional receiver. In fact, having a separate base station can be less costly, because it eliminates the need to pay for RTN services and communication costs. JAVAD GNSS offers a complete base/rover system (including J-Field, our state of the art controller software) for around $20K. In addition, the system includes “Base/Rover Setup” which can be used to painlessly configure the base and rover in about one minute. Another financial benefit is that productivity increases and more points per hour can be gathered: get a fixed solution and collect a point in seconds rather than minutes, particularly in difficult areas. Also, it eliminates the need to re-observe a point.

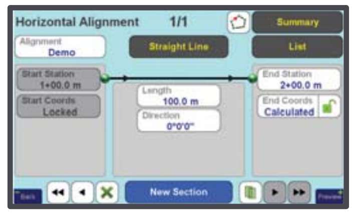
Continued on the last page...









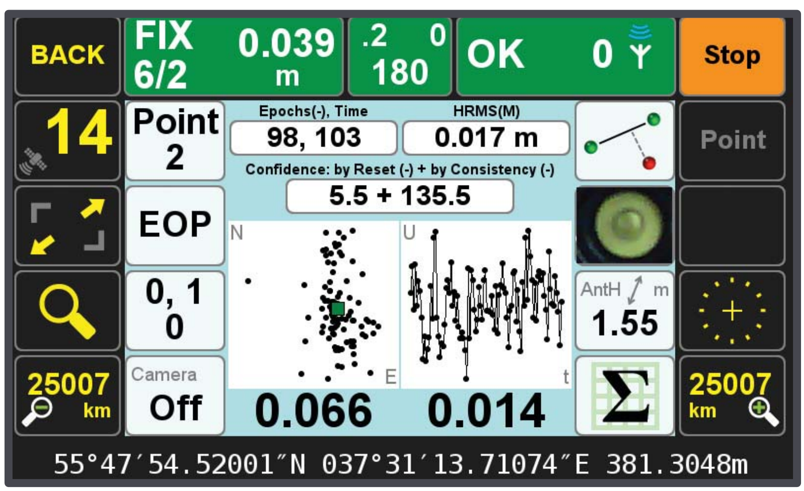


Store and Stake

Introducing GUIDE data collection in the TRIUMPH-LS. Visual Stake-out, navigation, six parallel RTK engines, over 3,000 coordinate conversions, advanced CoGo features, rich attribute tagging on a high resolution, large, bright 800x480 pixel display.
Versatile attribute tagging, feature coding and automatic photo and voice documentation.
The TRIUMPH-LS automatically updates all firmware when connected to a Wi-Fi internet connection.

View and Document your level

The downward camera of TRIUMPH-LS scans and finds the liquid bubble level mounted on the pole. Then focuses on the circular bubble automatically and shows its image on one of the eight white buttons of the Action Screen. You can:
• View the liquid bubble level on the screen.
• Document survey details including the leveling by taking automatic screen shots of the Action Screen, as shown here.
• Calibrate the electronic level of TRIUMPH-LS with the liquid bubble level for use in Lift and Tilt and automatic tilt corrections.



All these camera features are possible only in TRIUMPH-LS where camera, and GNSS antenna are co-located and all other modules integrated.

OMEGA

Rugged GNSS Unit

OMEGA is the most advanced GNSS receiver. It does not include integrated antenna and controller. It is suited for applications like **machine control** and in **marine** and **avionics** applications.

Adding GrAnt and Victor-LS makes a complete RTK system.

It is well suited for **monitoring and network stations**.

A variety of Radio Modems

Bluetooth and USB in all JAVAD radios

JLink 3G

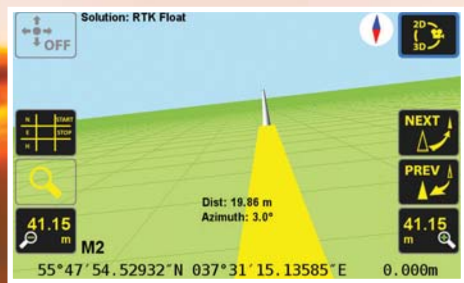
JLink 3G BAT

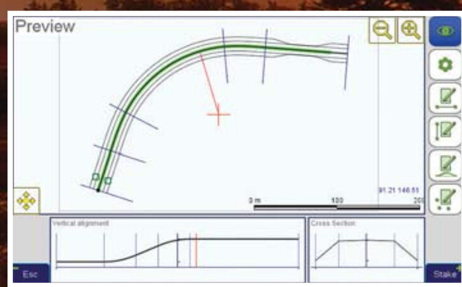
HPT435BT/HPT135BT/ HPT225BT

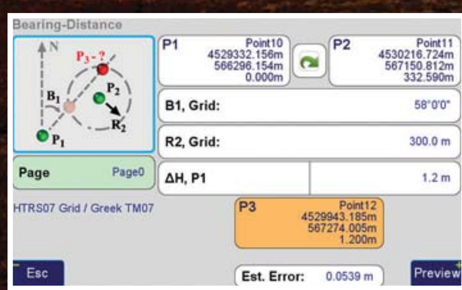
TRIUMPH-LS

Receiver+Antenna+Radio Modem+Controller+Pole

- 864 Channels for all GNSS signals
- 24 Hours Battery Life
- Interference monitoring of all GNSS and UHF channels
- Visual Stake out
- Lift & Tilt
- 6 parallel RTK engines



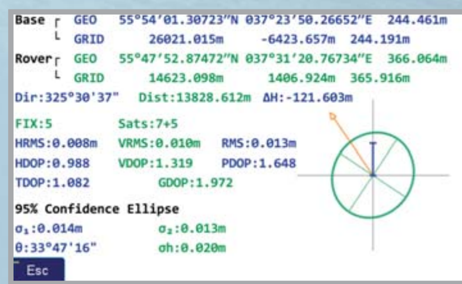




Victor-LS

The Rugged Field Controller

Victor-LS is a rugged field controller. It runs J-Field and can be used with TRIUMPH-1 and TRIUMPH-2.



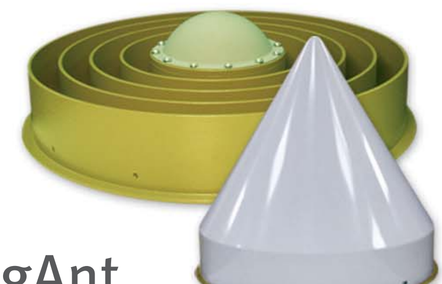
TRIUMPH-1M + Victor-LS

TRIUMPH-2 + Victor-LS

High performance Antennas

TriAnt

GrAnt



AirAnt

RingAnt

See details at **www.javad.com**

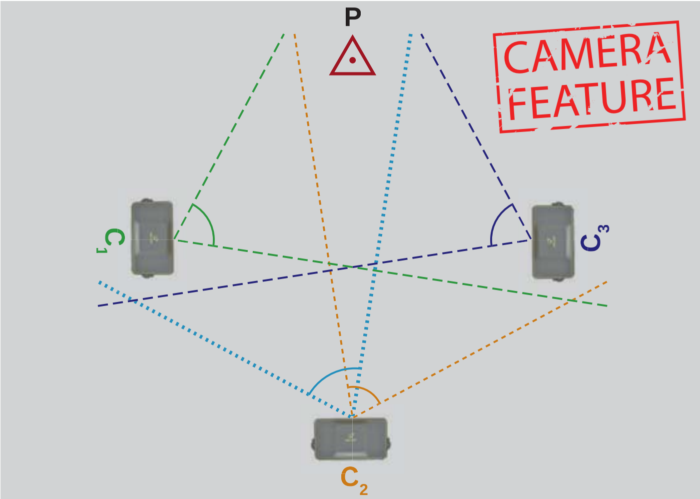
HPT404BT/ HPT104BT/HPT204BT

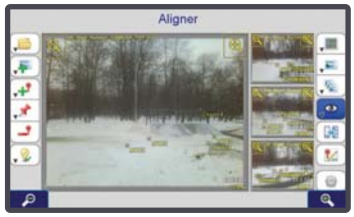
L-Band/Beacon/ Spread Spectrum

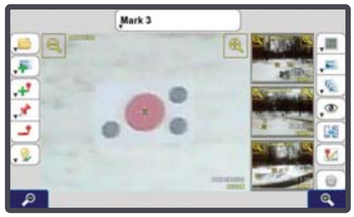
HPT401BT/HPT101BT/ HPT201BT

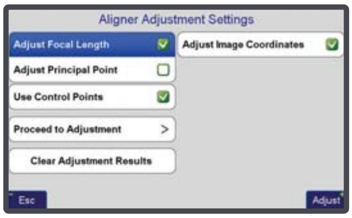
Offset Survey with built in camera

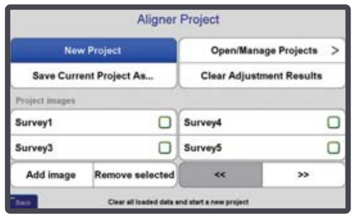
You can survey points with internal TRIUMPH-LS camera with accuracy of about 2 cm. Take pictures from at least three points. Leave a flag on points that you take pictures from, otherwise accuracy will be about 10 cm.









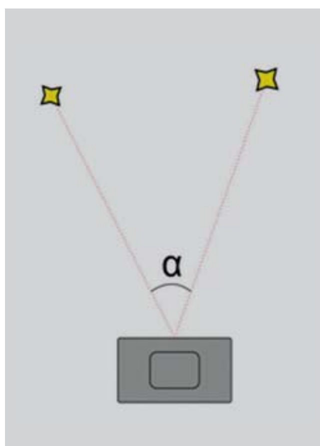


Visual Angle Measurement with Triumph LS

The new Visual Angle Measurement function of the TRIUMPH-LS allows measuring angles between points by using photos taken by the TRIUMPH-LS camera and use in CoGo tasks with the Accuracy of about 10 angular minutes.

To measure an angle:

- just take an image containing both objects of interest and open it in the Measure Angle screen
- select first and second point (using zoom to focus on necessary features)
- The angle between points is immediately displayed on the screen.

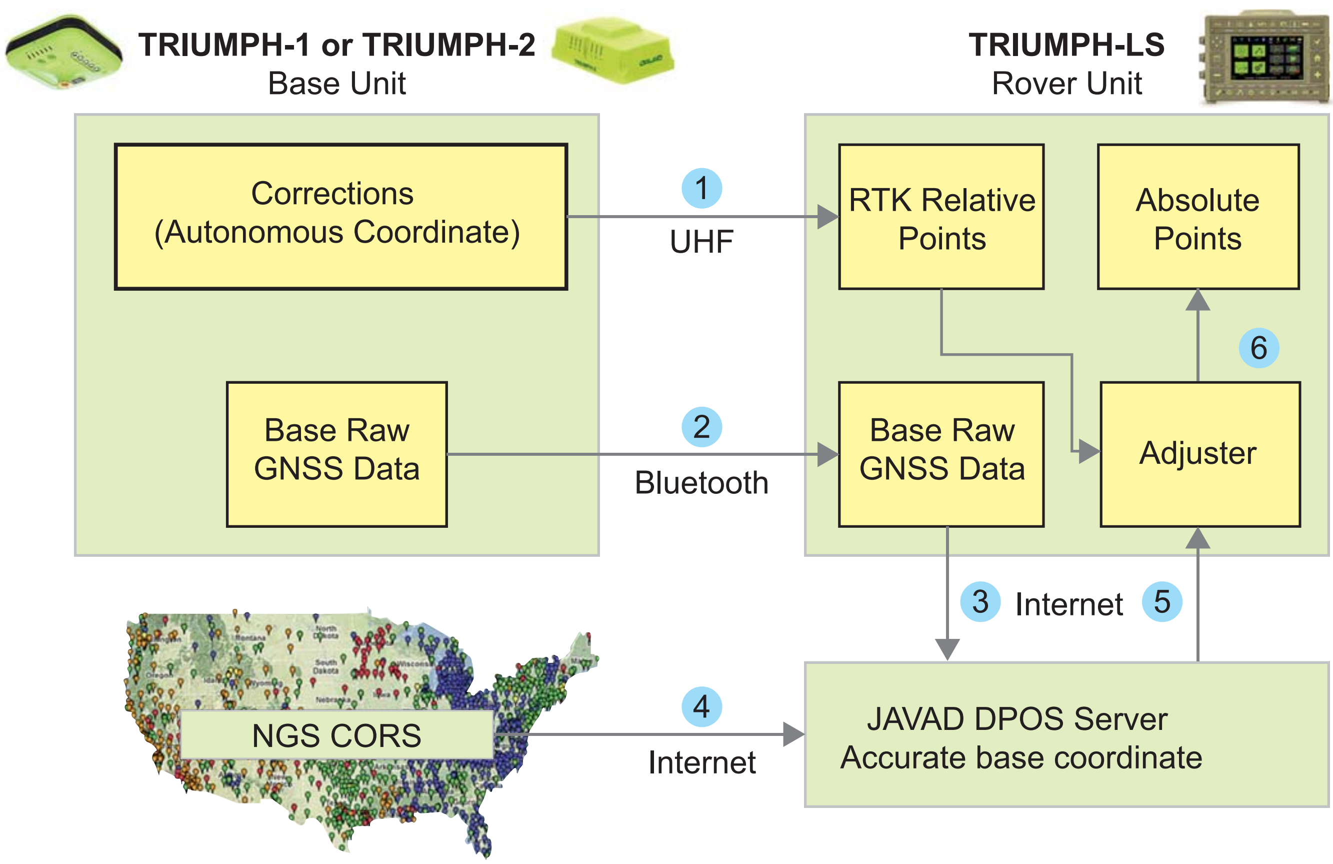


Second, the user may not have a known point to set the base station on, or lack confidence in the coordinates of the point. JAVAD GNSS has solved this problem reliably and automatically by offering "Verified-Base RTK" (VB-RTK). It is automatic, reliable, faster, less expensive, and it is traceable. Of course, the system can be used with RTN networks, too. It works much better than RTN, because usually the nearest actual "real" base station is many miles away, while a user can set up a base station near the RTK work area, usually less than a mile away.

