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

No: DL(E)-01/5079/17-19
Licensed to post without pre-payment U(E) 28/2017-19
Rs.150

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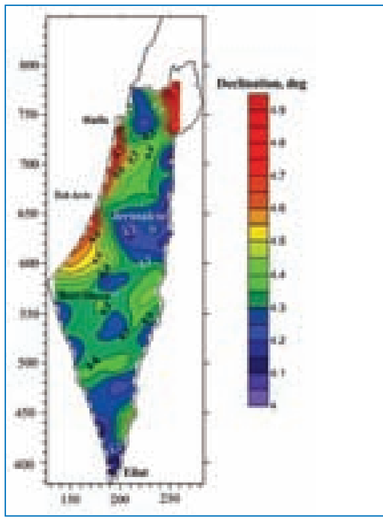
Coordinates

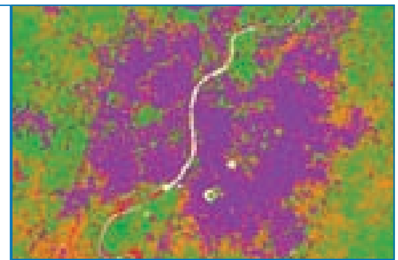
ISSN 0973-2136
Volume XIII, Issue 07, July 2017

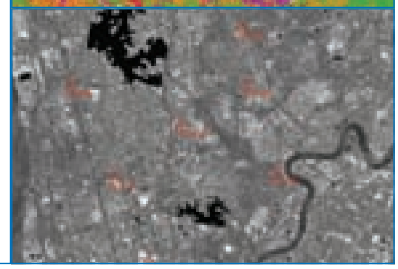
THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

GEOMAGNETIC OBSERVATIONS AND MEASUREMENTS

Positioning, Timing and Navigation System in Ukraine







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This issue has been made possible by the support and good wishes of the following individuals and companies
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Web www.mycoordinates.org

Annual subscription (12 issues)
[India] Rs.1,800 [Overseas] US$100

Printed and published by Sanjay Malaviya on behalf of Coordinates Media Pvt Ltd
Published at A 002 Mansara Apartments, Vasundhara Enclave, Delhi 110096, India.
Printed at Thomson Press (India) Ltd, Mathura Road, Faridabad, India

Editor Bal Krishna
Owner Coordinates Media Pvt Ltd (CMPL)
Designed at Ajay Singh (ajay.springproductions@outlook.com)

This issue of Coordinates is of 50 pages, including cover.

The recent launch of Michibiki 2

And other scheduled launches of

Michibiki satellites later this year,

Not only lead to new vistas of GNSS applications

But will also catalyze and accelerate the phenomena

Where the need is high precise systems

Like in controlling drones, driverless cars, robotics…

Using positioning and navigation technologies

In the land that leads

In automation and innovation.

Bal Krishna, Editor
bal@mycoordinates.org

10th Anniversary

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Geomagnetic Observations and Measurements in Israel

This paper presents a brief overview of the various activities of the Survey of Israel in the geomagnetic sphere, including ongoing and future projects, such as prediction of magnetic declination based on absolute declination annual measurements and formulation of an interactive comprehensive declination model

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One of the oldest studies in geophysical sciences is geomagnetism - the study of Earth's magnetic field, also referred to as the geomagnetic field. The phenomena associated with the geomagnetic field have been researched and monitored for centuries by many countries throughout the globe, mainly for its imperative role in protecting the biosphere of our planet. The surrounding geomagnetic field deflects away from Earth a substantial amount of plasma streamed from the sun in high velocities and extreme temperature – the solar wind. The interaction between the solar wind and the magnetic field of the Earth forms the magnetosphere, without which sun flares would erode Earth's atmosphere rendering it vulnerable to space radiation and thus uninhabitable.

Additionally, there is a strong connection between the discovery and motion of continents as well as exploration of oceans and the probing of the Earth's magnetic field (Wardinski, 2005). Another benefit of geomagnetic studies is the capability they provide to search for mineral aggregates such as metal ores. However, the most popular use of the Earth's magnetic field observations, ever since the discovery that a compass needle does not in fact points to the geographic north, is for orientation and navigation purposes.

Given the above, systematic observation and monitoring of the geomagnetic field are of a great importance. Much effort has been devoted to research in order to further explore and achieve greater understanding of the magnetic field of the Earth.
To this end, observatories worldwide were established as well as designated satellite network and analysis centers.

The Survey of Israel joined the geomagnetic collaboration nearly 40 years ago. Thenceforth its primary goal was to define the direction of the magnetic north in Israel and to determine its yearly variation as well as to carry out geomagnetic measurements, to process acquired data and to provide the data to the global geomagnetic network affiliated with IAGA (the International Association of Geomagnetism and Aeronomy).

Sources of Earth's Magnetic Field

Earth's magnetic field is very complex. It is commonly represented as a superposition of both internal and external sources. While the dominant component of all is, the *Main Field* or the *Core Filed*, which is produced by the electrical currents originated in the Earth's core. According to Paleomagnetic records (*the record of the strength and direction of the geomagnetic filed preserved by rocks – fossil records*), the geomagnetic filed was initially created approximately three billion years ago. However, due to Earth's core characteristics, such as size and electric conductivity, it would have been not able to sustain for billions of years. *Dynamo theory* is an explanation offered by scientists for this phenomenon that suggests a mechanism in the Earth's outer fluid core that constantly generates the geomagnetic *Main Field*. Second contributor to the internal components is the *Crustal Filed*, also known as *Lithospheric* or *Anomalous Field*, which is caused by magnetic minerals in the crust and upper

mantle. The external source called the *Combined Disturbance Field* is the product of electrical currents in the ionized upper atmosphere and magnetosphere (Amm, 2016, Chulliat et. al., 2015). Therefore, the *Total* Earth's magnetic *Field B* (also denoted as *F*) is a vector quantity represented by the sum of its components:
(1) $B_{Total} = B_{Core} + B_{crust} + B_{Disturbance}$

The mathematical methods used to denote the geomagnetic *Main Filed*, are very complex; several models based on spherical harmonic functions can be applied, among them the *International Geomagnetic Reference Field* (IGRF) and *World Magnetic Model* (WMM). However, the *Dipole Model*, which is the first order approximation of the Earth's magnetic field, provides a good description. This model views the Earth, as a spherical magnet whereas the generated filed resembles a dipole, with North and South poles located near the South and North geographic poles respectively. Those are theoretical antipodal poles connected by the dipole axis, which is tilted by about 11 degrees relative to the Earth's rotation axis.

Geomagnetic field components

The Earth's magnetic field is a vector quantity, i.e. it is characterized in a specific point by its direction and magnitude, which has different values at any given time or location. The geomagnetic field can be described by seven elements. These include the *Total Field* (*total Intensity*) - and its three perpendicular components: the *Northerly Intensity* -, the *Easterly Intensity* - and the *Vertical Intensity* (*Down Intensity*) -; the *Horizontal Intensity* - and two direction angels the *Declination* angle *D* and the *Inclination* angle *I* (Wardinski et. al., 2015). The magnitude is generally given in *Nano-Tesla* (nT) and the angular elements are measured in arc *Degrees, Minutes and Seconds* (DMS).

The *Inclination* or the *Magnetic Dip* angle is defined as the angular distance from the horizontal plane to the *Total Filed* vector and receives positive values downwards. Counter to *Geomagnetic Poles*, the *Magnetic Poles* represent the area on the surface of the Earth where *I* is or in other words, the *Horizontal Intensity* of the geomagnetic filed equals to zero.

At any given point on Earth, the compass needle aligns itself with the *Horizontal Component* or the *Magnetic North* direction, which does not coincide with the *Geographical* or the *True North* direction. The difference between these two directions, which is measured clockwise from the *True North* toward *H*, is the *Declination* angle or the *Magnetic Variation*. D is considered negative toward the West.

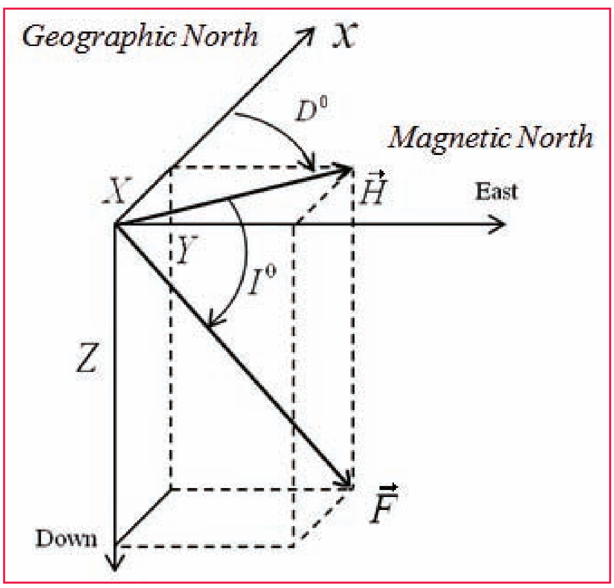

Figure 1: Geomagnetic Field Vector Elements in a Local Cartesian Coordinate System

A *Cartesian Coordinate System*, with *X* axis pointing to the geographical North, Y to the East and Z downward, is often employed in order to represent the Earth's magnetic field parameters, as given in *Figure 1*.

Geomagnetic Measurements

Earth's magnetic field is constantly changes in time. These changes can be classified into two main categories: long-term and short-term variations. The former is referred to as *Secular Variation* and reflects the annual changes in the field. Whereas the latter depicts rapid changes due to magnetic activities. Expression of these changes is manifested in the inconsistent values of the *Declination*.

Earth's polarity is not a constant and has a pattern of pole reversals every 200000 to 30000 years. During the last centuries, the magnetic field has been weakening, which may serve as an indication to yet another approaching pole reversal. Such an event will have devastating implications on life on Earth in general and humankind in particular. Furthermore, in the short run changes in the magnetic field influence numerous applications in navigation practices, equipment calibrations and research in various fields.

Monitoring of the changes in geomagnetic field requires two types of measurements: *Absolute* discrete measurements and continuous observations of field's *Variations*. Absolute measurements, which are commonly carried out on a weekly basis, include the two angular components: *Declination* and *Inclination* (in DMS) and the *Total Filed* magnitude – *F* (in nT). The vector components are then obtained using the following equations:

(2) $X = B * \cos I * \cos D$

$Y = B * \cos I * \sin D$

$Z = B * \sin I$

Magnetic Variations recordings are performed in observatories. The main objective of the geomagnetic observatories is to continuously monitor the changes of the three field's components ΔX, ΔY and ΔZ over long period of time and to maintain the accurate absolute value of the field in a fixed location and at a certain time (Amm, 2016).