VB-RTK records raw GNSS data at the base station while transmitting corrections to rover. At the end of work, the user returns to the base and again connects to it with the TRIUMPH-LS rover and stops the base. The rover then downloads the raw data from the base. The base station's raw data is then sent to our own DPOS (Javad Data Processing Online Service) and processed to NGS CORS data. The results are then returned to the TRIUMPH-LS rover. The coordinates from DPOS are compared against the base coordinates used for all RTK points collected from that particular base session and then (upon the user's confirmation) the RTK rover points are translated. All these steps are done automatically.

VB-RTK is useful even in situations in which the base was setup on a known point as the processed DPOS results can be compared against the known point coordinates to prove the base was setup on the right monument, that the point had not been damaged, that the coordinates were properly entered, that the instrument height was correct, etc.

As a separate note: Our Auto-Verify RTK system will never give a wrong fix without a clear warning. We are offering $10,000 to any US PLS who can prove otherwise and show even one bad fix without a clear warning.



You do 1, the rest is automatic

Future Indian Space - Renewing Policy Dimensions

This article is an extract from a paper prepared as a "suo-moto" policy-analysis for assessing Indian Space achievements and also for addressing future aspects of Indian Space Policy. While the paper in itself is a comprehensive policy analysis, the India-relevant part has been re-produced here

Dr Mukund Kadursrinivas Rao
National Institute of Advanced Studies (NIAS), India

Prof Sridhara Murthi K. R.
National Institute of Advanced Studies (NIAS), India

Dr V S Ramamurthy
National Institute of Advanced Studies (NIAS), India

> India needs a National Space Policy that has agreed-upon road-map and vision of long-term (say, 20-30 years) and "compartments" of short-term missions and plans

Indian space programme – past 40 years

Indian space activities originated from purely scientific interests of a large scientific community in 1960s with the sounding rocket launch experiments. The early space efforts owe much to the vision given by Dr. Vikram Sarabhai - "…… to be second to none in the application of advanced technologies to the real problems of man and society". This extraordinary vision was based on realism and pragmatism and with deep insights into the then socio economic context of the country. Soon, by late 1960s, India had accreted a programmatic concept of basic experiments on the technology and user-development front to found a "end-to-end" systems concept that was very critical for space systems. The mantra of self-reliance that Dr Sarabhai gave became the life current that enabled space program to overcome numerous challenges in learning and experimenting with new technologies.

From a policy analysis, the Indian space program evolution can be broadly categorized under three distinct phases:

- The proof of concept demonstrations of the use of the vantage point of Space for addressing the country's developmental needs and these were exemplified by the Satellite Instructional Television Experiment (SITE), the Satellite Telecommunications Experimental Project (STEP), and use of Landsat satellite data for natural resource management applications. The space segment was procured with international cooperation. By early 1970s, India was on its way to develop its first satellite – Aryabhata and started the "grand plan" of an indigenous end-to-end space technology development capability.
- The experimental phase saw the development of an end-to-end experience in the realization of space systems - experimental earth observation satellites like Bhaskara I and Bhaskara II; India's first experimental geostationary satellite APPLE and the initial space launch vehicles such as SLV-3 and ASLV characterise this phase. It facilitated competence building at the core level. Thus, by late 1970s and in 1980s, India invested considerably in building laboratories and facilities and also initiated a 3-pronged programme – Indian communication satellites in INSAT; Indian EO satellites in IRS and Indian launch vehicle programme through the Polar and Geo-synchronous launch vehicles.
- The operational phase was then taken up with an understanding of and analyzing the complex interplay of - evaluation of alternate approaches to arrive at the most optimal solutions; decide on exercising buy or build options parallel indigenous development plan to achieve self-reliance goals. This phase resulted in establishment of National Systems such as (i) Indian National Satellites (INSATs) / GSATs for communications, broadcasting and weather observations (ii) Indian Remote Sensing Satellite Series and (iii) Polar satellite Launch Vehicle, PSLV - all examples of operational space systems that have to meet stringent operational service performance criteria.

By early 2000, India had achieved a technological maturity of space systems and utilisation and this challenged it to envision missions to far-away Moon and thus came about Chandrayaan-1 – which originally started (in 2000) from a simple question "Can we go to the Moon?". Soon by 2002, India also started planning for its own Positioning Satellites systems in Indian Regional Navigational Satellite System (IRNSS).

Yet another aspect that emerged in mid 1990s and early 2000s was forays of Indian space products into the global market place – through Antrix Corporation which marketed Indian space capabilities globally and thereby capitalizing revenue models for Indian space. Most of the developments and manufacturing were organised into various units of about 16000 strong Indian Space Research Organisation (ISRO) with contract-mode industry-interfaces – which helped in the overall development process for ISRO.

Towards 2010s, India had challenges to comprehend because of failures of GSLV – even as PSLV emerged as a reliable launch vehicle for 2t class spacecraft and the work-horse for ISRO. But the successive failures of GSLV have posed tremendous challenges which are being systematically overcome in recent times. Yet another challenge that faced India was the gap in satellite communication transponders that started stifling the service segment of DTH, social broadcasting, data communications – and more so in terms of slowing down technology development in newer areas (like Ka-band and large class satellites etc).

In 2011, ISRO took upon a new challenge of a foray to Mars in the 2013 orbit-window for Mars. The Mars Orbiter Mission (MOM) was successfully launched in November, 2013 and has already completed more than 90% of its traverse to Mars as we write this paper. Soon, on September 24, 2014, MOM is envisaged to enter Mars orbit and starts its experiments of imaging and measurements. But more significantly, MOM would establish the fact that India can successfully undertake long-duration planetary missions and would have gained the basis experience in this regard.

Thus, one can see that over the past 50 years, India has made significant progress in space technology – achieving projects, missions, programmes and developing new applications.

Analysis of Satcom policy and Remote Sensing Data Policy

Towards end of 1990s, India had a mature satellite communications programme through its INSAT system and a remote sensing satellite through its IRS. Much of the space development and utilisation was pushed by ISRO with a visionary drive that envisaged a foundation of national-anchoring for Indian space but a growth in commercial and privatisation activities – for it was envisaged that it would be just impossible for ISRO to take up efforts to meet the growing demands that would emanate from 2000s and ahead. Thus, ISRO took up considerable think-tank activities to have a 2-pronged strategy of protecting national space interests and at same time preparing for large-scale commercial demands.

It was during these times that the Satellite Communication (Satcom) Policy was taken up and adopted by Indian government in 1999 and the Remote Sensing Data Policy (RSDP) was taken up and adopted by Indian government in 2001.

Satcom Policy

The Satcom Policy was adopted by India in 1999 but its evolution started from 1997 time-frame. The Satcom Policy-1999 was based on then technical developments in satellite technology as well as in the associated/alternate communications technologies and the aim was to develop a vibrant satellite communications regime for India that catered to national and commercial needs.

The main goals of the Satcom Policy-1999 were as follows:

- build national capabilities in satellite communications by way of a healthy and thriving communications satellite, ground equipment and satellite communications service industry AND sustained utilisation of Indian space capabilities - satellites, launch vehicles and ground equipment design
- make available INSAT systems for social-applications development and ensuring that INSAT system benefits a larger segment of the economy and population
- encourage and promote privatisation of satellite communications in India by way of encouraging private sector investment in space industry and also attracting foreign investments

Some of the innovative aspects of the Satcom policy-1999 were to change the paradigm at that time and included:

- authorizing capacity of Indian National satellites (INSAT) to be leased to non-government (Indian and foreign) parties on commercial terms. This was essential so that commercial services could ride on INSAT – envisaged to spur the DTH and VSAT market in India to a large extent.
- allow Indian parties to provide services including TV up-linking through Indian satellites – thereby to open up a variety of TV channels in India.
- co-ordinate and register satellite systems and networks by and for Indian private parties. The intent was clearly stated but this has not happened till 2014.
- satellites for government use to be made available by Department Of Space. However, there have been severe shortages in transponders available from DOS for social applications and thus impacting educational satellite services, tele-medicine services through satellites, state development communications and e-governance services. gap in demand-supply – growing demand for satellite capacity is a challenge
- DTH preference on Indian Satellite Systems
- the operations from Indian soil using foreign satellites under certain conditions

It was envisaged in 1999 that Satcom Policy would ultimately bring great benefit to India by way of big boost for DTH business, Vsat services, robust connectivity for education outreach across the country, reliable telemedicine connectivity, increased capacity leasing and a great growth in Indian ground equipment manufacturing. It was also envisaged that ultimately the Satcom policy-1999 should help position JVs for communication satellite ventures and also bring in a variety of new value-added services,

The corner stone of the Satcom Policy was the preference to be given to Indian Satellite Systems (ISS) while giving service licenses – thereby ensuring "protective cover" for INSAT for Indian services against any "market on-slaught" from global commercial systems. However, the pragmatism of the Satcom Policy is that it does not in any way prohibit the use of foreign satellite systems – which, after a due process, can be treated on par with ISS for service licensing in India. This has not happened – mainly due to deficiencies of appropriate procedures in implementation and subsequent emergence of canalisation of lease of foreign satellite capacity through DOS nominated agency – which has brought bureaucratic impacts.

The Satcom policy is silent on orbit-spectrum situation for Indian interests – which anyway is coordinated by ISRO and DOT. There is also a problem that there are not many such slots available globally for acquisition. Unfortunately, even as of 2014, additional orbit-spectrum resources for expansion of much needed infrastructure are eluding solution.

Remote Sensing Data Policy

The Remote Sensing Data Policy (RSDP) defines the Indian regulations for acquisition, dissemination of satellite images in India - earlier, RSDP-2001 and now RSDP-2011 governs how satellite images are to be acquired and distributed – allowing upto 1m images to be openly dissemination to users. The RSDP embeds the concept of "regulation" to address the dissemination for 1m images.

Thus, the RSDP-2001 provided the earliest "framework" for a comprehensive imaging policy – for the first time remote sensing was identified as a "public good" and the concept of national commitment to continued imaging programme through IRS was included. The RSDP introduced the concept of "one-window" access to any image (Indian or foreign satellite) - which today appears to be against "free market" concept. Another concept that RSDP-2001 started was of "regulatory use-determination" (mainly to stave off the hard-block of private sector access to 5.8m images "could become a security concern") whereby images upto 5.8m would be "available on non-discriminatory basis" but images better than 5.8m would be "regulated" for private sector users on case-by-case basis. The RSDP-2001 carried yet another major aspect – images would be screened to obliterate some geographic regions (then called Vital Areas/Vital points) so that such "map-erasing" methods also are applied to images. The RSDP also required foreign satellite images TO BE routed through the national agency – National Remote Sensing Centre (then Agency), NRSC.

It is clear that in RSDP-2001 was adopted when Indian imaging corresponded to 5.8m and the availability of Indian 2.5m or 1m was in still in "planning stage" – while 1m images from IKONOS, in 2000, made way into the image market, including in India. Thus, even though the RSDP clearly emanated from the competitive challenge of US 1m images against the Indian 5.8m IRS system in the Indian market – it was certainly a protective regime for IRS till it could also match with commercial 1m image availability from IRS systems (which happened only in 2006).

But there was a major path-way crafted in RSDP-2001 in the concept of "licensing" RS satellites and RS data acquisition/distribution in India – creating that "window-opening" for future Indian private RS satellites and Indian private agencies to acquire/distribute any satellite images in India. Such privatisation was envisaged even way back in late 1990s and was embedded into RSDP-2001. However, till 2014 no such licensing application has been encouraged and NRSC has continued to be the single "monopolistic" data provider. However, of late market-talk indicates few private players considering licensing applications for acquiring or distributing foreign satellite images in India – though the stage of private Indian RS satellites is still far away.

By 2005-06, India also launched 2.5m and 1m images but by then the larger proliferation of 1m images from US commercial satellites had also happened. Thus, the 5.8m thresh-hold of RSDP-2001 as "regime for non-discriminatory access" was found detrimental to Indian cause/users and was soon rendered irrelevant. Therefore, in RSDP-2011 a lower bar for "non-discriminatory access" to 1m was promulgated – but then fully retaining all other aspects of RSDP-2001.

The impact of RSDP has not been quite as envisaged – neither did the "protective regime" in early 2000s help stave the challenge of foreign 1m images because US 1m images became widely popular as against 5.8m/2.5m images and very limited 1m images from IRS systems; NOR did it help develop and position Indian private RS systems for satellites and distribution. With NRSC the "sole agency" for distributing images, it has become further monopolistic as it adopts IRS-centricity and pushes 2.5m and limited 1m images – thereby denying Indian users 0.3m level images for national development. At the same time, Indian is unable to match the resolution quality of US commercial systems (that have reached 0.3m level in global market) and has plans for a 0.5m imaging IRS in 2017 time-frame.

Indian space achievement metrics

India does not have a formal National Space Policy that has been legislated or formalised into a public-domain document. Indian space is still guided by Vikram Sarabhai vision of "……applications to the real problems of man and society" – which still serves as a national space policy tenet and has been guiding the developments over past 44 years. The programmatic definitions of Indian Space are made in the Five Year Plans of the Indian Government.

As of 2014, here are some metrics of the past 40 years and over the past 8 Five Year Plans (1974-2017):

- A cumulative budget of about INR 80.4 billion has been allocated by Indian government but actual utilisation has been INR 490 billion.
- Approval for 200 missions has been accorded by Indian government but 125 missions have been accomplished - out of which 111 missions have been successful.
- Independent access to space through a reliable and operational PSLV launch vehicle and a proven pre-operational Geostationary launch vehicle, GSLV incorporating an indigenously developed cryogenic upper stage
- World class satellite capability that cover a wide variety of applications satellites – INSAT, IRS and IRNSS for telecommunications, broadcasting, weather observations, remote sensing and navigation and scientific spacecraft including orbiters to the Moon and Mars.
- Wide use of INSAT communications systems have resulted in the wide outreach of TV signals (from early 1980s onwards) to almost whole of the country and growth of large-scale DTH and VSAT data communication business.
- The availability of low-priced and easily available IRS images (from about 20 IRS missions) and a great thrust to use of images and geographical information techniques proliferated IRS data into many governance and national building activities – by way of inventory and maps of natural resources, critical support to disaster management activities and environmental monitoring.
- Weather and ocean services modelling have derived a great boost from the availability of INSAT and Oceansat images/data on a variety of ocean and atmospheric data – thus consolidating the scientific services of meteorological department and Earth Sciences.
- Forays in planetary missions have been made through Chandrayaan-1 and MOM-1 to establish the technological capability of Indian space to undertake far-reaching planetary exploration and also undertaking advanced scientific studies.
- Unique missions for astronomical observations – Astrosat and operational Positioning Services – through IRNSS constellation have been planned but are yet to be launched or fructify.
- Global commercial operations of Indian space in 43 commercial/ foreign satellites on its PSLV; sale of IRS images and value-addition services and, more lucratively, transponder lease business in India are estimated to have resulted in revenue earnings of about INR 50 billion over the past 20+ years. It must be noted that this estimated revenue earnings includes a after-tax profitability of anywhere between 10-12% - thereby, meaning that Indian government has net-earned about INR 5 billion in profits.

Presently, in the 12th Five Year Plan (2012-2017), Indian Government has allocated INR 39 billion and has approved 58 missions over the 5 years period. The plan also makes forays into heavy communications satellites, advanced EO and weather satellites, achieving operational status of geo-orbit launch systems and also advanced missions for exploration of Mars, lander on Moon and IRNSS constellation.

Looking ahead – Renewing policy for space in India

(Much the ideation and concepts, in this section, have been adopted from a talk given by Dr K Kasturirangan in April, 2014)

India's achievements in space technology and applications, viewed at an overall national level, have created a deep sense of "national pride" and a "public ownership" of the programme with consistent support from different political parties. National space activities are valued as a critical and most-coveted development/achievement. India is a nation of high ambitions of large hard-working and intelligent population – who struggle and aspire to be way ahead in life and "be second to none" - fortunately, achievements of Indian space has provided that outreach to society.

Looking ahead, what are the challenges that face Indian Space?

- Building further focus and an un-interrupted future national capability in space is quintessential - the nation needs to be assured that space systems that best respond to national needs are made available all the time and that gaps in services do not get created as has been witnessed in satellite transponder capacities or high resolution imageries. A pragmatic long-term planning of Indian space is required with a visionary partitioning of roles for different segments in the national eco-system.
- Building a combinative ISRO and industry capacity is critical for future space success. Especially in areas of operational satellites for communications, remote sensing, security, positioning, disaster management requirements – the concept of industry building, owning and operating space systems must be positioned. It will be advantageous to expand space capacity in the nation and enable a space eco-system into private sector space in India and enable a combinative national space capacity of ISRO and industries to emerge.
- Maintaining the state-of-art in space technology and adopting a leap-frogging approach are essential so that India can be on par with state-of-art systems. This would require careful and judicious flexibility to "buy or build" approach for critical gap areas, assimilate and source/partner for newer technology systems, parallel approaches of source-and-develop for critical dependency systems etc. Such an approach is most critical if one has to maintain the excellence and also be equal and compete in global systems.
- Space has triggered many new services and products/applications – which reach out all over the country and deep into society at multiple levels - administratively and jurisdictionally. Newer institutional frameworks are called for down-stream national-level applications and delivery systems – especially to address delivery systems for large demand for societal applications related to space. In an end-to-end concept,

national space agencies must not "carry the burden" to undertake large national-level societal applications that emanate from administrative and governance demand. Space must be an instrument to spawn newer and larger structures/organisations for applications and usage.

- Intensifying a two-way international cooperation is a desirable strategy – On one side, to embark on major exploratory programmes through synergy of partnership and assimilating technology and experiences from other nations and on the second side, for reaching/bringing Indian capability in the global markets of space. This combined approach must be intensified by active participation in multi-lateral space frameworks and selective bi-lateral space cooperation – especially in future human space flight and planetary exploration activities.

We make an assessment that the need is for National Space Policy – basically looking far ahead and creating a roadmap that will look 30-50 years ahead but also knit and integrate the various elements into efficiently-performing assets for Indian capability.

Space activities – Why policy?

We visualise that in coming years there will be a burgeoning need for space based services and this will require more robust space infrastructure and timely and reliable access to such infrastructure for social and commercial service delivery systems. Revisit of current institutional arrangements or creation of new institutional measures will be necessary to meet the large scale demands of diverse sectors and removal of disconnects that afflicts efficiency of delivery system.

Satellite services are critical for India's development and society/citizen services – thus a long-term and success-oriented commitment of government support and resources for pursuing satellite technology development is essential. Of course, this commitment must also be dove-tailed to key services/ministry sectors to utilise space inputs in a service manner.

Space science and planetary missions have a major role to play in catering to national scientific/education goals and aspirations – thus, a long-term continuity of planetary/science missions and programme is important – with well-defined science benefits.

In coming years, there are going to be a large number of Indian space assets (in-orbit) – their tracking, monitoring, de-activation schemes/protocols and national liability protection become important. At same time, protection of Indian space assets and usage and safe-guard from debris, attacks and stifling contingencies will require extreme level of technological and legal protection regimes.

India will have to renew and develop more robust and operational launch vehicles for the continued and un-hindered access to space and at same time strengthening national technological capability in the complex regimes of launch vehicle technology.

Space activities will require high level of resource investment spread over years and decades – thus a long-term programmatic and investment road-map becomes critical as the high-level of investments for space activities must be well-justified with declared national benefits and transparency of progress in expenditures too.

Indian space will have to go 2-pronged – on one side to meet its national needs, India will have to build and boost national capacity with Indian private sector and appropriate global commercial sector; and for larger science and planetary activities frontal international cooperation at bi- and multi-lateral level will have to be the medium of collaborative programmes/investments sharing.

India will have to build and encourage Indian private sector in space business – not just to meet national needs but also to be globally competitive and efficient – so that Indian private sector will be able to build/develop national/global space business enterprises. Level playing fields for business and models of profitable revenue generation will have to be driven.

Finally, space will have to be developed as a vital tool for national security interests and safe-guarding Indian national interests.

India needs a National Space Policy that has agreed-upon road-map and vision of long-term (say, 20-30 years) and "compartments" of short-term missions and plans – but more importantly a holistic policy covering the gamut of space activities that will have to be pursued.

Justification of space at national level and endorsement of nation – political, bureaucratic, industrial, scientific and citizens will go a long way in furthering space and building the resilience for ups-and-downs of space activities.

Satellite communications will still be strongly justified as a vital element of national communications infrastructure for efficient and reliable communications of voice, data, image/video on various platforms and providing principal communication services for social sectors - tele-education as a medium of next generation education services, boost tele-medicine for contributing to securing health in society, DTH broadcasting for TV and mass media communication, for virtual private networks of government, banks, railways, defence, aviation and other areas. At same time, space will also play a role as critical "redundant" secure communications infrastructure in times of national emergencies, disasters, special events; national security and defence;

Satellite remote sensing and satellite positioning must provide on-demand imaging, observation and positioning services – thereby aiding to development of a National GIS, which holistically, in turn, will position GIS Decision Support Systems (DSS) that help bridge regional disparities in rural development and poverty reduction; support food security – agriculture and farmer benefits; infrastructure development; natural resources management and environment sustainability; operational national weather, ocean and climate services; support "operations" of city-management, aviation, logistics, railways, defence and other services.

Space justification must be in terms of helping build operational and sustaining national disaster and weather resilience; meet national security and defence needs – to secure the nation.

Justification for Indian space as an instrument for international cooperation will be most essential. While international cooperation must found science and planetary missions, regional space cooperation to share experience and knowledge will enable India to build a more comprehensive space regime in global efforts. In recent announcement, Hon'ble PM of India has made an announcement of India offering a SAARC-satellite and enabling sharing of Indian experience – a classic example of international cooperation tool of space.

Ultimately, citizen empowerment is most critical so that efforts must be to bring space benefits to every citizen of the country. Thus, an inclusive processing of involving citizens – especially the youth in space is most essential and important.

Space is also essential to grow science and knowledge endeavour for next generation.

National Space Policy ... Possible tenets

Indian space policy must include following explicit tenets:

- Set a long-term vision for Indian space that is in complete alignment with stated national goals and also cover a 20-30 years for space activities
- Express sovereign right to access space and bring benefit to Indian citizens from space activities – basically, pursuit of (civilian) space activities and access to space and involve in shaping international space policies, agreements, rules etc

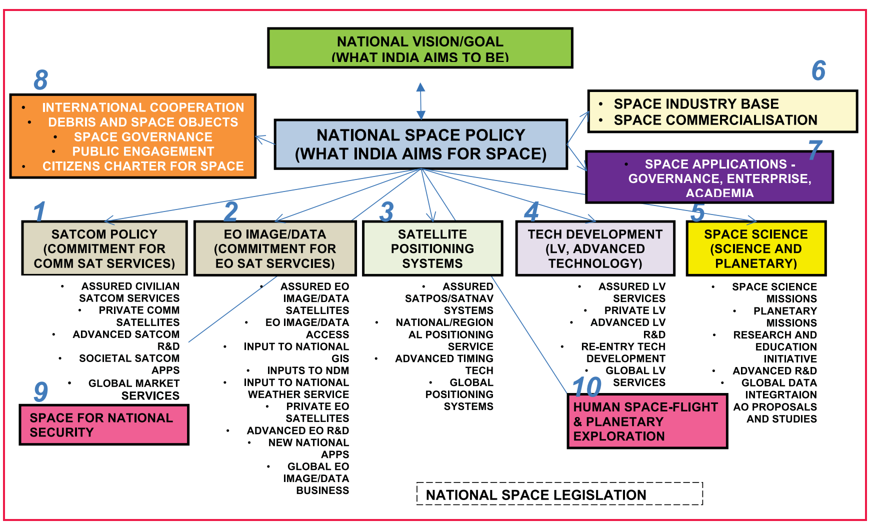


Figure 1: National Space Policy – Elements

~100-150 MISSIONS	HUMAN SPACE-FLIGHT PROG INITIATED	++PLANETARY/ SCIENCE MISSIONS	LARGER GLOBAL BUSINESS	~INR 1000 B INVESTMENT

SEGMENT	PRESENT	FUTURE
Technology Development/ Investments	Government Academia	• Government • Academia • Indian Space Industry
Satellites – build, operate	Government	• Government (Advanced, Science, Planetary, HSF) • Industry (Operational Satcom, EO)
Launch – build and market	Government	• Government (Advanced) • Industry (Operational)
Ground Systems development	Government Industry	• Industry
Space based Services	Government Industry	• Government (Societal, Advanced) • Industry (Operational, Commercial) • Academia (Science, Planetary)
Planetary Exploration and HSF	Government	• Government (National/Intl. Coop Missions) • Academia (Science) • Industry (Dev Support)
International Cooperation	Government	• Government (Multi-lateral) • Industry (Commercial)
Investments	Government – 100%	• Government – 50% (??) • Industry – 50% (??)