Geomagnetic observations in Israel

Magnetic Observations in Israel are performed by the *Survey of Israel*, which is a government agency for Mapping, Geodesy, Cadastre and Geoinformatics. Israel is part of the global network of magnetic observatories and was established with the following objectives in mind:

1. To determine the local magnetic Declination (magnetic North) within the borders of Israel and to monitor its annual changes.
2. To map the geomagnetic field components.
3. To provide data and services to various organizations, such as Israel Defense Force and civil aviation companies.
4. To contribute to the global geomagnetic network by supplying magnetic data to World Data Centers.
5. To provide data for research work in fields of geology, geophysics, archeology, etc. to research facilities both nationally and internationally.
6. To carry out studies in different areas related to geomagnetic field measurements, e.g.: super sensitive magnetic gradiometer, the Dead Sea sinkholes, cosmic weather, geological deep structure, tunnels detection, etc. (Shirman, 2016).

During the period of the British Mandate, the British Admiralty carried out the first geomagnetic measurements of the *Declination* in 1918. Following are the values obtained in several locations along the coastal zone: *Atlit* - 0° 15' W; *Caesarea* - 0°20' W, *Yafo* - 0° 25' W; and *port Yavne* - 0° 20' W. In the years of 1917-1948

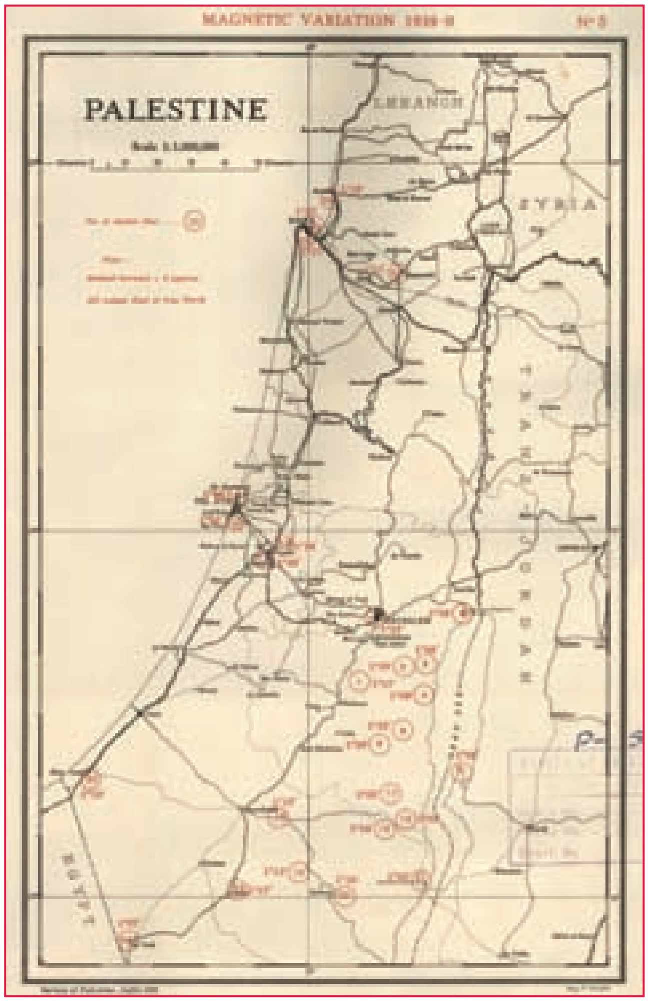

Figure 2: Declination Values – 1939

Magnetic Variation measurements were continued by *Survey of Palestine* at several stations located in the central area of the Mandate territory as well as along the cost.

Figure 2 presents an archive map depicting *Declination* values recorded by the *Survey of Palestine*. It is important to note that all values are East of the *True North*, contrary to the values recorded in year of 1918, with values ranging between and Additionally, the *Declination* value at the coastal area and the central area is about 30'.

Further *Magnetic Variation* measurements were carried out by the *Survey of Israel* in 1958 at three locations along the coast and from there after at the magnetic observatories.

Regular geomagnetic observations in Israel started in 1976 with the

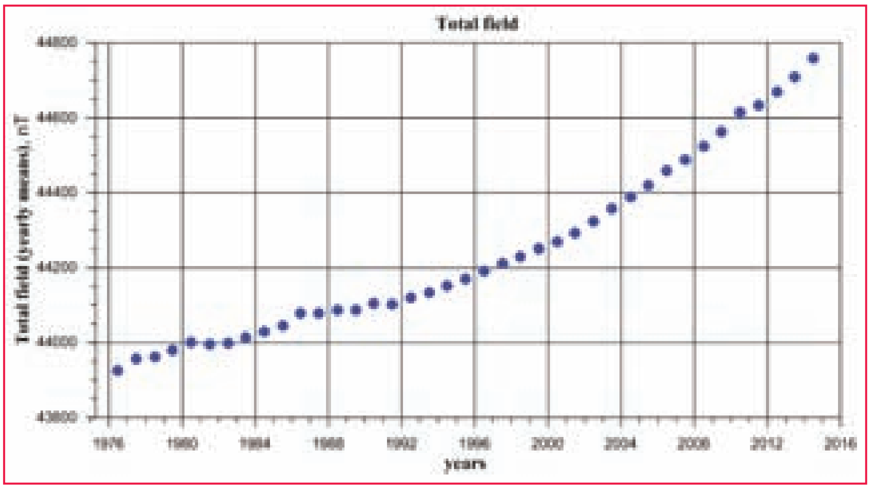

Figure 3a: Total Field Mean Annual Values for the period of 1976–2014

establishment of the *Amatsia* magnetic observatory, located in the center of Israel. The *Bar-Gyora* observatory was opened in 1989 and has been operating simultaneously with *Amatsia* for several years. Presently there are three active observatories, which serve for the purposes of continuous magnetic data acquisition and monitoring: *Mt. Hermon* (in the North), *Bar-Gyora* (in the Center) and *Eilat* (in the South) observatories. *Bar-Gyora* is the central station that provides data to the *World Data Center* along with *Eilat* observatory. Weekly absolute measurements of *Total Field*, *Declination* and *Inclination* are performed at the observatories' locations as well.

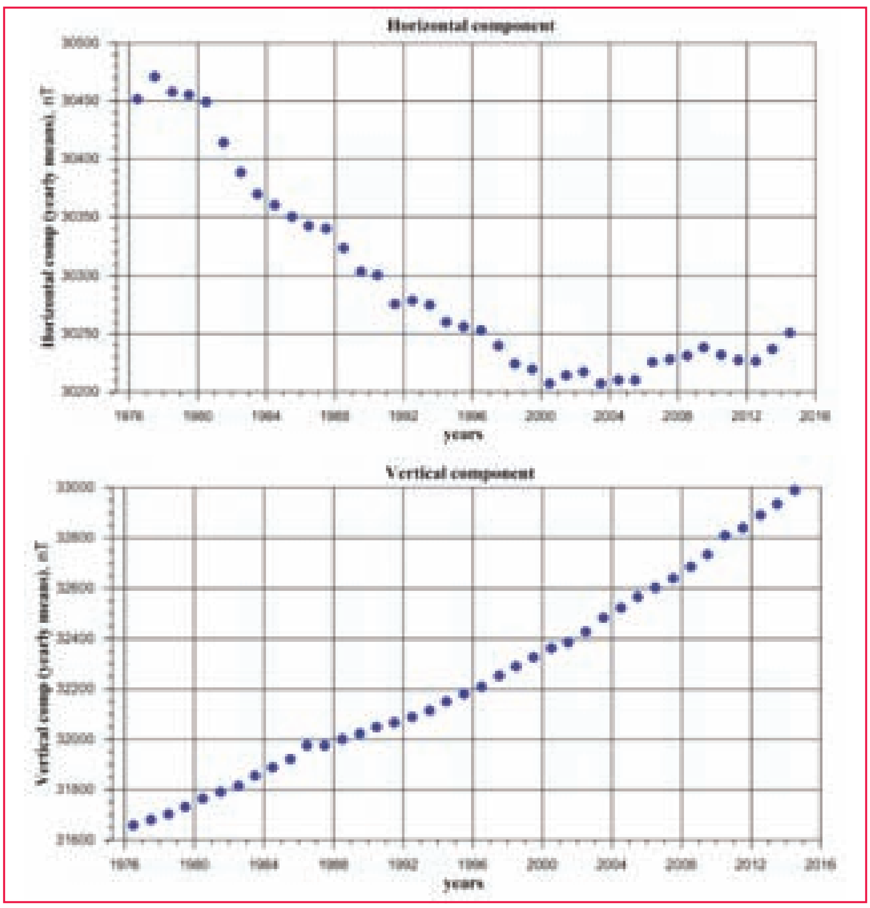

Figure 3b: Horizontal and Vertical Components Annual Mean Values for the period of 1976–2014

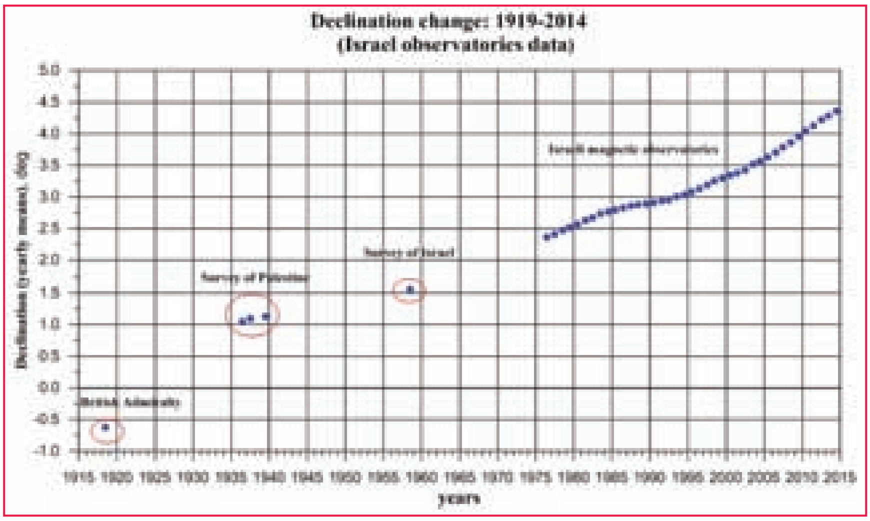

Figure 4: Declination Values for the period of 1918-2014

For the past 40 years, *Research Division* of *SOI* has been responsible for performing geomagnetic observations, processing the acquired data and supplying it to numerous organizations for navigation and mineral exploration purposes, geological and geophysical studies, as well as for various research projects. Following a brief review of the observed data.

Figure 3 presents the *Secular Variations* of the geomagnetic field. The changes are shown in *Total Field* values as well as in *Horizontal* and *Vertical* components (*Figures 3a and 3b* respectively).

It is worth mentioning that contrary to the global trend of decreasing magnetic dipole, the total filed at certain areas, like Israel, is growing stronger.

As mentioned earlier, changes in the geomagnetic filed are reflected in the *Declination* values as shown in *Figure 4*. As can be clearly seen from the chart, over the past century or so, there has been a monotonic increase in *Declination* values. Starting at approximately 0.3 degrees to the West and growing toward 4.5 degrees to the East nowadays. These changes correspond to the *Horizontal Component* decrease at a rate of 5 to 20 nT per year.

Geomagnatic mapping in Israel

One of the most significant efforts undertaken by the *Survey of Israel* is mapping. Given that *Delineation* measurements are vastly used for navigation and cartography, manufacturing of geomagnetic charts is a priority service. To facilitate this requirement a repeat station network was established including *Amatsia* and *Bar-Gyora* observatories. Measurements were performed during two surveys taking place in 1984 and 1993 years.

Figure 5 depicts a map of magnetic declination and the *Total Filed* values. As mentioned previously, *Magnetic Declination* value varies depending on geographic location. It can be seen from the map that for the period of 2014 the *Magnetic Variation* values are changing within the interval of 4.85 to 3.95 degrees throughout the territory of Israel. The *Declination* reaches its maximum level in the coastal zone of the Mediterranean Sea and in the area adjacent to the Golan Heights, whereas its minimum is reached both in the eastern and southern parts of Israel.

The total filed values vary from 42700 nT at the Southern region and rise to 44600 nT toward the Northern part of Israel.

Ongoing and future projects

Main purpose of the geomagnetic observatories is to collect data, which in turn allow monitoring the changes in magnetic components. Routine work of the *Survey* of *Israel Research Division* includes carrying out discrete measurements, performing continuous observations, conducting scientific analysis of the collected data and systematically maintain the facilities. However, alongside routine, day-to-day responsibilities the members of the *Research Division* have been engaged in various research projects. Following is a short outline.

An international collaboration between Canada and Israel gave rise to innovative project, which address the subject of potential Earthquake prediction. The long-term precise observations of field anomalies concerning this project are part of a multi-sensor geophysical monitoring program for observing active tectonic faults. A supersensitive total field Magnetic Gradiometer used to this end is the most promising instrument for monitoring earthquake related magnetic field signals.

Another partnership, national in this case, between *SOI* and the *Israeli Institute of Geophysics* utilizes magnetic data to detect sinkholes along the shores of the *Dead Sea*. This highly hazardous phenomenon started occurring in the *Dead Sea* region for the last two decades and caused significant damage. The geomagnetic method for detecting these sinkholes employs observations of negative dipole anomaly. Several magnetic surveys that were carried out at five different sites confirmed the method's premise to a great extent and shown much promise.

The establishment of a *Space Weather Research Infrastructure* is another scientific project, which is the result of a mutual effort by *Tel-Aviv University*, the *Ministry of Science Foundation* and the *Survey of Israel*. Magnetic Storms inflict rapid changes on the magnetic field, which in turn may cause damage to power grids, lead to breakdowns in communication networks etc. Weather monitoring might just provide the magnetic storms forecast needed to anticipate such events (Shirman, 2016).

Future projects include prediction of magnetic *Declination* based on absolute

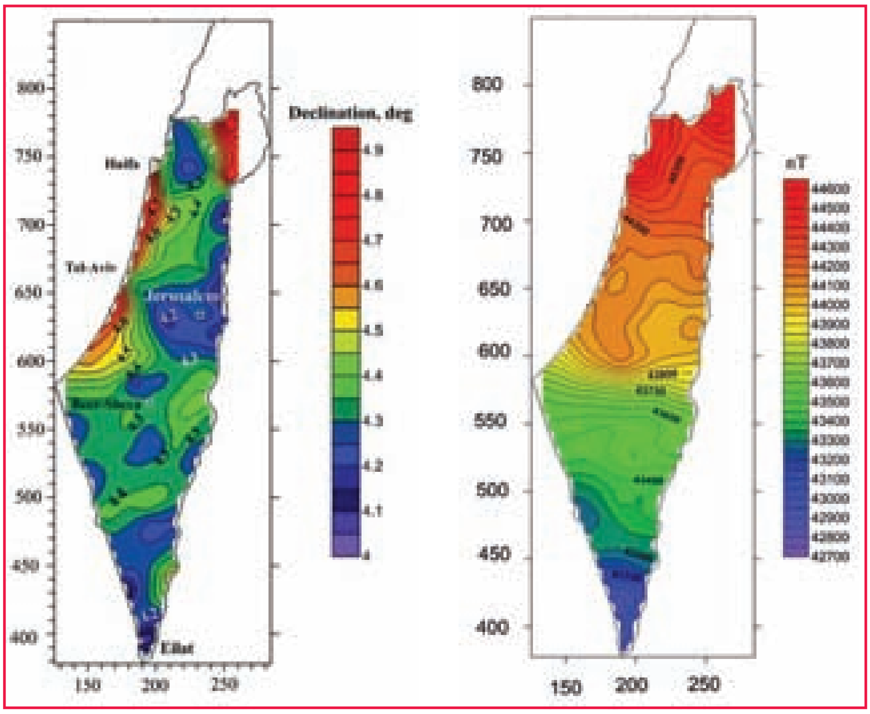

Figure 5: Magnetic Declination and Total Field Maps – 2014

measurements of the last several years. By analyzing the data and determining the rate of annual change, it is possible to estimate the *Declination* values for the upcoming years. Another thrilling project is the establishment of an interactive *Declination* model. The main purpose of which is to allow online calculation of *Declination* values at any given time and location within the boundaries of Israeli state.

Summary

The importance of geomagnetic observations is evident both from scientific and practical aspects. The need for defining the *Magnetic North* and tracking changes in the magnetic field of the Earth stems from this understanding. Thus, magnetic observatories must remain functional for many years to come.

Survey of Israel considers forty years of continuous geomagnetic measurements that meet the requirements of IAGA international association, a notable achievement. Currently there are three operating magnetic observatories on the territory of Israel, which pose a significant contribution to the widening of global geomagnetic network in addition to providing high quality magnetic data for commercial as well as academic uses.

References

Amm O., (2016): Geomagnetism Course, Finish Meterological Institute

Chulliat, A., Macmillan S., Alken P., Beggan C., Nair M., Hamilton B., Woods A., Ridley V., Maus S. and Thomson A., (2015): “ The US/UK World Magnetic Model for 2015-2020: Technical Report”, National Geophysical Data Center, NOAA

Jankowski J. & Sucksdorff C., (1996): “Guid for magnetic measurments and observatory practice”, IAGA

Shirman B., (2016): “40 years of magnetic observatories and 100 years of magnetic diclination measurment in Israel”, Survey of Israel

Wardinski I., (2005), “Core Surface Flow Models from Decadal and Subdecadal Secular Variationof the Main Geomagnetic Field”, Doctoral thesis, FU Department of Earth Sciences

Effect of ground control points in distribution and location on geometric correction of corona satellite image

This paper deals with geometric correction of CORONA satellite image which make use of non-parametric approach.

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Digital images collected form airborne or space-borne sensors often contain systematic and non-systematic geometric errors that arises from the earth curvature, platform motion, relief displacement, nonlinearities in scanning motion, the earth rotation, etc. [1]. The intent of geometric correction is to compensate for the distortions introduced by these factors so that the correct image will have the highest practical geometric integrity.

The geometric correction process is normally implemented as a two-step procedure. First, those distortions that are systematic, or predictable, are considered. Second, those distortions that are essentially random, or unpredictable, are considered.

Systematic distortions are well understood and easily corrected by applying formulas derived by modeling the sources of the distortions mathematically. Random distortions and residual unknown systematic distortions are corrected by analyzing well-distributed ground control points (GCPs) occurring in an image. In the correction process numerous GCPs are located both in terms of their two image coordinates (column, row numbers) on the distorted image and in terms of their ground coordinates (typically measured from a map, or GPS located in the field, in terms of UTM coordinates or latitude and longitude). These values are then submitted to a least squares regression analysis to determine coefficients for two coordinate transformation equations that can be used to interrelate the geometrically correct (map) coordinates and the distorted-image coordinates.

After producing the transformation function, a processing called resampling is used to determine the pixel values to fill into the out matrix from the original image matrix. The process is performed using the following operations.

1. The coordinate of each element in the undistorted output matrix are transformed to determine their corresponding location in the original input (distorted-image) matrix.
2. In general, a cell in the output matrix will not directly overlay a pixel in the input matrix. Accordingly, the intensity value or digital number (DN) eventually assigned to a cell in the output matrix is determined on the basis of the pixel values that surround its transformed position in the original output input matrix [4].

Commonly used methods for resampling are nearest neighbor, bilinear interpolation, and cubic convolution.

Study area and data set used

The reference image which is already geometrically corrected was acquired in

Table 1: Specification of Data Set Used

	Reference Image	Image to be corrected
Satellite	IKONOS	CORONA J-1
Spatial Resolution	1 m	2.75 m
Year of Acquisition	1993	1966
Image Band Used	Pan	Pan

1993 by IKONOS comprising the region of Yangon, Myanmar. The image to be geometrically corrected was acquired in 1966 by CORONA that captured the same region as reference image.

Geometric correction

There are four different levels of geometric correction of remotely sensed imagery.

(a) **Registration**- alignment of one image to another image of the same area.

(b) **Rectification**- alignment of image to a map so that the image is planimetric, just like the map; also known as geo-referencing.

(c) **Geocoding**- A special case of rectification that includes scaling to a uniform standard pixel GIS.