Figure 2: Possible Scenario IFFF in Next 10-12 Years... Anywhere Around

- Creation of social/economic multiplier by committing un-interrupted space-based national and commercial services for intensive social and national contribution - theme-oriented space configuration plan and develop/ procure space assets planning. This can cover communication, remote sensing, positioning etc
- Establishing India's own global navigation system to achieve autonomy in access to global satellite navigation signals and also performances comparable to the best of the breed global systems
- Ensure and justify future investments in space - especially high-investments for human space-flight capacity and continuity planetary missions by constantly providing a technology and investment roadmap.
- Ensure wide usage and applications of space by government, industries and citizens
- Facilitate and develop strong Indian industrial capability in space technology – so that Indian private sector can develop and provide space assets to meet national demand and pursue global space markets - providing India space products and services
- Undertake advanced technology development – especially in creating roadmap towards a robust launch capacity, lower costs of access to space - Reusable Launch Vehicle Technology, human rating of launch vehicles and advanced planetary programmes and human space-flight related technology
- Space for security needs – establish parallel production-line and for protection of India's space assets should receive adequate attention. Creation of specialized facilities for increasing Space Situation Awareness (SSA) and effective means to deal with denials has to be developed

- Enhancing academics and research in space technology for qualitative developments and even some disruptive developments in space by spread of space activities in university systems and a healthy competition among academic research organisations
- Adopt a space governance model that outlines national and global level compliance to legal regimes and self-conduct
- Strong promotion of international cooperation in space at bi-lateral, multi-lateral and business levels
- Determine and define metrics for evaluating space programmes and mission achievements/performance and performance and social audits. This is essential for commitment for mid-course corrections, policy and strategy changes
- Commit to regular policy/ strategy roll-over reviews and updations at national level.

A possible visualisation of National Space Policy is given in Figure-1. In such a possible policy framework, a possible scenario for near-future space development is shown in Figure-2.

In the far term of 50 years, the range of space applications would have expanded wide and into different areas of governance, commerce and services. The Space Policy needs to outline how maintaining national and societal relevance of space and creating a society-oriented space configuration is sustained; developing technologies related to aerospace plane, lunar bases and space tourism, planetary habitats, inter-stellar space exploration, contributing in developing regulatory developments and sustainable space operations.

We propose the following components for the comprehensive Indian Space Policy:

- Indian Space Vision – in alignment with national vision. This can be long-term vision of space programmes/missions (this could be rolled over every 5-10 years).
- A comprehensive Satellite Communications Policy that ensures un-interrupted and advanced satellite services for communications – public services, commercial and citizen services
- A pragmatic Remote Sensing Policy that commits availability of best quality remote sensing satellites data for land, oceans and atmosphere for national development – government needs, commercial needs and research needs
- A far-looking National Positioning Systems Policy that maintains national space-based Positioning services, augmentation service in an operational manner – for security, governance, commercial and citizen services.
- Indian Space Transportation Policy that ensures India's technological competency in space launch sector by way of development of efficient and advanced space transportation systems that are reliable, efficient and affordable and that support Indian space access needs operationally and also support launch business of global markets competitively.
- A National Space Science policy which covers a long-term and continuity planetary science plan of exploration, research and knowledge capability for India and builds science and research capability in Indian universities and institutions.
- A Space Industrialisation Policy that envisions developing and positioning a vibrant and superior Indian space industry capability which can simultaneously undertake full-scale space missions development for national needs and global markets.
- A National Space Applications Policy which will encourage "integration actions" of dove-tailing space technology into user domain of governance, business and research education by way of end-to-end user solutions concept.
- Indian Space International Cooperation Policy that will outline the international cooperation aspects as a 2-way mechanism – of India gaining/ participating from cooperation and of India contributing in international arena. Issues of international Space Governance – debris, code of conduct, planetary treaties etc are key for future and a policy perspective is essential.
- Human Spaceflight programme element that clearly outlines the full panorama of human spaceflight plan and national commitments that are required.
- National Space Security policy that outlines the space security aspects of Indian national space.
- A Public or Citizen Space Charter which enables defining (on regular periodicity) the benefits that Space Policy is bringing to India and its citizens and provides metrics for measuring performance.

At some time in coming years, space legislation would also be appropriate to position a long-term commitment and public endorsement.

NIAS feels that such a comprehensive policy exercise is essential and needs to be taken up. NIAS proposes to continue working on these lines.

Conclusions

Great heights were achieved in the post independent India in space endeavours through unfolding the utilitarian and pacific visions of Space. India must expand its role into the next stage of exploratory regime of space to scale new heights and become a significant contributor to meeting national needs, explore beyond and understanding of cosmos in modern terms and become a major partner of the Global Exploration Efforts of Space in the 21st Century – for which a National Space Policy is critical.

This study is undertaken by NIAS to demonstrate a unique and rational approach which integrates scientific analysis of all core issues and over-arching assessment of staking issues in the development of the necessary space policy tenets. The perspectives of policy brought out by the study, although depicted in the national context of India, are highly relevant to different regions of the globe since they strike at the roots of fundamental issues that characterise the structures in which generation and applications of space are being pursued.

The original paper may be referred at http://nias.res.in/docs/IAC-14_E3_2_7x 20955IndianSpacePolicyPaper.pdf


MicroSurvey
CAD 2015
Unlock Your Full Potential
• Built on IntelliCAD® 8
• 64-bit and 32-bit versions
• Improved performance
• DWG 2013 support (AutoCAD® 2013, 2014, 2015)
• Layer states and filters
• Quick-select
• Adaptive grid
• New 3D orbit commands
• Dynamic licensing
• AutoMAP plotted descriptions
• AutoMAP substitution codes
• Google Earth™ KML export
• Leica codelists & ghost points
• Line/curve/tie table selections
• COGO bearing rotation display
• Draw cluster error vectors
• More .xyz point cloud formats
MicroSurvey CAD 2015 is now available, and you owe it to yourself to try it!
Unlock the full potential of your workstation with the 64-bit version of MicroSurvey CAD. Harness the power and capabilities of the integrated IntelliCAD 8 engine, and experience faster drafting and calculation operations while working with larger drawings, more points, and an overall more powerful MicroSurvey CAD than ever before.
Download a free demo from our website: www.microsurvey.com
FREE DEMO
® MicroSurvey is registered in the U.S. Patent and Trademark Office by MicroSurvey Software Inc. MicroSurvey is part of Hexagon.
Google Earth is a trademark of Google Inc. AutoCAD is a registered trademark of Autodesk, Inc., in the USA and other countries.
PART OF HEXAGON
MicroSurvey®

The role of LIS in instigating development of a NSDI in Tanzania

This paper identifies and discusses the standards supportive of the proposed integrated LIS and highlights elements that can be agreed, standardized, and shared as part of the development of a national SDI

Eric Mwaikambo
School of Geospatial Sciences, Ardhi University, Dr es salaam, Tanzania

Dr Martin Hagai
Head of Department, Department of Geo-informatics and Geodetic Sciences, School of Geospatial Sciences,, Ardhi University, Dar es salaam, Tanzania

A nation-wide Land Information System has the potential for providing the basis on which a National Spatial Data Infrastructure can be developed, given the strong similarities between the two concepts. In a country such as Tanzania where agriculture is the main sector of the economy, proper management and administration of land is of prime importance, and an LIS is an indispensable tool for effective and efficient land delivery services. Likewise, SDI must be developed to support the efforts to fulfill the vision of the nation. Among other issues, the Tanzania 2025 Vision places emphasis on transforming the current low productivity agricultural economy to one led by modernized and highly productive agricultural activities. The national SDI should support LIS to realize the nation's vision. However, as is the case for many countries, LIS and SDI are developed through different independent projects. This poses problems of possible misalignment of LIS and SDI, a situation which can bring about conflicts and duplication of efforts (Siriba, and Farah, 2008).

Currently, there is no formal SDI in Tanzania. Nevertheless, most of the core elements of SDI exist. These have been developed over the years for use with legacy land information systems and have the potential for providing the foundation for a national SDI. These include:

(i) A vibrant land policy and an active institutional framework for land management and administration,

(ii) Application of technologies especially in ICT, such as improved access to internet brought about by a newly established optic-fiber network that connects most districts in the country, and

(iii) Availability of fundamental spatial data such as- topographic maps, geodetic control network, and cadastral data.

The least developed element for both LIS and SDI relates to standards. Standards provide a framework for the development of any system (IT or otherwise) and represent codes of best practice. Using standards ensure interoperability between data elements of separate systems and greatly enhances the sustainability of systems, as it ensures a greater ease of transformation and portability in future development of both LIS and national SDI. The standards that will affect the integrated LIS include: Standards related to business processes and LIS professionals, e.g., land surveyors, land administrators or property valuation officers; standards relating to geographic information; standard for describing land information; standards relating to ICT; standards for storing and archiving documents, and standards for software development practices and methodologies. There is also a need for defining a number of national standards for the use of coordinate systems and projections, common transformation parameters between coordinate systems and formalize unique parcel identification numbering system.

Development of an integrated Land Information System in Tanzania

Tanzania is located on the east coast of Africa between latitude 1°S and 12°S, and 29°E and 41°E. It is bordered by Kenya and Uganda to the north, Rwanda, Burundi, and Democratic Republic of Congo to the west, Zambia to the southwest, Malawi, and

Figure 1: Tanzania on Africa map (left) and provincial administrative boundaries (right)

Mozambique to the south, and the Indian Ocean to the east (Figure 1).

Tanzania mainland has an area of about 931,000 sq. km of which 886,000 sq. km is land, the rest is water. 23% of the land is allocated to reserve areas such as national parks and forests. Only 5% of the land area is cultivated. The rest is pastureland. The islands of Zanzibar have an area of 2,611 km^2 (NBS, 2011). According to a 2012 census, Tanzania had a population of 45 million (NBS, 2012). In 1964, Tanganyika united with the isles of Zanzibar and became the United Republic of Tanzania. Zanzibar has its own cadastral system. Therefore, the land information described herein does not include the isles.

Tanzania's economy depends heavily on agriculture, which accounts for about one-third of GDP, provides 85% of exports, and employs about 80% of the work force. Tourism is growing in importance and ranks as the second highest foreign exchange earner after agriculture. Mineral exploitation (gold, diamonds and tanzanite) has increased significantly in the last decade. Tourism is Tanzania's biggest source of economic growth. It provides over 3% of the GDP, and accounts for half of Tanzania's exports (CIA 2013). Agriculture being the main economic sector, proper management of land is critical for the nation's sustainable economic development.

Major land reforms in Tanzania were introduced as a result of the Land Policy of 1995 and the subsequent land laws of 1999, namely Land Act No. 4 of 1999 (Cap 113) and Village Land Act No. 5 of 1999 (Cap 114). Other laws include Land Use Planning Act No. 6 of 2007, Urban Planning Act No. 8 of 2007, The Unit Titles Act, The Mortgage Financing Act, Survey Ordinance Under revision and Valuation Bill.

Prior to the Land Policy of 1995, bare land had no value in Tanzania. The value of land was determined on the basis of existing improvements (developments) made on the land such as buildings and crops. One of the most remarkable reforms in the Tanzanian land policy was the recognition that bare land has monetary value and that it can be transacted much like any asset.

The increased value for both land and land related properties as well as a fast growing population has tremendously increased demand for land. Also, land related transactions involving sale, transfer, and mortgage of land has increased (Derby, 2002). This increase has contributed to problems in operational processes and handling of different transactions in land, poor storage of land records and general inefficiency in delivering core land administrations functions.

Remarkable efforts to computerize land records as a way of improving land delivery services at the Ministry of Lands, Housing, and Human Settlement Development (MLHHSD) began in 2002. From 2002 to date, the following applications have been developed and are currently in operation;

(i) Land Rent Management System (LRMS) – This is an in-house developed application which assists in assessing, collecting, and keeping records related to land owners and respective land rent payment data. LRMS is a standalone system, and currently has been deployed to 40 out of 130 local authority land rent collection centers.

(ii) Surveys Registration System (SRS) – This was also developed in-house and is used to manage and speed up the entire process of submission, checking, approving, and registration of all cadastral surveys throughout the country. Checking, approval and registration of cadastral surveys is currently centralized at the Surveys and Mapping Division (SMD) of the MLHHSD.

(iii) Management of Land Information System (MOLIS) – This is a web-based land information system developed by a consultant. The system is being used for performing most of the land management functions at the MLHHSD, and the three municipal councils of Dar es Salaam city. LRMS has been integrated in MOLIS.

The above mentioned applications operate in isolation and some functions, which are essential to realize an electronic Land Information System, are still being carried out manually. A critical setback of the existing land information system is lack of a direct link with digital cadastral information. MOLIS operates only with alphanumeric data. All spatial information is handled and processed manually. This is a major hindrance to effective service delivery due to increased time spent on searching and processing manual cadastral information (paper-based maps). That is why, despite all the above mentioned efforts to computerize land delivery services, efficiency has not improved satisfactorily. At present, issuance of a title deed may take about six months compared to the previous period of one year. Still, this is seen as a very long period and Tanzania has a long way to go in terms of registering land and improving land information systems (Kironde 2009).

To address challenges of the land sector in its effort to provide better land management services to the public, the Tanzanian government has initiated a project to develop an Integrated Land Information System. ILIS is expected to address all functions of the land sector. It will provide tools for handling land management functions; namely town planning, cadastral surveying and land delivery services.

The ILIS development project is divided into two phases- design and implementation phases. The design phase started in July 2012. The implementation phase is expected to be completed after 18 months. The project is overseen by the Ministry of Land, Housing and Human Settlements Development (MLHHSD) responsible for land management and administration.

Spatial Data Infrastructure and Land Information System

Spatial data creation and use is increasingly becoming more popular in recent years. In simple terms data or an entity is spatial if it has shape and location, and thus can be represented by a symbol on the map. Based on this understanding of spatial data, it is evident that most of the data handled in information systems is spatial in nature. Humans live and work in certain places, all base maps, cadastral maps and so on, are intrinsically spatial information.

After societies realized the usefulness of attaching spatial attributes to business entities and creating thematic maps, the concept of spatial data infrastructure (SDI) was coined. It has been given a number of different definitions. One of them says SDI is an initiative intended to create an environment that will ensure that a wide variety of users who require coverage of a certain area will be able to access and retrieve a complete and consistent datasets in an easy and secure way (Rajabifard, 2002). According to another definition, SDI is "coordinated series of agreements on technology standards, institutional arrangements, and policies that enable the discovery and use of geospatial information by users and for purposes other than those it was created for" (Kuhn, 2005).

The main components of SDI can be categorized as people, policy, standards, access networks, and data. The nature and relationship between the components can be summarized as follows; people (data producers, value-adders and data users) can access and use spatial data by means of technology through well defined policies on standards and access networks. SDI core components have a dynamic nature due to the fact that technology which affects all the components changes from time to time. Likewise, people's requirements on spatial data change with time as well as jurisdiction. See Rajabifard (2002) for a detailed treatment of SDI components. Figure 1 shows the general SDI model, including the SDI core components.

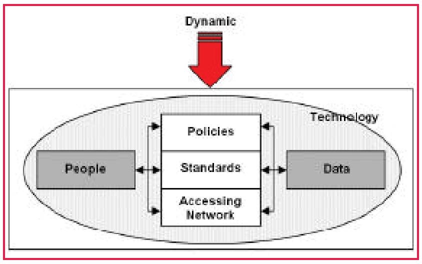


Figure 2: SDI core components (After Rajabifard, 2002)

SDI can be created for smaller levels or jurisdictions, but usually it is thought to be a national level infrastructure and is comparable to other kinds of infrastructures like road or electricity networks. On the basis of the above considerations, following elements can be agreed, standardized, and shared as part of a national spatial data infrastructure for Tanzania:

(i) Spatial data (information), and the metadata cataloging and describing it
(ii) Tools and technical platforms for creating, editing, publishing, and sharing spatial data
(iii) Technology standards (including data and data exchange models)
(iv) Institutional arrangements (like agreement on spatial data providers)
(v) Land information policies

Challenges of National SDI development in Tanzania

Creating SDI is usually a government project. Examples are the National Spatial Data Infrastructure (NSDI) in United States, Canadian Geospatial Data Infrastructure (CGSDI), Australian Spatial Data Infrastructure (ASDI), and the European Commission INSPIRE initiative (Hall, 2003).

Efforts to develop a national SDI in Tanzania have not yet been successful. These efforts can be traced back to 2003, when a Steering Committee was set up in March 2003 to oversee the development of the proposed NSDI (Mtalo, 2003). The committee comprised volunteers who had the technical know-how but unfortunately had no resources at their disposal to make substantial progress. Apart from an SDI draft policy prepared in 2005, no further progress of the National SDI initiative has been reported to-date.

The challenges of NSDI development in Tanzania have been studied by Hagai (2010), Kalunde and Ondulo (2006), Johansson (2005) and to a great extent seem to be a result of limited knowledge and general lack of awareness on SDI. Other major factors reported include lack of a National SDI Policy, limited funds to sustain SDI; lack of institutional leadership to coordinate SDI development activities, and lack of political commitment. This is in agreement with other studies such as Clausen (2006), Nedovic et al (2004) which point out that awareness is a critical motivate for adoption and development of SDI.

The relationship between LIS and SDI

The importance of the relationship between LIS and SDI was underscored by the Bogor Declaration on Cadastre Reforms in 1996, which stated that the spatial cadastral framework usually a cadastral map – should be a fundamental layer within a national SDI (FIG, 1996). In Tanzania, the Ministry for Lands, Housing and Human Settlements Development (MLHHSD) is a key provider of spatial data and the integrated LIS will therefore be a basic pillar of SDI. Outcomes of ILMIS project can be utilized to build the basics of a national spatial data delivery platform and national SDI. Therefore ILMIS must implement the following basic SDI information system components:

(i) A spatial data repository
(ii) Application software for creating and updating data
(iii) Processing services like datum and projection transformations
(iv) A geo-portal for searching, browsing and querying metadata, services, and resources
(v) Internet services for publishing and delivering data
(vi) Application software for accessing and analyzing spatial data

Spatial standards

Spatial data in ILIS must conform to a number of standards in the form of either ISO standards and/or OGC standards. Client and server components

Table 1: Spatial Standards

SN	Standard	Reference
1	WMS (ISO 19128)	**Web Map Service** WMS is a service that delivers tiled or un-tiled graphics. http://www.opengeospatial.org/standards/wms
2	WFS/ WFS-T (ISO 19142)	**Web Feature service (Transactional)** WFS (-T) is a service that delivers geometry in the form of GML (see below). It can offer the possibility to create, update and delete geometry (Transactional). http://www.opengeospatial.org/standards/wfs
3	WMTS	**Web map tile Service** A tile cache service is often used in order to avoid the rendering of static geometries more than once. http://www.opengeospatial.org/standards/WMTS
4	Simple Feature Access (ISO 19125)	**Simple feature access** It is a standard for storing and querying geometry data. http://www.opengeospatial.org/standards/sfs
5	CS-W	**Catalog service for the Web** A catalog service is used to publish metadata about geodata. http://www.opengeospatial.org/standards/specifications/catalog
6	OGC-KML	**OGC Keyhole Markup Language** Is a vector data format http://www.opengeospatial.org/standards/KML
7	WCS (ISO 19128)	Web Coverage Service http://www.opengeospatial.org/standards/WCS
8	GML (ISO 19136)	Geographical Markup Language http://www.opengeospatial.org/standards/GML
9	Metadata (ISO 19115 & 19139)	**Metadata** http://en.wikipedia.org/wiki/Geospatial_metadata

must be able to work with some or all of the standards listed in Table 1.

The most important spatial data standards, namely the Land Administration Model, Geodetic Reference Frame and Unique Parcel Identification System are discussed in the following paragraphs.

Land Administration Domain Model

One of the most important international standards to be part of Tanzanian SDI is ISO 19152. Land Administration Domain Model (LADM) was approved recently in November 2012. It defines terminology for land administration and provides an abstract conceptual model (see Figure 3) with four packages;

1) Parties (people and organizations)
2) Basic Administrative Units (BAU), (condominium, farm lot, etc.)
3) Rights, Responsibilities and Restrictions (RRR)
4) Spatial Units (parcels and the legal space of buildings and utility networks), Spatial Sources (surveying) and spatial representations (geometry and topology).

LADM is a standard that describes spatial data and provides a technical model for storing spatial data, documents, and related property rights. Van Oosterom et al (2011) prove that the LADM is very versatile in adapting to different data needs. It is therefore highly recommended that ISO 19152 LADM should be adopted as one of the first standards in Tanzania national SDI.

Geodetic Reference Frame

Defining a Geodetic Reference Framework consists of defining ellipsoid, datum, projection, and coordinate system. Two common frameworks in Tanzania are the Local coordinate system and Universal Transverse Mercator (UTM). The local coordinate system includes different projections for each specified locality, usually an urban area, and frequently

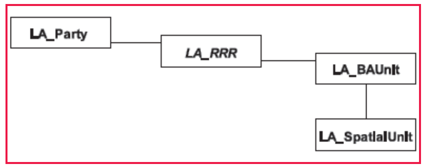


Figure 3: Basic Entities of LADM

different projections for different areas within the country. If all official geographic measurements within a country are made in the same measurements framework, the resulting maps, geo-referenced aerial photographs, and satellite images are compatible and can be layered on top of each other without any extra preprocessing and conversions.

Establishment of a new geodetic control network for Tanzania based on the international WGS 84 reference datum as part of the African Geodetic Reference Frame (AFREF) initiative started in 2006, and is expected to be completed in June 2013. The objective of the AFREF initiative is to unify and modernize the geodetic reference frame for Africa, and the national and regional reference networks. When fully implemented, it will consist of a network of permanent GNSS/GPS stations whose generated data would be freely available to users anywhere in Africa (RCMRD, 2007). It is highly recommended that MLHHSD should declare this as the official coordinate systems and transformation parameters should be made available for conversion from old reference systems to the new coordinate systems and projection.

National Level Unique Parcel Identifier

Currently, there is no nationally adopted numbering system for parcels. In order to create a software system that handles parcels centrally and in order to ensure the uniqueness of each parcel, such a numbering system should be adopted and enforced in Tanzania. According to IAAO (2012), the desired characteristics of Unique Parcel Identification Number (UPIN) are;

Uniqueness, there must be an assured one-to-one relation between parcel and parcel identifier; Permanence, parcel identifiers should not be allowed to change once they have been assigned a parcel; Simplicity, parcel identifiers should be composed of as few digits as possible; Ease of use, it is preferable that parcel identifiers is human readable i.e., that one can infer location from the components of the identifier.

Despite many options and problems in each of the numbering types as elaborated in IAAO (2012), a standard for national parcel numbering should be like the standard geodetic reference frame that is defined and put in place before ILIS implementation.

Strategies towards a political win to national SDI development

Strategies to win political support for development of a national SDI in Tanzania are based on increasing awareness to policy and decision-makers not only on the benefits of SDI, but also on the costs or penalty that the government incurs as a result of not acting to address SDI issues. In the first approach, advocacy for SDI is based on explanation of both tangible and intangible benefits of SDI to the society using cost-benefit models, see Craglia and Campagna (2009), and Craglia, and Johnston (2004). The second approach tries to present to decision-makers the costs or welfare loss that the government (and society) incurs as a result of operating without SDI (Mwaikambo and Hagai, 2011). The challenges of developing an ILIS in an environment operating without SDI being discussed here are typical examples of the costs (inconveniency experienced) as a result of not acting to address SDI.

Therefore, as part of the strategy to win political support for SDI development, ILIS project should help speed up formulation of SDI policy by creating awareness on the critical need of SDI for efficient and effective functioning of ILIS. Accessibility of land information and an effective linkage of ILIS with other Ministry Departments and Agencies (MDAs) require the support of a national SDI. MDAs provide ILIS with critical information such as place names and addresses, political/administrative boundaries, citizenship status, social-economic and demographic data.

The absence of a SDI hinders effective operation of a land administration system in Tanzania and impedes seamless ubiquitous accessibility of land information, thereby jeopardising effective land delivery services to the public. This is an example of the costs of not acting to put in place a national SDI. Development of a national SDI will help minimize further incurrence of such costs now and in future.

It was noted in the previous sections that lack of awareness and motivation is a major setback for development of a national SDI in Tanzania. In fact in many countries, SDI is yet to be recognized as an enabling platform for land administration (Steudler, 2004) since less than 5% of SDI nodes worldwide support land administration (FGDC, 2007). Therefore, the ILIS project can instigate SDI development by helping to create awareness on the need for a national SDI to support effective functioning of the ILIS. This can be done during stakeholders meetings throughout the ILIS project. The main agenda for the SDI awareness campaign should include fast-tracking formulation and adoption of a national SDI policy.

Conclusion

The concepts of LIS and SDIs are very similar, especially when referring to Tanzania whose major sector of the economy is agriculture. One of the main aspirations of Tanzania as a nation is to transform the current low productivity agricultural economy to modernized and highly productive agriculture by 2025. Modern agriculture can thrive better when there is proper management and administration of land. An LIS is seen as an indispensable tool for effective and efficient land management to ensure security of land tenure, free from land conflicts and minimal bureaucracy in land delivery services. Likewise, the Tanzania national SDI should support efforts to fulfill the country's vision by ensuring easy access to and sharing of spatial data including land information. SDI and LIS are interdependent; LIS would be part and parcel of national SDI (node).

Developing ILIS without SDI in place poses challenges which must be addressed in order to design and implement ILIS in such a way that it complies with SDI standards. In places where ILIS is not properly aligned with SDI, there is a possibility of conflicts and duplication of efforts. On the other hand, development of ILIS should act as a catalyst to make headways for SDI development.

This study has identified three aspects where development of a national SDI can take full advantage of the integrated LIS development project in Tanzania. Firstly, there are several existing elements which have been developed as a result of legacy LIS and could be leverage for national SDI initiative. These include; land policies and institutional frameworks, access networks, and availability of core spatial data e.g., topographic maps, geodetic control network, and cadastral information. Secondly, most of the standards needed by ILIS will also be very useful for the national SDI. Thus, when these standards are implemented in ILIS, they will be adopted for use in the national SDI as well, reducing both cost and effort. The standards include the WGS 84 geodetic reference framework, Land Administration Domain Model, and Unique National Parcel Identifier. The third aspect relates to raising SDI awareness among policy and decision-makers, and general public. ILIS project provides a platform for raising awareness on the critical need of national SDI for efficient and effective functioning of ILIS during stakeholder's conferences and workshops.