(d) **Orthorectification**- Correction of the image, pixel by pixel for topographic distortion [2]

Image rectification is carried out in this work that is CORONA image of Yangon region is rectified to a georeferenced IKONOS image which has UTM coordinate using ERDAS IMAGINE software. The following GCPs configurations are considered.

Configuration 1: GCPs are well-distributed and their corresponding locations are easily identifiable in both images.

Configuration 2: GCPs are not well-distributed, but their corresponding locations are easily identifiable in both images.

Configuration 3: GCPs are well-distributed, but their corresponding locations are not easily identifiable in both images.

Configuration 4: GCPs are not well-distributed and their corresponding locations are not easily identifiable in both images.

For GCPs configurations 1 and 2, control points are carefully chosen because the acquisition time between the two images is too high. Theses control points are place at the places where it doesn't change over time.

Polynomial Equation

A polynomial is a mathematical expression consisting of variables and coefficients. A coefficient is a constant, which is multiplied by a variable in the expression. The variables in

Table 2: Types of Resampling Method

Type	Description
Nearest Neighbor	New pixels value get from closet pixel of old pixel
Bilinear Interpolation	New pixels value calculated from the weighted average of 4(2×2) nearest pixels
Cubic Convolution	New pixels are computed form weighting16(4×4) surrounding DNs

Table 3: RMS Error for Different GCPs Configuration

GCPs Configuration	1	2	3	4
Polynomial Order	3	3	3	3
Minimum Requirement of GCPs	10	10	10	10
Total Number of GCPs Used	11	11	11	11
RMS Error	0.4129	0.5416	0.8658	0.9700

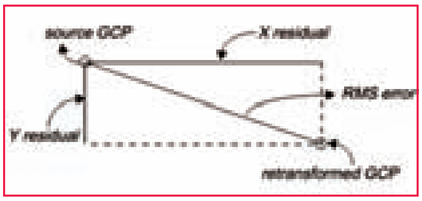


Figure 1: Residuals and RMS Error Per Point

polynomial expressions can be raised to exponents. The highest exponent in a polynomial determines the order of the polynomial. A polynomial with one variable, x, takes the following form:

$$A + Bx + Cx^2 + Dx^2 + \ldots + \Omega x^t \qquad (1)$$

Where,

A, B, C, D… Ω = coefficients

t = the order of the polynomial

A polynomial with two variables, x and y, takes the follow form:

$$x_0 = \left(\sum_{i=0}^{t}\right)\left(\sum_{j=0}^{t}\right) a_k \times x^{i-j} \times y^j \qquad (2)$$

$$y_0 = \left(\sum_{i=0}^{t}\right)\left(\sum_{j=0}^{t}\right) b_k \times x^{i-j} \times y^j \qquad (3)$$

Where t is the order of the polynomial a_k and b_k are coefficients

The following first-order polynomial transformation equations can be used to determine the coefficient required to transform pixel coordinate measurements to the corresponding other coordinate values.

$$x_0 = a_1 + a_2X + a_3Y \qquad (4)$$

$$y_0 = b_1 + b_2X + b_3Y \qquad (5)$$

where, (X, Y) are the input pixel coordinates and (x_0, y_0) are the output (geographic) coordinates.

The second-order transformation equations for X and Y are

$$x_0 = a_1 + a_2X + a_3Y + a_4X^2 + a_5XY + a_6Y^2 \qquad (6)$$

$$y_0 = b_1 + b_2X + b_3Y + b_4X^2 + b_5XY + b_6Y^2 \qquad (7)$$

The third-order transformation equations for X and Y are

$$x_0 = a_1 + a_2X + a_3Y + a_4X^2 + a_5XY + a_6Y^2 + a_7X^3 + a_8XY^2 + a_9YX^2 + a_{10}Y^3 \qquad (8)$$

$$y_0 = b_1 + b_2X + b_3Y + b_4X^2 + b_5XY + b_6Y^2 + b_7X^3 + b_8XY^2 + b_9YX^2 + b_{10}Y^3 \qquad (9)$$

The number of control points should be more than the number of unknown parameters in polynomial equations, because the errors are adjusted by the least-square method. The number of unknown parameters in polynomial transformation equation can be obtained using the following equation

$$N = \frac{(t+1)(t+2)}{2} \qquad (10)$$

Where,
N = minimum number of GCPs
t = the order of polynomial transformation

Depending on the geometric distortions, the order of polynomial is determined. Usually a maximum of third-order polynomial is sufficient for existing remote sensing images [1].

As the image to be rectified is highly distorted, third order polynomial transformation is chosen in this work. Based on equation (10), minimum numbers of GCPs should be at least 10 GCPs. Total number of GCPs chosen for this work is eleven.

Interpolation

Once applying geometric transformation, image may be shear, rotate, transformed or skewed. Pixel interpolation is necessary for filling missing values of area. For that

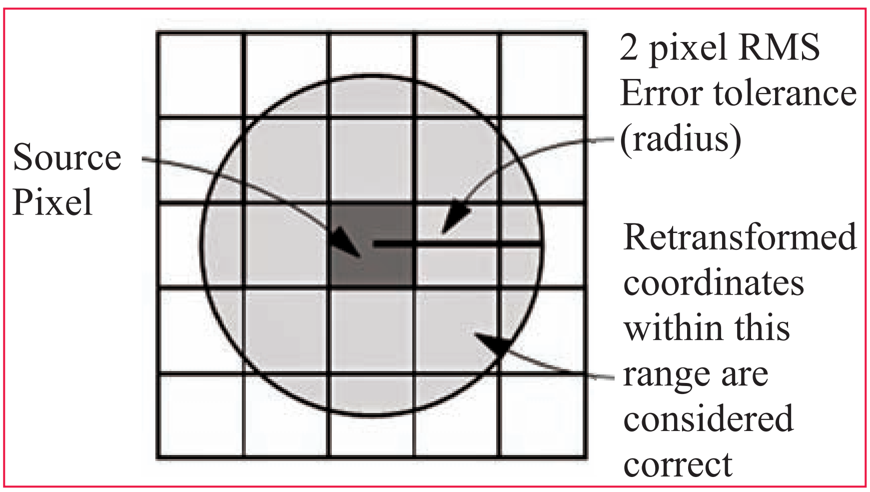


Figure 2: RMS Error Tolerance

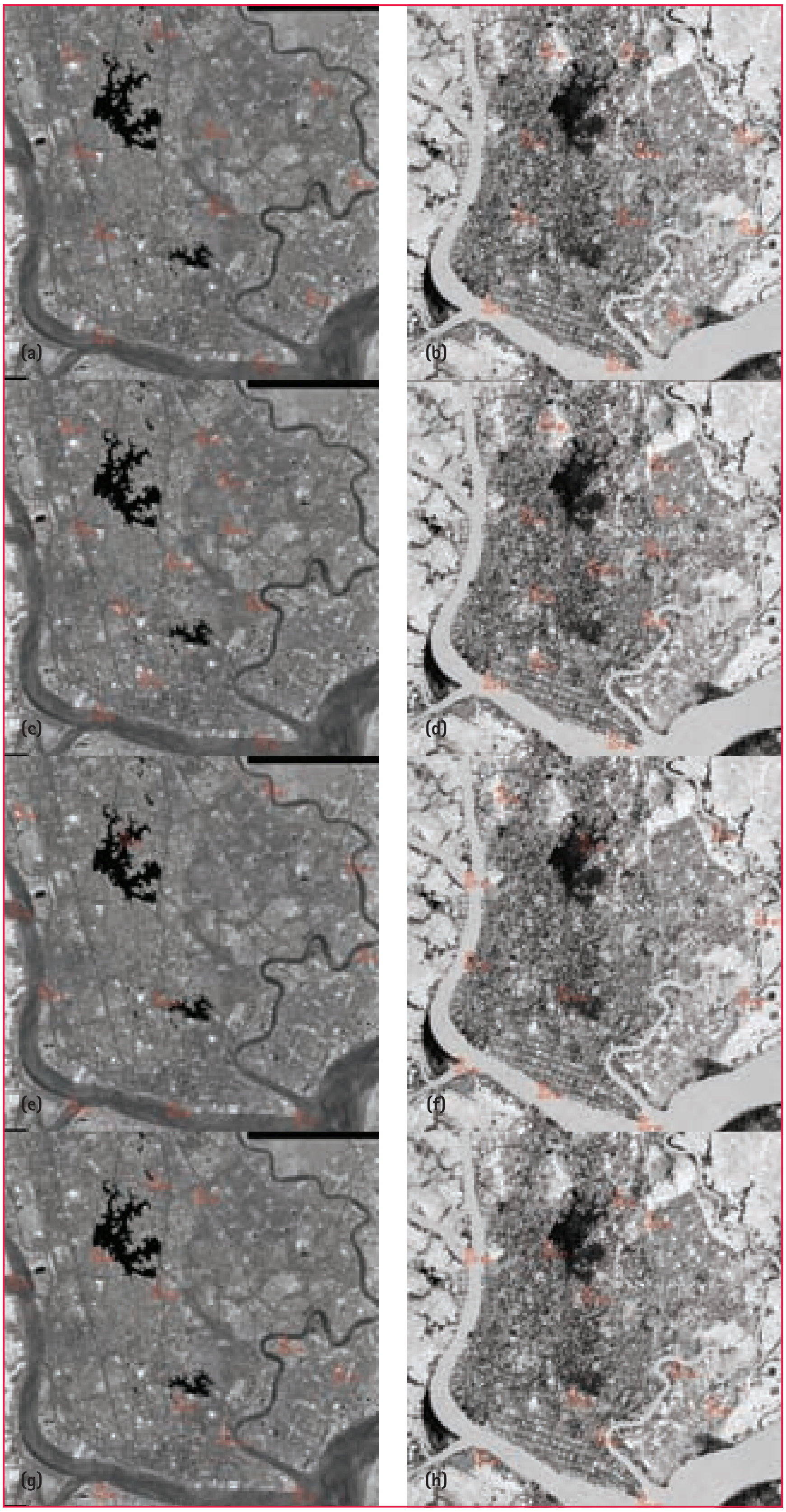


Figure 3

(a) & (b): GCPs Distribution and Location on Reference and Distorted Images for GCPs Configuration 1
(c) & (d): GCPs Distribution and Location on Reference and Distorted Images for GCPs Configuration 2
(e) & (f): GCPs Distribution and Location on Reference and Distorted Images for GCPs Configuration 3
(g) & (h): GCPs Distribution and Location on Reference and Distorted Images for GCPs Configuration 4