Successful implementation of an integrated ILIS will create a conducive environment for development of a national SDI in Tanzania, because most of the pillars of SDI in terms of land policies and institutions, core spatial datasets, and standards will be already in place.


PENTAX
W-800
Reflectorless
WinCE Total Station
A truly integrated system
G3100-R1
Positioning System
Precision satellite surveying,
with wireless communications
R-2500DN
Reflectorless Total Station
w/built-in digital camera
Capture the full picture!
BL-100
Digital
Automatic Level
Increase your Efficiency!

Recommendations

In order to ensure successful implementation of ILIS, it is recommended that; the standards at the national level must be defined and published before development of ILIS and SDI. ISO standards and/or OGC can be adopted by ILIS and thus at the moment there is no need of trying to develop new standards specific for Tanzania. With the exception of a Unique Parcel Identifier which can be developed within a short period of time.

It is important to ensure that a metadata is available for a smooth realisation of both ILIS and SDI. Use of open-source metadata systems such as *Geonetwork* (http://geonetwork-opensource.org/) is highly recommended because the system has proven to be very useful and has been adopted by the United Nations and other organisations around the globe.

Also it is recommended that conversion of paper based spatial data be done before implementation of the ILIS and must conform to the existing requirement of the cadastral survey accuracy. This is important to ensure that such data could be useful to all stakeholders who have different levels of spatial data accuracy.

References

CIA. 2013, The World Fact Book; Tanzania. Accessed on 10 January 2013. https://www.cia.gov/library/publications/the-world-factbook/geos/tz.html

Clausen,C., Rajabifard ,A., Enemark, S., and Williamson, I. (2006) Awareness as a Foundation for Developnig Effective Spatial Data Infrastructures: Shaping the Change. XXIII FIG Congress Munich, Germany, October 8-13, 2006

Craglia M and Campagna M. 2009. Advanced Regional SDIs in Europe: Comperative Cost-benefit evaluation and impact assessment perspectives'. *International Journal for spatial Data infrastructures research 2007*

Craglia,M and Johnston,A. 2004. Assessing the Impacts of Spatial Data Infrastructures: Methods and Gaps, 7th AGILE Conference on Geographic Information Science, Heraklion, Greece. 29 April-1May 2004

Derby, F. 2002. Improving and Facilitating Land Title Registration Processes in Tanzania. FIG XXII International Congress. Washington, D.C. April 19-26 Registry. http://www.registry.gsdi.org last accessed 11January 2007.

Figure 1996. The Bogor Declaration on the Cadastral Reform http://www.Figure net/commission7/reports/bogor/bogordeclaration.html last accessed on 24 Sep.2012

Hagai, M., 2010. Assessment of SDI Readiness Index: A Case Study of Dar es Salaam City, Tanzania http://www.gsdi.org/sic1 Accessed on 16 May 2012

Hall, M, 2003. Spatial Data Infrastructures in Australia, Canada and the United States. Accessed on 5 January, 2013. http://inspire.jrc.ec.europa.eu/reports/stateofplay/rpAUCAUSAv5.pdf

IAAO (2012) Standard on Digital Cadastral Maps and Parcel Identifiers, International Association of Assessing Officers http://www.iaao.org/uploads/standard_digital_cadastral_mapping.pdf Accessed on 16 May 2012

Johansson, J., 2005. Improving Access to Geographic Information; Exploring the National Spatial Data Infrastructure Initiative in Tanzania. MSc Thesis for the C-Seminar in Peace and Conflict Studies, University of Umeå. http://www.tzgisug.org/wp/%3Fwpfb_dl%3D3 Assed on 15 May 2012

Kalunde,W. and Ondulo J., 2006. Geoinfarmation Policy in East Africa. XXIII FIG Congress, Munich,German, October 8-13,2006

Kironde , J. 2009. Improving Land Sector Governance in Africa: The Case of Tanzania;

Responding to New Challenges" Workshop on "Land Governance in support of the MDGs:Washington DC March 9-10. Last accessed 14 Sep.2012

Kuhn, W. Geospatial Semantics: Why, of What, and How? In Spaccapietra, S. Zimányi, E. (Eds.): Journal on Data Semantics III. Lecture Notes in Computer Science, 3534 (3), 1-24, 2005

Mtalo, E., 2003. Background Paper for the Proposed Workshop on National Spatial Data Infrastructure and Geo-information Management Needs Assessment. Dar-es salaam, Tanzania. 11/March/2003.

Mwaikambo, E. and Hagai, M., 2011. The Need for Assessing Costs of Inefficient Access to Fundamental Spatial Datasets in Least Developed Countries. The First Conference on Advances in Geomatics Research. Kampala, Uganda. August, 2011.

National Bureau of Statistics (NBS).. 2011. Tanzania in Figures. Accessed on 11 May 2012 http://www.nbs.go.tz/takwimu/references/Tanzania_in_Figures2010.pdf

National Bur eau of Statistics (NBS). 2012. 2012 Population and Housing Census. Accessed on 5 January, 2013 http://www.nbs.go.tz/takwimu/references/Tanzania_in_Figures2010.pdf

Nedovic-Budica, Z , Feeneyb, M., Rajabifardb,A., Williamson, I., 2004. Are SDIs serving the needs of local planning? Case study of Victoria, Australia and Illinois, USA. *Computers, Environment and Urban Systems* 28 (2004) pp. 329–351

Oosterom, P. van, Stoter, J., Ploeger, H., Thompson, R. and Karki, S. (2011). 'World-Wide Inventory of the Status of 3D Cadastres in 2010 and Expectations for 2014', paper presented to FIG Working Week 2011, Marrakech, Morocco.

Rajabifard, A and Williamson, I, 2002. Spatial Data Infrastructures: Concept, SDI Hierarchy and Future Directions .Geomatics' 80 Conference, Tehran, Iran April 2002

Regional Centre for Mapping of Resources for Development (RCMRD). 2007. African Geodetic Reference Frame (AFREF)-Newsletter, May 2007, pp 1

Siriba, D. and Farah, H 2008. Mainstreaming Spatial Data Infrastructures in Land Management and Administration. GSDI 10 Conference Proceedings 25-29 Feb 2008.

Steudler, Daniel Rajabifard Abbas and Williamson Ian P. 2004. Evaluating Land

Administration Systems. Journal for land Use Policy. Vol. 21, pp. 371-380.

GLONASS update

GLONASS-K1 to replace an existing GLONASS-M in six months

GLONASS-K1 No. 12 satellite (GLONASS 702K) will be brought into service after a six-month test period and replace an existing GLONASS-M satellite, which will subsequently become a reserve satellite.

"For a smooth transition to a multi-functional group and due to issues with the very complex GLONASS-K2 satellites, we decided to continue with the GLONASS-K1 intermediate range of satellites and we are preparing for the launch of nine units of this series," said Nikolai Testoyedov, CEO of Information Satellite Systems Reshetnev.

Testoyedov recalled that the original plan was to launch only two GLONASS-K1 satellites and then move on to the GLONASS-K2 satellites. "In the beginning, really, we wanted after the two GLONASS-K1 satellites No. 11 and 12, to go for the launch of more advanced GLONASS-K2 devices. But, unfortunately, the plans had to be adjusted somewhat because of the sanctions restricting the delivery of radiation-resistant electronic components from the West. We have to put a hold on the in-depth development of technical and technological documentation and that delays us in terms of moving ahead by at least a year or two."

Agreement between Roscosmos and Transport Ministry

An interagency agreement for the maintenance, development and use of GLONASS was signed Dec. 5 between Russia's Ministry of Transport and the Russian Space Agency, according to Roscosmos. The agreement seeks to increase the efficiency of the use of civilian infrastructure for the development of GLONASS coordinate-time and navigation for the Russian Federation, as well as international cooperation in the field of satellite navigation.

$100 million joint venture in India by GLONASS Union

Russian non-profit partnership GLONASS Union and India's Eirene Systems may set up a joint venture to develop and produce satellite navigation receivers for the ERA GLONASS emergency response system, with about $100 million investments, according to the union's President Alexander Gurko.

"We are joining efforts with our partners from India to develop, produce and implement joint solutions in navigation using our GLONASS technology and Indian own navigation system IRNSS. The sides may develop GLONASS/GPS/IRNSS receivers for markets of Russia, India and the third countries," Gurko said.

GLONASS Union is the sole contractor on the creation of the ERA GLONASS response system, which relays information about road accidents to emergency services. *http://itar-tass.com*

Glonass to provide Brazil with alternative to GPS

"Brazil will have an alternative to GPS as a civil-use localization system. So all Brazilians will be able to access this system, and this will mean an increase in the number of satellites as people will be able to connect to both GPS and Glonass. Also having more localized data and more stability," Geovany Borges, Glonass project coordinator in Brazil said.

Borges, who is also a professor of the University of Brasilia, noted that the mode of operation of Russia's Glonass is similar to that of the GPS. Russia's first overseas Glonass ground station was launched in Brazil in February 2013. *http://sputniknews.com*

Newest GPS satellite goes active

The fourth modernized GPS satellite launched this year has completed in-orbit testing and joined the constellation. Launched from Cape Canaveral atop a ULA Atlas 5 rocket on Oct. 29, the GPS 2F-8 satellite became an active member of the navigation network l, Boeing announced. The Boeing-built Block 2F series of a dozen spacecraft offer advanced atomic clocks, stronger anti-jamming, and a new third civil signal and longer design life. *http://spaceflightnow.com/*

China to roll out own Global Navigation System by 2020

China's Beidou system will be fully operational by 2020, Xinhua news agency reported citing the head of China Aerospace Science and Technology corporation.

"The system's completion will help nurture a satellite navigation industry chain, producing economic and social benefits in diversified fields, including mapping, telecommunications and disaster relief," Lei Fanpei, said. *http://sputniknews.com/*

India to launch 4 navigation and 5 foreign satellites in 2015, says ISRO chief

ISRO will launch five foreign satellites apart from its own four navigation satellites and a communication satellite in 2015.

"We will be completing the IRNSS (Indian Regional Satellite Navigation System) constellation by launching four more satellites and operationalise the navigation system. The geosynchronous satellite launch vehicle (GSLV) rocket is getting ready to launch GSAT-6 communication satellite," ISRO chairman K Radhakrishnan said. He said astronomy satellite Astrosat will be launched in 2015. *www.ndtv.com*

FCC to authorize foreign GNSS signals for use in US

A rule largely aimed at opening trade in telecommunication services will require

Russia and other international providers of GNSS services to apply for authorization before their navigation signals can be legally used in the United States, according to a Federal Communications Commission (FCC) official. The provision will also require manufacturers to get multi-constellation receivers certified for U.S. use. The rule, which is implemented and enforced by the FCC, has its roots in the World Trade Organization Telecom Agreement of the late 1990s. It has only recently become an issue for the satellite navigation community as non-GPS GNSS constellations — known as radio navigation satellite systems (RNSS) in the world of radio spectrum regulation — have come into service.

New EGNOS service definition document released

The European GNSS Agency on behalf of the European Commission has released new version for the three EGNOS Service Definition Documents (SDD) already available for the EGNOS users:

- Safety of Life Service SDD (v2.1)
- EDAS Service SDD (v2.1)

These are the current versions in force for each of the EGNOS SDDs.

The EGNOS Service Definition Document (SDD) describes the characteristics and conditions of access to the corresponding EGNOS service offered to users. Each SDD also contains updated information about the EGNOS system architecture and a Signal-In-Space (SIS) characteristic, the service performance achieved, EGNOS interfaces with users and provides information on the established technical and organizational framework, at European level, for the provision of this service. *www.gsa.europa.eu*

GSA earns ISO 9001 certification

The European GNSS Agency (GSA) has been ISO 9001 certified for all its activities. ISO 9001 is an internationally recognised certification of an organisation's quality management system standards. The GSA is one of three EU agencies who are ISO 9001 certified. *www.gsa.europa.eu*

NASA seeks GNSS remote sensing innovations

NASA "seeks innovative approaches to the development of GNSS remote sensing techniques and algorithms to study the Earth's environment from the ionosphere to Earth's interior." The announcement says NASA is seeking to emphasize the use of reflected GNSS signals for the characterization of the Earth's surface and mitigation of natural hazards.

Notices of Intent are requested by January 20, 2015, and the due date for proposals is March 20, 2015. *Visit the announcement page for details.*

Cabs in Delhi and MP in India must have GPS

Delhi transport department, India has announced a modified radio taxi scheme that attempts to bring all app-based taxi services under its ambit. The rules call for mandatory GPS in all taxis, call centres to be run by cab companies, clean fuels such as CNG etc.