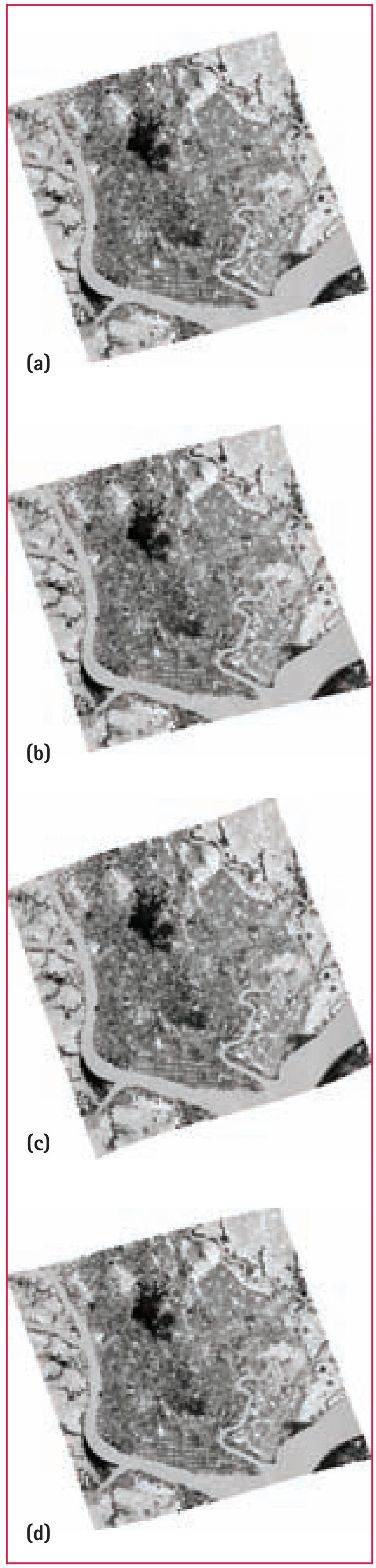


Figure 4 (a), (b), (c) & (d): Rectified Images of GCPs Configuration 1, 2, 3, and 4

pixel brightness values must be determined. There may not be any direct one-to-one relation between base image and image which is rectified. There is mechanism for determining the brightness value, this process is known as pixel interpolation.

Resampling

Resampling process used to determine the digital values to place in the new pixel location of the corrected output image, this process known as a resampling. Resampling required to estimate a new pixel between existing pixels due to non-integer transformed (x, y) . Table 2 shows types of resampling method [2] .

RMS Error

RMS error is the distance between the input (source) location of a GCP and the retransformed location for the same GCP. In other words, it is the difference between the desired output coordinate for a GCP and the actual output coordinate for the same point, when the point is transformed with the geometric transformation.

RMS error is calculated with a distance equation:

$$RMS\ Error = \sqrt{(x_r - x_i)^2 + (y_r - y_i)^2} \qquad (11)$$

Where, x_i and y_i are the input (source) coordinates, and x_r and y_r are the retransformed coordinates

RMS error is expressed as a distance in the source coordinate system. If data file coordinates are the source coordinates, then the RMS error is a distance in pixel widths. For example, an RMS error of 2 means that the reference pixel is 2 pixels away from the retransformed pixel.

Tolerance of RMS Error

The amount of RMS error that is tolerated can be thought of as a window around each source coordinate, inside which a retransformed coordinate is considered to be correct (that is, close enough to use). For example, if the RMS error tolerance is 2, then the retransformed pixel can be 2 pixels away from the source pixel and still be considered accurate [3].

> Based on experimental result, geometric correction accuracy of distorted image depends not only on the location of GCPs where they are placed at easily identifiable places building corner, road intersection, etc. but also on their distribution

Experimental result

Table 3 shows the result on geometric correction using third order polynomial with different GCPs distribution and location.

Discussion and conclusion

In this work, image to map geometric rectification of distorted image is performed based on third order polynomial. Rectification is carried out by four types of ground control points configuration in such a way that the impact on different distribution patterns of ground control points and their corresponding location is analyzed.

The first GCPs configuration is that GCPs are located at the places where they are easily and accurately identifiable in both images and their distribution is even across the image.

The second GCPs configuration is that GCPs are put at the points which are distinct, but they are not well distributed across the image.

The third GCPs configuration is that GCPs distribution pattern is uniform across the image but they are not accurately identifiable.

The last GCPs configuration is that GCPs are not well distributed and their corresponding locations are not distinct.

Finally, the results on geometric rectification are evaluated by using the total root mean square error (RMSE). Based on the result, it shows that RMSE is the lowest in the case where GCPs distribution pattern is uniform across the image and their locations are at road intersection, building corner, and distinct natural features. RMSE is getting higher on GCPs configuration two to four by order. The worst case is that RMSE is the highest where GCPs distribution pattern are not evenly spread across on both images and their corresponding locations are not distinct.

In conclusion, based on experimental result, geometric correction accuracy of distorted image depends not only on the location of GCPs where they are placed at easily identifiable places (building corner, road intersection, etc.), but also on their distribution (evenly spread across the image).

References

[1] Bhatta. B., 2008. Remote Sensing and Gis. Oxford University, India, pp. 317-616.

[2] Chintan . D., Rahul . J., Srivastava. S., 2015. A Survey on geometric correction of satellite imagery. International journal of computer applications, Vol 116 – No.12.

[3] Erdas, Inc. 1999. Erdas Field Guide, Retrieved August 30, 2016, from www. gis. usu.edu/ manuals/ labbook/ erdas/ manuals.

[4] Thomas. L., Ralph . K., Jonathan , C., Remote Sensing and Image Interpretation. Wiley, India, pp. 495.

The paper was presented at Asian Conference on Remote Sensing (ACRS), Colombo, Sri Lanka 17-21 October 2016

Galileo update

Additional eight satellites for Galileo

Europe's Galileo navigation constellation will gain an additional eight satellites, bringing it to completion, thanks to a recently signed contract. The contract to build and test another eight Galileo satellites was awarded to a consortium led by prime contractor OHB, with Surrey Satellite Technology Ltd overseeing their navigation platforms.

This is the third such satellite signing: the first four In Orbit Validation satellites were built by a consortium led by Airbus Defence and Space, while production of the next 22 Full Operational Capability (FOC) satellites was led by OHB.

These new batch satellites are based on the already qualified design of the previous Galileo FOC satellites, except for changes on the unit level – such as improvements based on lessons learned and reacting to obsolescence of parts. *http://www.esa.int*

Two more satellites join Galileo working constellation

Two further satellites have formally become part of Europe's Galileo satnav system, broadcasting timing and navigation signals worldwide while also picking up distress calls across the planet.

These are the 15th and 16th satellites to join the network, two of the four Galileos that were launched together by Ariane 5 on 17 November, and the first additions to the working constellation since the start of Galileo Initial Services on 15 December.

The launch into space and the manoeuvres to reach their final orbits still left a lot of rigorous testing before the satellites could join the operational constellation.

Their navigation and search and rescue payloads had to be switched on, checked and the performance of the different Galileo signals assessed methodically in relation to the rest of the worldwide system.

This lengthy testing saw the satellites being run from the second Galileo Control Centre in Oberpfaffenhofen, Germany, while their signals were assessed from ESA's Redu centre in Belgium, with its specialised antennas.

The tests measured the accuracy and stability of the satellites' atomic clocks – essential for the timing precision to within a billionth of a second as the basis of satellite navigation – as well as assessing the quality of the navigation signals.

Oberpfaffenhofen and Redu were linked for the entire campaign, allowing the team to compare Galileo signals with satellite telemetry in near-real time.

Making the tests even more complicated, the satellites were visible for only three to nine hours a day from each site.

The satellites are now broadcasting working navigation signals and are ready to relay any Cospas–Sarsat distress calls to regional emergency services. *https://phys.org/*

LogicJunction and IndoorAtlas partner in Healthcare

LogicJunction and IndoorAtlas team up to create enhanced patient experience associated with navigation inside of large, complex hospital buildings using a state of the art mobile app powered by the IndoorAtlas' technology. The IndoorAtlas powered mobile app is the newest addition to LogicJunction's suite of well-established wayfinding solutions that help patients and visitors pre-plan hospital visits using the web, navigate around the facility with the help of kiosks, and receive customized electronic directions from volunteers or kiosks upon arrival. The wayfinding app will help hospitals provide GPS-like indoor navigation to their mobile community who prefer smartphones to other forms of information retrieval.

Seiler Instrument chooses TerraGo Magic

TerraGo has announced a new partnership with Seiler Instrument. Seiler is utilizing TerraGo Magic to build an advanced GNSS collaboration app platform to provide its customers with a complete mobile field-to-GIS solution, including integration with Trimble® GNSS receivers enabling survey-grade accuracy on smartphones and tablets.

Europe's Vedecom, Israel's Karamba developing self-driving car

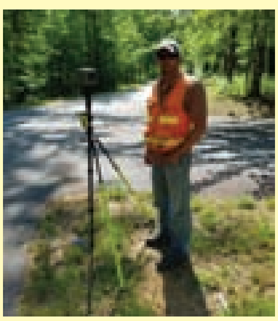
European self-driving car company Vedecom Tech and Israel's Karamba Security are partnering in developing fully autonomous cars that will be deployed for limited use in certain European cities within the coming year. Vedecom Tech says the completely autonomous vehicles will be launched for commercial use in late 2017 and in 2018 by municipalities in France, Germany, Italy, Portugal and the Netherlands. Karamba's systems will protect the car from possible cyber attacks on external communications between vehicles and surrounding infrastructure, as well as the car's internal electronics. *www.reuters.com/*

TRIUMPH-LS and J-Field

Hands free operation

RAMS

Remote Assistance & Monitoring Services (RAMS) allows you to connect to your TRIUMPH-LS from anywhere in the world when both your computer and TRIUMPH-LS have access to the Internet. Every function of J-Field that is available to the operator of the TRIUMPH-LS that's in the field, is available to the remote viewer!



There's nothing else on the surveying market like RAMS, that I'm aware of. What an extremely handy tool that works really well and is perfectly integrated into the field software!

Over the past year I've kept the LS system mostly to myself, learning as much as I could about it and getting comfortable with it before I started training any of my crew leaders to use it. Recently I've started training one of my guys to use it, the most experienced of my field team and an extremely bright guy.

This morning, while on a project 40 miles away, I was re-walking him through setup/ground projections and I was logged on to RAMS watching/helping his setup process. ***It's an amazing thing to be able to step in and help out a crew from the office!*** *It's been incredibly helpful the countless times I've called @Adam for help.*

I have to say, this is excellent work by the Javad team!!

Here's a cool screen grab of him staking to his base point to make sure everything was jiving.

Wes Cole
Asheville, NC

TRIUMPH-LS in use • J-Field features

What Do You Use the TRIUMPH-LS For?

In some ways, I would use the LS for any of the items you list, but my specific work is boundary and topographic. About the only thing I won't use the LS for is precise vertical (hard surface topo for example) that requires better than a centimeter, particularly if I have to collect a lot of points with that accuracy requirement. This is pretty uncommon for my needs though.

I would use it for many types of construction layout. I don't do a lot of construction layout work though. It's the way to layout utility corridors.

Shawn Billings, PLS
Kilgore

The more fitting question for me would be what don't you use the LS for.

I even used it to set the locations for the post holes on my construction project and then drilled them. I did not have to shave out any of the holes. The posts went in perfectly.

The LS is a workhorse when it comes to open sky topo. I finished the field in just a few hours and never cut anything. I was able to crawl around and get to where I needed then let the LS work.

Adam Plumley, PLS

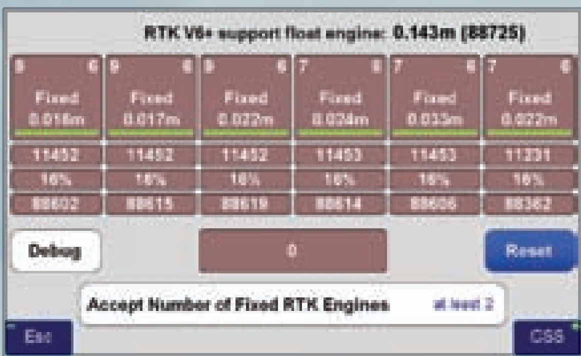
The TRIUMPH-LS and its field software, J-Field,

have many revolutionary and innovative features as compared to current GNSS systems:

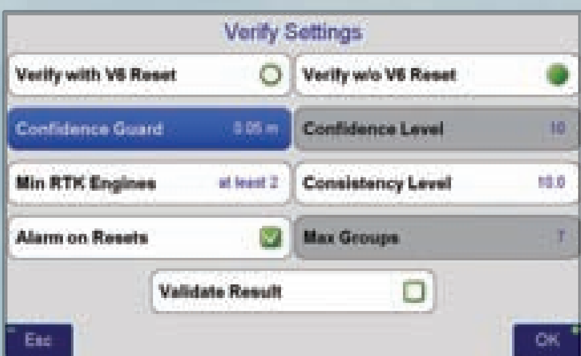
- The TRIUMPH-LS contains everything needed to function as a **complete RTK rover** in one small, compact, ergonomic and very portable unit: an **864 channel GNSS receiver, a UHF or spread spectrum radio, a GSM modem, a Wi-Fi adapter, two internal cameras, a flashlight, and a bright 800x480 pixel display.** Included with the system is a collapsible monopod rover pole which allows the unit to be quickly folded up to fit in a very small space, **perfect for carrying the system through the woods** or quickly stowing inside a vehicle. The lack of a data collected bracketed to the rover pole increases further increases its portability and the user can **carry the system through the woods** without having to worry about a data collector bracketed to the rover pole getting caught in brush.

- This system was ergonomically engineered; the head height vertical display allows the user to operate the TRIUMPH-LS while standing in an upright position and looking forward. The user does not need to bend their neck to look down to view the display as is traditionally done with a system having a data collector attached to a rover pole. This feature allows the system to be used **without the neck soreness** that can plague a user bending their head downward to view a data collector for extended periods of time.

- The field software, J-Field, is included **at no extra charge** with the system. There is no need for an external data collector or software. J-Field is constantly being improved and updates will always be available free of charge with the system. The updates can be **downloaded through Wi-Fi** and are very simple to install, requiring only a couple button presses to update the system.



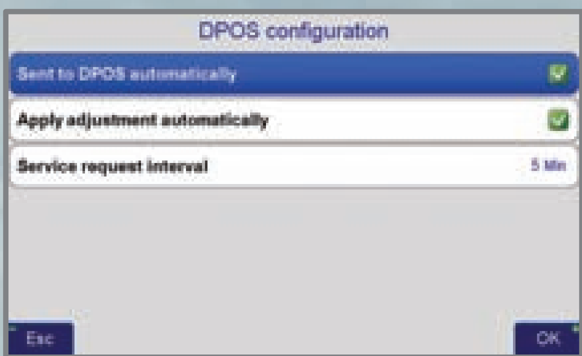
- J-Field, features **6 separate parallel RTK engines** that all run simultaneously with separate assumptions. This allows for fixes to be obtained quicker than if only a single RTK engine was used.

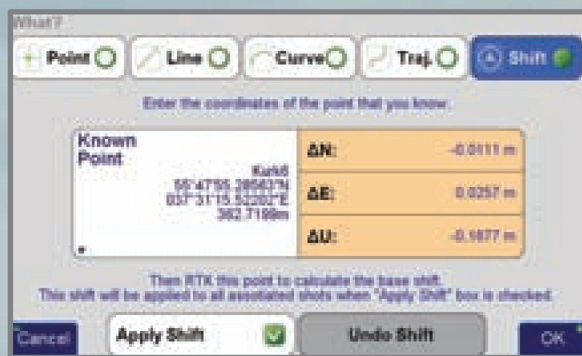


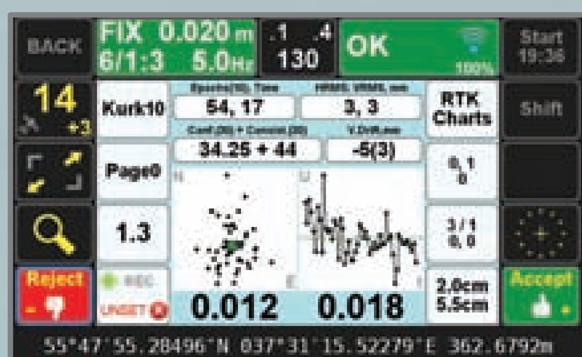
- It has an advanced **RTK verification system** that can be used in difficult RTK environments where there is high multipath and/or tree canopy cover. This process will automatically reset the RTK engines and eliminate points from being collected with bad RTK fixes that often plague other systems in difficult locations.

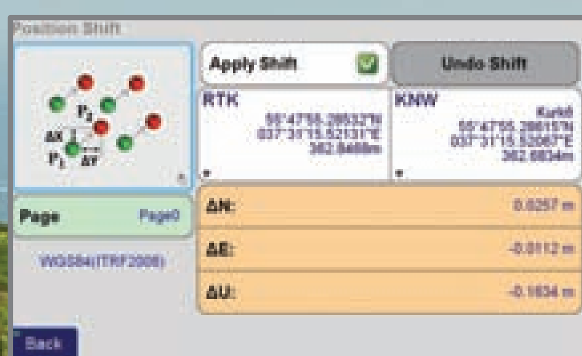
- J-Field has many **customization** features that can be used to increase productivity as your knowledge of the system grows. The stake and collect screens have **10 white boxes** that are easily customized to display a number of fields which the user may desire.

• Post processing raw data is very simple in J-Field. GNSS raw data files can be configured to be stored **for each RTK point automatically**. After stopping your local JAVAD base station, the raw base station data is downloaded into J-Field where it can then easily be uploaded to JAVAD's post-processing server, **DPOS (Data Processing Online Service)**. Autonomous base station coordinates and all the RTK points collected from the base station session can then be adjusted to a solution obtained from processing the base station data with **NGS CORS data**.
Base to rover vectors can also be processed with DPOS. This allows the user to compare the RTK coordinates with the post-processed coordinates and then choose the desired coordinate for that point. This feature is very useful when surveying in areas outside of the base station's radio range as points can still be collected and post-processed in these areas.

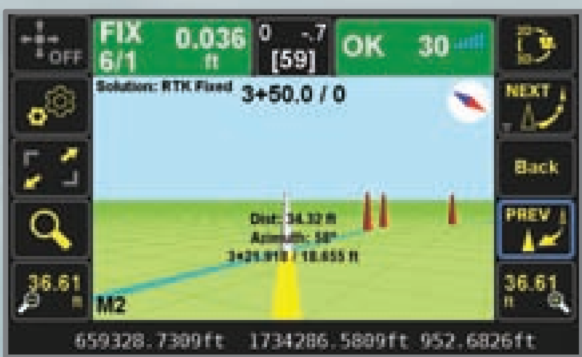


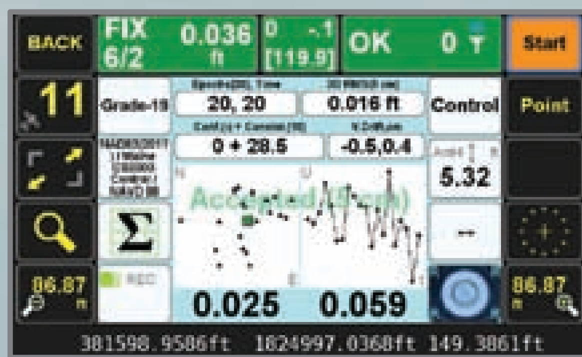




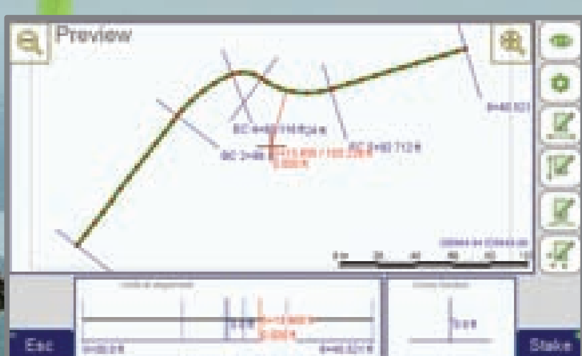


- It contains a **built-in compass and tilt sensors**. The built in compass allows for the quick and efficient stake out of points. Forward/back and left/right offset readings relative to the face of the display show precisely where the stake out point is located. This stakeout method allows **reduces the time** required to stake out a point as compared to using traditional north/south and east/west offsets. The built-in tilt sensors can be used in lieu of having to plumb the rover pole. Taking advantage of the tilt sensors is also a **"Lift & Tilt"** mode that allows for collection of topo points without having to press any buttons. In this mode, when the TRIUMPH-LS is plumbed a point will automatically start collecting and can be programmed to collect a set number of epochs or to stop collection when the unit is tilted. After the point is collected the user tilts the TRIUMPH-LS and walks to the next point which will be collected when the unit is plumbed again.