The Madhya Pradesh government has made GPS-based navigation system compulsory for all taxis. Police verification of drivers working for car-on-rent and taxi service operators have also been made mandatory. *http://timesofindia.indiatimes.com*

GNSS researchers awarded Water Resources Prize

The GPS Reflections Group at the University of Colorado, Boulder, led by Dr Kristine M Larson, has received the Creativity Prize from the Council for the Prince Sultan Bin Abdulaziz International Prize for Water.

Larson and her colleagues — Dr. Eric E. Small (University of Colorado), Dr. Valery Zavorotny (NOAA) and Dr. John Braun (University Consortium for Atmospheric Research) — were selected for the prize based on their development of a new, unexpected, and cost-effective technique, GPS interferometric reflectometry (GPS-IR), to measure soil moisture, snow depth, and vegetation water content.

FAA to ramp up drone education, regulation

According to Michael Huerta, head of the Federal Aviation Administration, regulations are in place to prevent drones from interfering with large aircraft — but education about drone safety and regulation enforcement needs to be improved in order to actually keep airways safe.

"That is certainly a serious concern and it is something that I am concerned about," Huerta told Candy Crowley on CNN's "State of the Union" Sunday. "That's why we are very focused on education. That's why we're also focused on enforcement. We've enforced hundreds of these cases where we have seen someone operating one of these things carelessly and recklessly and posing the danger to aircraft, and that can't happen."

Since drones have entered the commercial market, the FAA reports pilots have seen up to 25 cases per month of drones flying above the regulated limit of 400 feet, with some flying as high as 2,000 feet in the air. Huerta says the FAA is working to educate people about the dangers of flying drones that high, since enforcement of the small, unmanned aerial vehicles can be difficult. *www.suasnews.com*

Trimble, VDOS, Clayco and Woolpert permitted to fly drones

FAA has rolled out permissions for four companies to commercial operate UAVs/ drones in the US. The permits were granted to Trimble Navigation Limited, VDOS Global LLC, Clayco Inc. and Woolpert Inc., which received two permits. These permissions allow the operators to fly the drones under 55 pounds (25 Kilograms) to fly under the 100 feet (30 meter) with in the line of site of the operator.

Designed to carry astronauts to destinations in deep space, including an asteroid and Mars, Orion was launched from Cape Canaveral Air Force Station in Florida on December 5, a day after the initial launch was postponed. As it returned from its mission and prepared for splashdown in the Pacific Ocean 4.5 hours after takeoff, the GPS/inertial-guided Ikhana was on hand to capture the historic moment on video.

FAA lets Ohio company operate drones for surveying

Southwestern Ohio company will be allowed to fly drones in U.S. airspace for the purpose of aerial surveys. The Federal Aviation Administration(FAA) granted Woolpert Inc. permission to fly the unoccupied aircraft systems in commercial operations. Woolpert is an engineering, architecture and geospatial firm based in the Dayton suburb of Beavercreek. It was among four companies that received regulatory exemptions this week. U.S. Transportation Secretary Anthony Foxx found that the drones do not need an FAA-issued certificate of airworthiness to conduct the work because they don't pose a threat to national airspace users or to national security.

By 2017, Virtual Singapore to be ready

Singapore is likely to see its first 3D city model platform for knowledge sharing and community collaboration by 2017, according to National Research Foundation (NRF). The cost of the project is S$73 million. It will display geometric, geospatial, topographical information ranging from components within a building, down to fine details like type of vegetation and composition of a building's material. The 3D model's realistic representation of physical Singapore will support agencies' modelling, analysis and policy planning, in areas such as urban and infrastructure development, disaster management and homeland security.

Tsunami warning system: India to do 3D mapping of coast

On the 10th anniversary of the 2004 Indian Ocean tsunami, Minister for Science and Technology and Earth Sciences Harsh Vardhan said under the pilot project 3D GIS mapping of Cuddalore and Nagapattinam (both in Tamil Nadu) was being taken up. The workshop was organised at the Indian Tsunami Early Warning Centre to mark 10 years of the tsunami which claimed 2.38 lakh lives in 14 countries. As many as 10,749 people were killed in India. The centre, which is a joint effort of 14 institutions, is pursuing technical enhancements like integration of data from GNSS networks, real-time inundation modelling, location-based warning dissemination systems to improve accuracy and timeliness of tsunami warning. *http://zeenews.india.com*

Odisha, India Spatial Data Infrastructure & State Data Policy

In another bid to facilitate access to Government owned data with the stakeholders for planning, execution, governance and academic purposes, Govt of Odhisha, India have embarked

Galileo update

One Galileo back on track

A European Space Agency (ESA) Galileo satellite that had slipped into an erroneous orbit soon after deployment last August is reportedly back on its feet, so to speak. The unmanned craft sent its first navigation signal in space on Saturday 29 November 2014 after reaching a new target orbit.

A European Space Agency (ESA) Galileo satellite that had slipped into an erroneous orbit soon after deployment last August is reportedly back on its feet, so to speak. The unmanned craft sent its first navigation signal in space on Saturday 29 November 2014 after reaching a new target orbit.

This is the fifth of six satellites to start contributing to the ESA's Galileo global positioning (GPS) network. However the sixth satellite remains unaligned and incapable of inter-satellite communication.

The repositioning commands were a success thanks to the collaborative efforts of the German and French space agencies, and were uploaded to the satellite via an extended network of Galileo ground stations.

Still, it should be noted that this wasn't a perfect recovery. As opposed to the ideal obit that the other four satellites are in, the fifth Galileo will now fly over the same ground location every 20 days. This compares to a normal Galileo repeat pattern of every 10 days. Now we wait for the ESA to attempt to recover their sixth. *www.natureworldnews.com*

ESA receives 10th Galileo satellite

The European Space Agency (ESA) received the Flight Model 6 (FM06) Galileo navigation satellite at the European Space Research and Technology Center (ESTEC) in the Netherlands. The satellite brings to four the number currently at ESTEC as ESA prepares for future launches.

There are currently six Galileo satellites in orbit. ESA launched the satellites two at a time in 2011, 2012 and 2014. The most recent Arianespace Soyuz launch delivered the latest two satellites into the wrong orbit due to a malfunctioning upper stage, however ESA was able to raise the fifth satellite's orbit to allow checking of its navigation payload.

ESTEC officials have completed the acceptance testing for FM03 and FM04, and recently completed FM05's thermal vacuum trial. FM05 will proceed through radiofrequency testing after Christmas. The latest arrival, FM06, will undergo thermal vacuum testing in January.

OHB in Germany is building 22 Full Operational Capability (FOC) satellites with navigation payloads from SSTL in the United Kingdom. ESA and the European Commission are currently planning the launch schedule for Galileo. *www.satellitetoday.com*

upon establishment of Odisha Spatial Data Infrastructure with a distinct Odisha Data Policy. The draft data policy prepared has been preparedby ORSAC

State has decided to launch State Data policy on the principles of avoiding redundancy, allowing openness, interoperability and improving the quality and utilization of Govt owned data base. The objective is to facilitate accessibility of data base to all the stake holders, projection of data on a common electronic platform and sharing of authentic data for the purposes of supporting inclusive growth and good governance.

RMSI launches ConflateX™

RMSI has recently launched ConflateX™, a scalable data conflation solution that addresses the key business challenges of improving spatial accuracy and data integrity of network assets by aligning them to a more precise and accurate real world system. It helps organizations to deploy integrated, more spatially accurate network data. This helps them in managing reliable asset networks efficiently while meeting stringent safety and regulatory requirements.

SuperGIS 3D Earth Server updates with stronger functionality

Supergeo Technologies has released the latest SuperGIS 3D Earth Server 3.2 with diverse enhancements and structure modifications to elevate user experience of 3D GIS data viewing. It is the enterprise GIS sever that allows organizations to display and share huge geospatial data in 3D view, a breakthrough technology in traditional GIS systems. *http://www.supergeotek.com*

NASA's Ikhana UAS captures Orion Splashdown

As NASA's new exploration spacecraft Orion made its way back to Earth from its first test mission, the Ikhana unmanned aircraft system captured its return—making it possible for NASA to stream the parachute deployment and splashdown footage on live television.

Facebook using GPS, WiFi, Bluetooth to personalize experience

Facebook is getting even more up close and personal. The main policy change that seems to have grabbed the most intrigue is that It will be using GPS, Bluetooth and Wi-Fi signals to personalize your Facebook experience. But, the info they're gathering on you is actually nothing that new — what they'll be doing with it is. It says it will be giving it to marketers in hopes of providing more targeted, and even area-specific ads. Facebook will also use it to connect you with friends nearby. This is a service they already provide if you choose to participate. *http://wwlp.com/*

MapmyIndia to provide GPS navigation on Tata Bolt

LBS and maps company MapmyIndia has expanded its partnership with Tata Motors to provide GPS navigation in Tata's upcoming hatchback car Bolt. As part of the partnership, MapmyIndia says that Tata Motors' customers will get a MapmyIndia Navigation app specially coded for integration between the user's phone and the in-dash screen. *www.medianama.com*

Baidu Inc Partners with Nokia to improve location services

Baidu Inc partnered with Nokia Corporation to improve its location services for Chinese users travelling overseas. Under the agreement, the Chinese-language internet search provider will use Nokia's HERE maps for its desktop, iOS and Android mapping apps for locations outside mainland China starting with Taiwan. Other countries and territories will follow at the latter stage of the project. *www.valuewalk.com*

Broadcom Introduces GNSS Location Hub for Smartphones

Broadcom Corporation has announced the launch of the industry's first Global Navigation Satellite System (GNSS) location hub for smartphones to support the Galileo satellite system.

The BCM4774 system on chip supports multiple constellations, delivering premium performance and enhanced device intelligence while consuming minimal power. With a planned deployment of up to 30 additional satellites for Galileo, smartphones with built-in support for this new system will experience an even higher level of accuracy and better positioning.

The power-saving abilities of the BCM4774 are a boon for device makers, developers and consumers and reduce power consumption up to 95% by offloading calculations from the application processor (AP).

Stesalit India unveils android based mobile mapping software

Stesalit has introduced the SXgeoCloud mobile mapping software that provides GIS data collection suite and with active sync to enterprise GIS systems, such Esri Geodatabase as through a mobile and cloud architecture. SXgeoCloud currently is available with the Sxtreo series of GPS/GNSS devices from Stesalit to its Indian customers.

FARO® CAM2® SmartInspect 1.2

FARO Technologies, Inc has released FARO CAM2 SmartInspect 1.2, the industry's first full-featured portable software for basic geometric measurements without CAD, for FARO Laser Tracker and FaroArm. This release reinforces FARO's continued commitment to simplify 3D measurement. The CAM2 SmartInspect 1.2 can now interface with the FARO Laser Tracker, to provide a simple and efficient solution for those who require the accuracy and large measurement volume provided by the capabilities of the laser trackers, but not the complexity of CAD-based software. *www.faroasia.com*

Integration of Hyperspectral and NDVI Sensors with EnsoMOSAIC Survey System

MosaicMill has integrated Rikola hyperspectral and Nikon D800 CIR sensors with EnsoMOSAIC manned survey system. Dual sensor system enables simultaneous collection of 35 Mpix CIR/RGB images and 1 Mpix 40-band hyperspectral images. Data from both sensors are processed into seamless orthomosaics with EnsoMOSAIC image rectification software and into point clouds and elevation models with EnsoMOSAIC 3D software. This integrated system can be installed into practically any aircraft, including mono and bimotor Pipers and Cessnas as well as ultra light vehicles.Two sensor system has major advantages in forestry and agriculture mapping as CIR/RGB images can be used for canopy surface modeling and vegetation index calculations.

Debate on US discrimination of Glonass system in UN

Moscow intends to bring the issue of alleged discrimination against GLONASS by the US to the United Nations, according to GLONASS Union President Alexander Gurko.

"This is the first-ever case of introduction of licensing and certification of navigation systems. If the United States decides to license providers of the global navigation satellite systems, certify multisystem receivers, and impose restrictive measures against GLONASS… a danger of discrimination against using GLONASS will be created," Gurko said. *http://sputniknews.com/*

Russian Resurs-P satellite of remote sensing put in orbit

Russia's satellite of remote sensing of the Earth Resurs-P number 2 has separated from the Soyuz-2.1b carrier rocket and reached the designated orbit, a spokesman for the Russian Space Agency told TASS. The satellite is designed for detailed, broadband and hyperspectral opto-electronic surveillance of the Earth surface. These data will be used by Russia's ministry of natural resources, hydrometeorological service, emergencies ministry, ministry of agriculture, federal agency for fisheries and others. The satellite also has Nuklon equipment to explore outer space and register radiation. *http://itar-tass.com/*

Optech announces Titan multispectral airborne lidar sensor

Optech has announced the latest addition to its innovative line of airborne laser terrain mappers (ALTM), the Optech Titan, launching a new era in remote sensing. For the first time ever, multispectral active imaging of the environment can occur day or night, enabling new vertical applications and information extraction capabilities for lidar.