- With the built in GSM modem, it is very easy to connect to **RTN networks**. Alternatively, it can also be connected through Wi-Fi using a mobile hotspot.



What a beautiful picture!

And how ugly competition can get!

A competitor's dealer at a state show takes one of our happy TRIUMPH-LS customers to his booth and tells him when Javad dies we will buy his company and close it.

How ugly a person can get! Instead of promoting innovation, he wants to kill it for his personal stupid benefits.

Also the idiot does not know of two things:

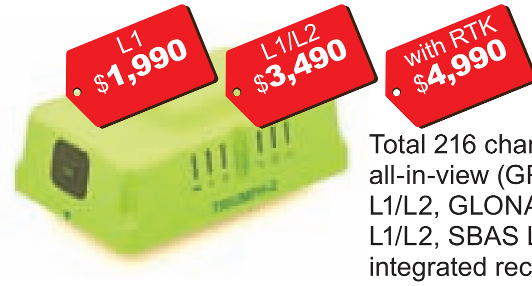
1. That I am healthy like a horse and have no intention to die anytime soon.

2. That JAVAD GNSS is not a start up company. Over 130 people working on the TRIUMPH-LS alone. It is a solid deep rooted institution which does not depend on any one person, including myself.

TRIUMPH-1M

864 channel chip, equipped with the internal 4G/ LTE/3G card, easy accessible microSD and microSIM cards, includes “Lift & Tilt” technology.

TRIUMPH-2



Total 216 channels: all-in-view (GPS L1/L2, GLONASS L1/L2, SBAS L1) integrated receiver.

The one and the only Digital Radio Transceiver in the world!

Unique adaptive digital signal processing, which has benefits: the full UHF frequency range and all channel bandwidths worldwide • the best sensitivity, dynamic range, and the highest radio link data throughput • embedded interference scanner and analyzer • compatibility with another protocols. Cable free Bluetooth connectivity with GNSS receivers and Internet RTN/VRS access via embedded LAN, Wi-Fi, and 3.5G

And all this with competitive prices!

HPT435BT/HPT135BT/HPT225BT*

$2,710

35 W UHF/VHF Transceiver

HPT404BT/HPT104BT/HPT204BT*

$1,640

4 W UHF/VHF Transceiver

HPT401BT/HPT101BT/HPT201BT*

$2,070

1 W UHF/VHF with internal battery

L-Band/Beacon*

$1,550

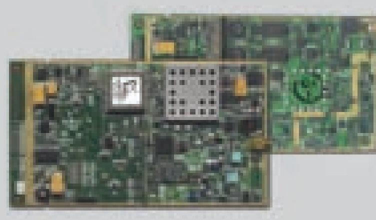
Receivers for multiple applications

JLink 3G LTE BAT*

$2,735

Web-interface Wi-Fi, Ethernet, 3.5 G, UHF/VHF/FH915, internal battery

OEM Solutions



$840

902-928, 360-470, 225-255, 138-174 MHz

*Power, data cables and antenna are included.

Back

JAVAD
www.javad.com

PNT systems in Ukraine: European Cooperation Aspects

The main goal of establishing Positioning and Timing and Navigation Systems in Ukraine (STNSU) is to meet users requirements, related to increasing accuracy, continuity and reliability of positioning and navigation utilizing GNSS capabilities

Serhii Chernolevsky
Deputy Chief, Foreign Economic Relations and International Cooperation Division, National Space Facilities Control and Test Center, State Space Agency, Ukraine

State Space Agency of Ukraine (SSAU) ensures Space Policy on the following directions: creation of launch vehicles and spacecraft launches; remote sensing, including creation of space observation systems; satellite navigation using GNSS; space monitoring and analysis; seismic and geophysical monitoring, including monitoring of nuclear test ban treaty; space science and exploration.

Ukraine has developed the Positioning & Timing and Navigation System using global navigation satellite systems (GNSS). This System has been established in the framework of the National Space Programs of Ukraine (1998-2012) and on the basis of standards adopted by the European project EUPOS. (Figure 1).

Main tasks of the System are:

- continuous monitoring of GNSS signals and integrity of radio-navigation fields of the operational systems: GPS, GLONASS, and perspective EGNOS, Galileo and BeiDou GNSS;
- generating and distributing via Internet differential corrections for governmental authorities, governmental scientific and industrial enterprises, commercial enterprises and individuals in Ukraine. (Figures 2, 3, 4).

These tasks envisage various projects implementation in the sphere of satellite navigation, including public-private partnership projects and international GNSS projects, particularly, EGNOS and Galileo European international cooperation programs.

In this sphere, Ukraine demonstrates positive results of the public-private partnership through utilization of 10 state stations and 110 private stations. (Figure 5).

A few years ago, the SSAU on behalf of Ukraine participated in the EUPOS project, but due to force majéur the Ukraine's involvement into the project became limited. Considering the Agreement on

Figure 1

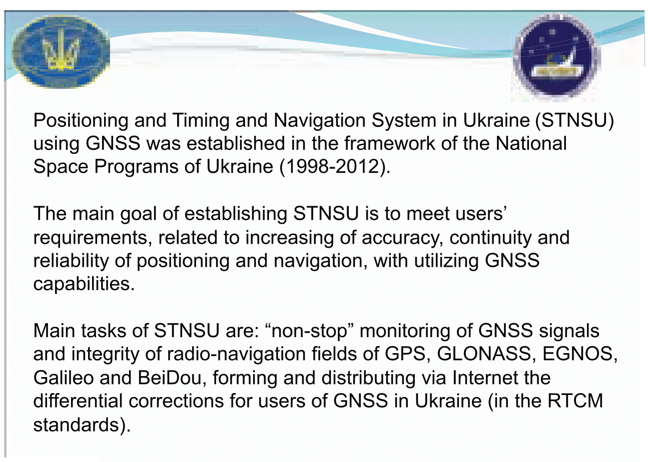


Figure 2

Association between Ukraine and the EU it is vital to reestablish full-scaled Ukrainian participation in the EUPOS project as well as in other international projects and forums in GNSS sphere.

According to the Cooperation Agreement on a Civil Global Navigation Satellite System (GNSS) between the European Community and its Member States and Ukraine, which entered into force in 2014, Ukraine implements steps towards the extension of the satellite navigation system EGNOS and Galileo to Ukraine, and works in close cooperation with the European Commission experts to choose location for the RIMS installation in Ukraine. (Figure 6).

The extension of EGNOS to the territory of Ukraine is planned to be implemented through the ground infrastructure involving Ukrainian Integrity Monitoring Stations.

The "Ukrainian" RIMS will cover the entire territory of Ukraine as well as the eastern border of the EU (eastern part of Romania). The service will be provided