China launches remote sensing satellite

A Long March-4B rocket carrying the Yaogan-26 remote sensing satellite blasted off from the launch pad at the Taiyuan Satellite Launch Center in Taiyuan, capital of north China's Shanxi Province, Dec. 27, 2014. Yaogan satellites are mainly used for scientific experiments, natural resource surveys, crop yield estimates and disaster relief.The satellite will mainly be used for scientific experiments, land surveys, crop yield estimates and disaster prevention. *http://english.cri.cn/*

Brazil's INPE provides Indian satellite images

The National Institute for Space Research (INPE) has started the processing and distribution of Indian satellite data ResourceSat-2. The images can be accessed for free through INPE's official portal. Developed by India, ResourceSat-2 satellite has three imaging cameras: LISS-3, LISS-4 and AWIFS. The data will be distributed in Brazil by INPE the Advanced Wide Field Sensor (AWIFS) data, which has spatial resolution of 56 meters and LISS-3, with a spatial resolution of 23.5 meters.

63rd successful launch in a row of Ariane 5

Ariane 5 has been successfully launched from Kourou, French Guiana, for the 63rd time in a row, developed and built by Airbus Defence and Space. The required performance for this, the 221st Ariane flight – for which Arianespace conducted the launch operations – was to transport 10,210 kg into geostationary transfer orbit, with the two satellites weighing a total of 9,480 kg. The remaining mass was for the SYLDA dual launch system and the satellite integration hardware. *www.astrium.eads.net*

L'Avion Jaune Selects Septentrio's RTK Technology for YellowScan

Septentrio has announced that L'Avion Jaune, a leading service provider and airborne sensors integrator in the field of aerial surveys with a decade of experience in UAV technologies has selected the Septentrio AsteRx-m™ for its robustness and low-power consumption, to equip the YellowScan system, which is the world's lightest all-in-one solution designed to deliver quality aerial surveys carried out using a LiDAR sensor aboard UAVs. The self-contained system integrates into a small package all the necessary equipment for conducting airborne surveys: a 3D laser scanner, an AHRS, a controller, an autonomous power supply module and the AsteRx-m™, a high-performance precision GNSS receiver. *www.septentrio.com*

High Accuracy GIS Total Solution by FOIF SuperGIS

Supergeo Technologies has announced the cooperation with Suzhou FOIF Co. (FOIF) in providing worldwide surveyors with high accuracy GIS turnkey solution.

Having more than 50-year experience in geo-related surveying equipment manufacturing, FOIF presents gyroscope station, total stations, theodolites, laser products, GNSS and so on. By collaborating with FOIF, a reputed and professional hardware provider, Supergeo is able to provide users around the world with a complete GIS solution. FOIF is offering a special offer for worldwide GIS users. www.foif.com

Vector V104™ GPS Compass

Hemisphere GNSS has announced Vector V104, the world's smallest high-accuracy, dual-receiver GPS compass and the latest addition to its innovative precise heading and positioning product line. Based on the company's patented Crescent® Vector™ technology, the Vector V104 integrates two GPS antennas, a multi-axis gyro, and a tilt sensor into a single, easy-to-use system. The dual integrated antennas provide both heading and position data, and the gyro and tilt sensor improve system performance and provide backup heading information if the GPS-based heading is ever lost. The Crescent technology provides highly accurate code phase management and outstanding multipath mitigation. This results in excellent accuracy and stability, enabling the user to install the V104 in areas where competing products have difficulty.

FOCUS 30 Robotic Total Stations aid Saskatchewan Bridges

Across the vast remote prairies and boreal forests of Saskatchewan lie numerous bridges, large and small, traversing the drainage basins of this huge landlocked province. Building and repairing bridges is a continuing important task for Canada Bridge, a division of Minty's Moving. With the acquisition of the Spectra Precision FOCUS 30 total station, a fully motorized robotic solution, bridge positioning and elevations are achieved with a new level of accuracy and efficiency. The result is fewer problems: better bridge alignments and elevations for smoother rides, and lower longer-term maintenance costs.

SP80 GNSS Receiver Tops Five in Sarawak Rainforest Competition

When the Land Survey Department of Sarawak, Malaysia wanted to upgrade its cadastral survey capability, it held a competition among six leading brands to determine the best GNSS receiver for its needs. The clear winner in all seven of the benchmark test was the Spectra Precision SP80 GNSS receiver. The test took measurements to two points each more than 13 km distant. The Spectra Precision SP80, with its

240-channel chipset optimized for tracking and processing signals from all GNSS constellations, won this contest repeatedly with all measurements within five millimeters of the known distance.

Leica GR10 & GR25 Unlimited reference receivers

Leica Geosystems has extended its Spider product family with the new GNSS Unlimited for the Leica GR10 and GR25 GNSS receiver series, allowing receivers to be upgraded to the latest technology standards at any time. Both receivers are especially designed for Continuously Operating Reference Stations (CORS) infrastructure and monitoring applications, supporting GPS, GLONASS, Galileo, BeiDou and QZSS. In addition, the classic Leica GRX1200+GNSS has been enhanced to support the Chinese BeiDou navigation system.

COWI to operate two new Leica ALS80-HP scanners

COWI, based in Denmark, is the first mapping company in Europe to start operating two new Leica ALS80HP airborne scanners. The new advanced technology will be used for large area scanning as well as forest assessment, and supporting engineering design services. *www.leica-geosystems.com*

GNSS Timing Products for LTE Market by Trimble

Trimble has introduced a new portfolio of time and frequency products to address the synchronization needs of the growing LTE small cell market. The products are designed for a wide range of small cell synchronization applications. The products provide increased holdover capabilities and more robust signals with multi-constellation GNSS technology to sync wireless networks more efficiently.

Automation in Trimble Positions Software Suite

Trimble has announced a new version of its Trimble® Positions™ software suite. It includes automated workflows to streamline data collection and increase productivity for GIS professionals in a variety of industries such as utility companies, environmental management agencies and municipalities.

With Trimble Positions, GIS professionals benefit from increased productivity through a streamlined and integrated workflow for managing GNSS data collection. Trimble Positions is a collection of Esri software extensions that provide high-accuracy capabilities on the Trimble GeoExplorer®, Juno®, and Yuma® series of field handheld computers, and on Trimble Pro series receivers. *www.trimble.com*

USDA certifies CompassData's CompassTA™ Elevation Verification Software

CompassData has announced that its CompassTA™ elevation accuracy software has received OCIO-ITS certification from the U.S. Department of Agriculture (USDA). Certification allows 40,000 USDA users the opportunity to utilize CompassTA software for elevation accuracy verification of LiDAR point clouds, digital elevation models (DEM), and other raster data sets. *www.compassdatainc.com*

Broadcom Seeking to address Pay-TV Piracy with GNSS-Enabled Chipset

Broadcom has combined a GNSS receiver with a satellite Outdoor Unit (ODU), enabling pay-TV operators to geo-lock content to subscribers. The company hopes the new product, which took roughly a year to complete, will reduce the theft of premium video content.

Eos Positioning Launches Arrow High-Accuracy GNSS Receiver

Eos Positioning Systems has introduced a new line of high-accuracy GNSS receivers for smartphones and tablet computers, including both sub-meter and RTK performance for all mobile platforms: iOS, Android, and Windows. The entry-level product, the Arrow Lite, is Bluetooth compatible with all mobile devices. The Arrow 100 is Eos's advanced real-time, sub-meter GNSS receiver that utilizes both GPS and GLONASS, and is expandable to Galileo, Beidou and QZSS. It offers superior tracking under tree canopy, around buildings and in rugged terrain. In addition to supporting SBAS in North/Central America, Europe, Northern Africa, Japan, India and Russia, the Arrow 100 also supports OmniSTAR's worldwide, real-time sub-meter service.

The most advanced Arrow receiver is the Arrow 200, a dual-frequency, multi-constellation RTK GNSS receiver capable of 1-cm accuracy in real time.

Two GNSS New Modules by u-blox

u-blox NEO/LEA-M8T set new industry benchmark for satellite-based precision timing

u blox announces the NEO-M8T and LEA-M8T precision timing modules. The compact, surface-mount modules are able to generate a precise reference clock with <20 ns accuracy.

Northrop Grumman to Supply Navigation System for SBIRS GEO-5 Satellite

Northrop Grumman Corporation has been selected by prime contractor Lockheed Martin to provide its space inertial reference system for the US Air Force Space-Based Infrared System's (SBIRS) fifth Geosynchronous Earth Orbit (GEO) satellite. Northrop Grumman will provide its Scalable Space Inertial Reference Unit (Scalable SIRU) for sensor pointing/stabilisation and attitude control on the SBIRS GEO-5 mission.

Geographic Calculator 2015

Blue Marble Geographics has announced the release of the Geographic Calculator 2015. This major release features several new Administrative Tools, support for Geoid Creation in conjunction with Global Mapper v16, and support for Magnetic Declination. *www.bluemarblegeo.com*

MARK YOUR CALENDAR

February 2015

Smart Future Cities: The Role of 3D Land and Property and Cadastral Information
2-3 February
Melbourne, Australia

The Unmanned Systems Expo
4 - 6 February
The Hague, The Netherlands
http://www.tusexpo.com

International LiDAR Mapping Forum (ILMF)
23-25 February
Denver, Colorado, USA
www.lidarmap.org/international

The International Navigation Conference
24-26 February
Manchester, UK
www.internationalnavigationconference.org.uk/

March 2015

Locate15
Brisbane, Australia
10 – 12 March
www.locateconference.com

Remotely Piloted Aircraft Systems Symposium
23 to 25 March 2015
MontrÈal, Canada
http://www.icao.int/meetings/rpas/

Munich Satellite Navigation Summit 2015
24 – 26 March
Munich, Germany
www.munich-satellite-navigation-summit.org

April 2015

European Navigation Conference 2015
7 – 10 April
Bordeaux, France
http://enc-gnss2015.com/

The World Cadastre Summit, Congress & Exhibition
20-25 April
Istanbul, Turkey
http://wcadastre.org/page/45-en-home

Interexpo GEO-Siberia-2015: Open-Source Geospatial Solutions for Public Benefits
20 – 22 April
Novosibirsk, Russia
http://expo-geo.ru/event/4-Intereksspo_GEO-SIBIR/

2015 Pacific PNT Conference
20 – 23 April
Honolulu, HI United States
www.ion.org/

May 2015

AUVSI's Unmanned Systems 2015
4-7 May
Atlanta, USA
http://www.auvsi.org/

RIEGL LiDAR 2015 Conferences
5 – 8 May
Hong Kong and Guangzhou, China
www.riegllidar.com/

MundoGeo Connect
May 5 to 7, 2015
Sao Paulo - Brazil
http://mundogeoconnect.com/2015/en/

Baska GNSS Conference 2015
10 - 12 May
Baska, Krk Island, Croatia
www.baskagnssconference.org

36th International Symposium on Remote Sensing of Environment
11-15 May
Berlin, Germany
http://www.isrse36.org

FIG Working Week and General Assembly
Sofia, Bulgaria
17 – 21 May
www.Figure net

GEO Business 2015
27 - 28 May
London, UK
http://geobusinessshow.com/

June 2015

HxGN LIVE Las Vegas 2015
1 – 4 June
Las Vegas, Nevada USA
http://hxgnlive.com/las.htm

TransNav 2015
17 - 19 June
Gdynia, Poland
http://transnav2015.am.gdynia.pl

July 2015

13th South East Asian Survey Congress
28 – 31 July, Singapore
www.seasc2015.org.sg

August 2015

UAV-g 2015
30 August - 2 September
Toronto, Canada
www.uav-g-2015.ca

September 2015

ION GNSS+
14-18 September
Tampa, Florida, USA
www.ion.org

INTERGEO 2015
15 – 17 September
Stuttgart, Germany
www.intergeo.de/intergeo-en/

October 2015

Commercial UAV Expo
5 - 7 October
Las Vegas, Nevada, USA
www.expouav.com

2015 IAIN World Congress
20 – 23 October
Prague, Czech Republic
www.iain2015.org

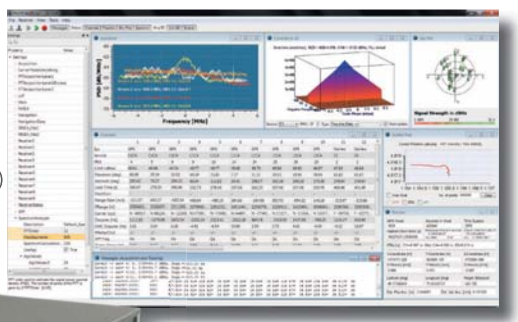
www.ifen.com

300 channels

SX3 - GPS/GNSS Navigation Software Receiver

GPS | GLONASS | Galileo | BeiDou | QZSS | SBAS

- **300 real-time tracking channels (with Intel i7-4790K at 60% CPU load)**
- **4 RF chains with 55 MHz RF bandwidth each**
- Customer extendable capabilities using API (data I/O, signal processing, ...)
- Supports all GNSS bands simultaneously
- Real-time signal and navigation processing



Applications

- **Geodetic reference station**
- Ionospheric scintillation monitoring
- Multipath signal evaluation
- And many more ...

For additional information, contact us.

For Americas
IFEN Inc.
+1 951 739 7331
M.Wilson@ifen.com

For EMEA & APAC
IFEN GmbH
+49 8121 2238 20
sales@ifen.com