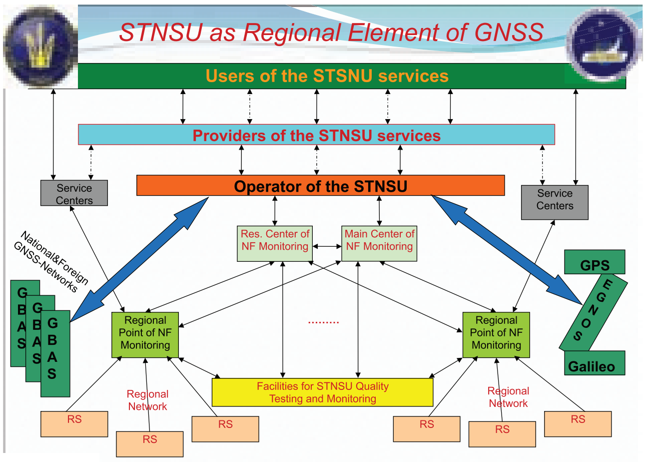


Figure 3

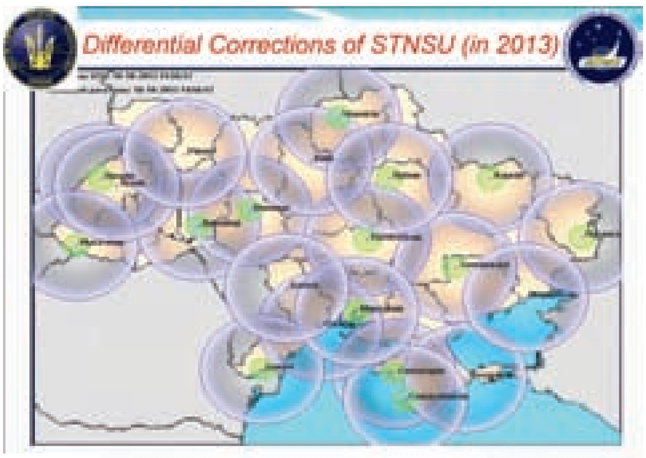


Figure 4

Figure 5

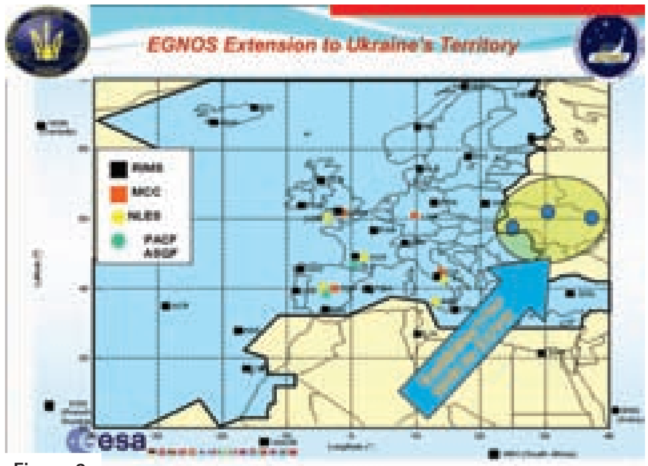


Figure 6

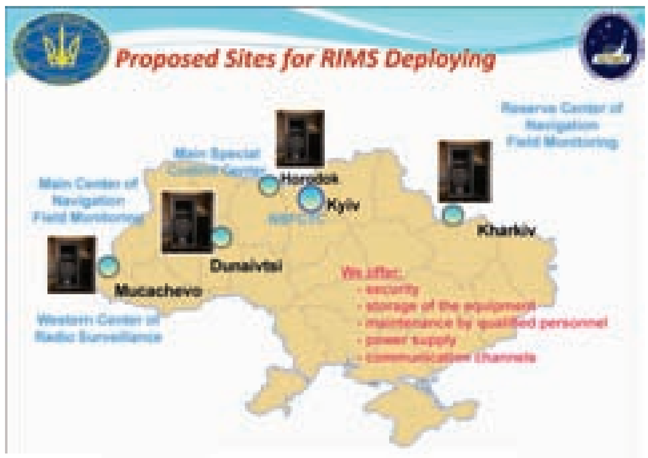


Figure 7

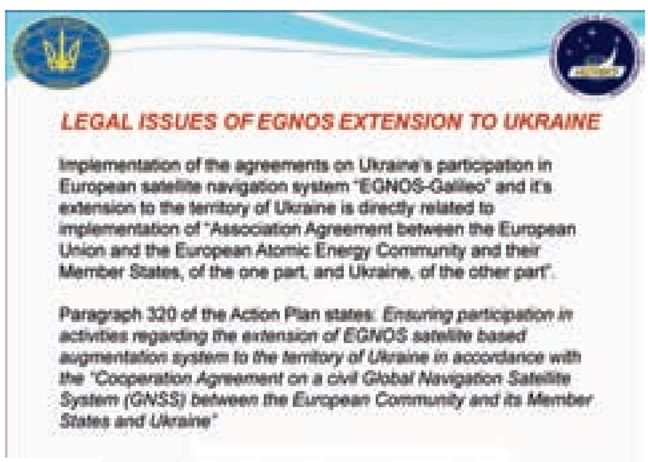


Figure 8

within the land and air borders of Ukraine, where Ukraine is responsible for the international air navigation. (Figure 7).

According to the Article 320 of the Action Plan on Implementation of the Association Agreement between Ukraine and the European Union and its Member States for the Years 2014–2017 approved by the Decree of the Cabinet of Ministers of Ukraine as of September 17, 2014, the SSAU was appointed in charge of the extension of the European satellite navigation system EGNOS to Ukraine. (Figure 8, 9, 10).

Within the framework of the EU technical assistance TWINNING Project "Strengthening of the SSAU Institutional Capacity to Implement European Space Programmes in Satellite Navigation (EGNOS/Galileo) and Remote Sensing (GMES)" several missions of experts to the SSAU had been organized, which were aimed at transferring experience and exchange of best practices in satellite navigation in the EU Member States and the development of Ukrainian legal framework in the field of satellite navigation and its harmonization with the European legal framework.

In order to study the best practices and work experiences of public entities and between commercial service operators and customers in satellite navigation 54 Ukrainian specialists from space industry took part in 6 Study Tours and 5 Internships. They visited INTA, European Satellite Services Provider - ESSP and other companies in Madrid (Spain) and European GNSS Agency (GSA) in Prague (Czech Republic). Besides, 647 experts from Ukrainian Space Agency, Space Industry and Official Bodies have participated at the working sessions of TWINNING Project. Therefore, Ukrainian specialists had a lot of opportunities to learn the working processes of the operators of satellite navigation services as well as ground infrastructure facilities of Galileo: control centers, satellite constellation control stations, control receiving stations, etc.

As a result of this activity Ukrainian and EU experts based on the best European practices and standards developed the Draft Law of Ukraine "State Regulation of Satellite Navigation" and "State Regulation of Remote Sensing."

In order to discuss these Draft Laws the SSAU and the NSFCTC organized several round tables with participation of various stakeholders in space industry and Ukrainian ministries and organizations. Currently, the Draft Laws are submitted for approval to the Cabinet of Ministers of Ukraine. (Figure 11).

During several missions to Ukraine the European experts carried out analysis of the SSAU activity on the EGNOS/Galileo extension to Ukraine. Ukrainian experts obtained knowledge about the technical aspects on the EGNOS/Galileo extension to the territory of Ukraine, its

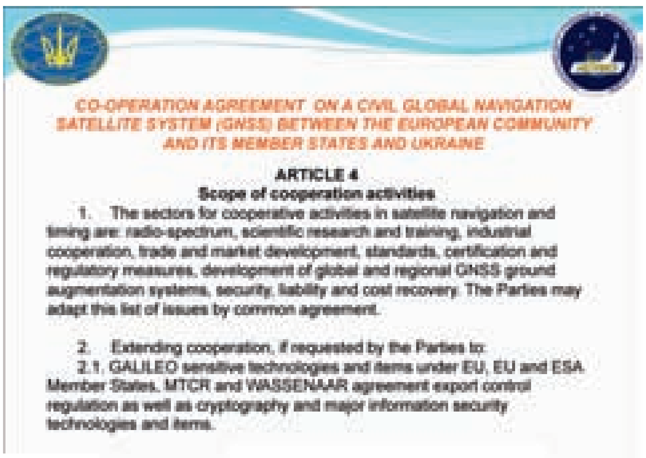


Figure 9

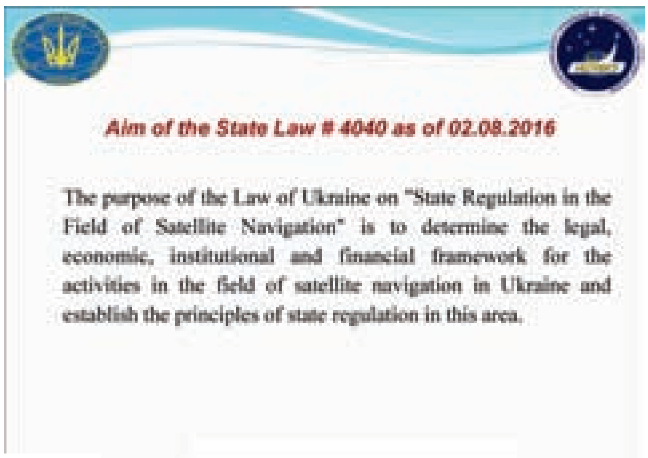


Figure 11

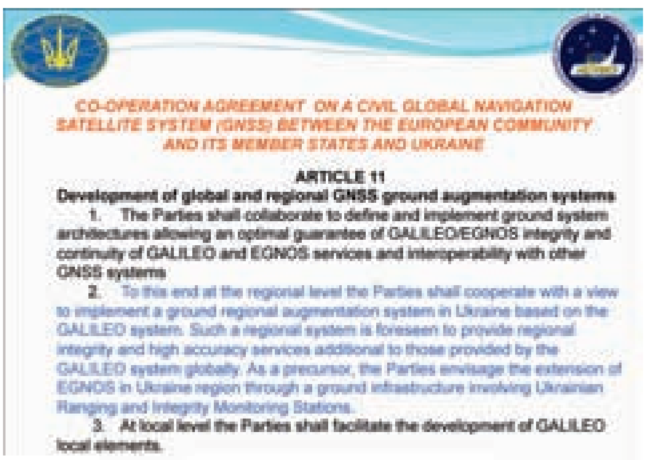


Figure 10

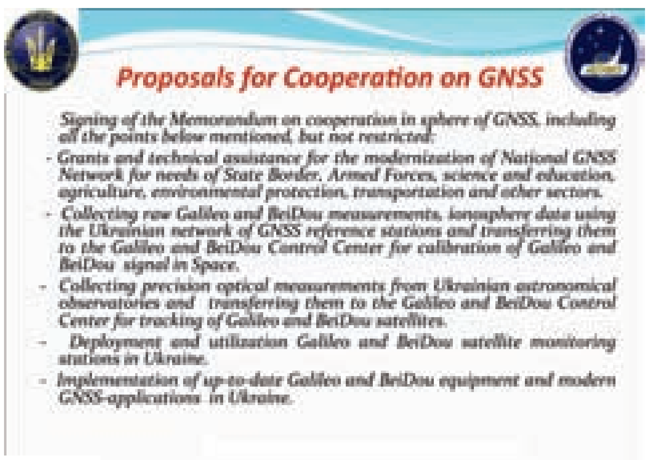


Figure 12

advantages and benefits, as well as about key sectors (transport and industry), where these systems will be applied.

During particular round table the Ukrainian specialists were presented recommendations for the State control over the satellite navigation activities and they succeeded in learning the experience of cooperation between public authorities, operators of commercial services and its customers. The representatives from other relevant industries (aviation, maritime, road transport, agriculture, etc.) also took part in those meetings.

The PRS service was of a great particular interest as it will be ensure secure use of Galileo system by the public entities.

Proposals on cooperation in the GNSS sphere. (Figure 12).

Taking into consideration vital importance of the space monitoring task and permanent interest of the international community to adhere to the legislation on the peaceful uses of outer space, great interest in solving problems of the safety of spaceflights, space debris accumulation issues, space weather monitoring issues (sun monitoring, solar wind, the Earth's magnetosphere, ionosphere and thermosphere that can affect spacecraft and ground facilities critical infrastructure or endanger people’s life or health), Ukraine is constantly improving the existing software and hardware as well as develops new software and hardware for space monitoring. In cooperation with the leading scientific institutions of Ukraine, the National Space Facilities Control and Test Center conducts researches on space monitoring and administers the catalogue of space objects. (Figure 13).

The National Space Facilities Control and Test Center of the State Space Agency of Ukraine is actively developing the Space Monitoring and Analysis System (SMAS). The sources of information for SMAS are the following: (Figure 14, 15).

Optical surveillance facilities of the National Space Facilities Control and Test Center (telescopes, laser telemeters, etc); Optical surveillance facilities of the Ministry of Education and Science of Ukraine, and the National Academy of Sciences of Ukraine; Radio-technical facilities of the National Space Facilities Control and Test Center (“Dnipro” Daryal-type surveillance station).

Considering the integration process of Ukraine to the European and global community and we would like to propose to consider the possibility of joint use of the above mentioned facilities. (Figure 16).

Achieving these objectives could allow generating public benefits for the Ukrainian economy as well as creating science and business opportunities for both national and global companies.

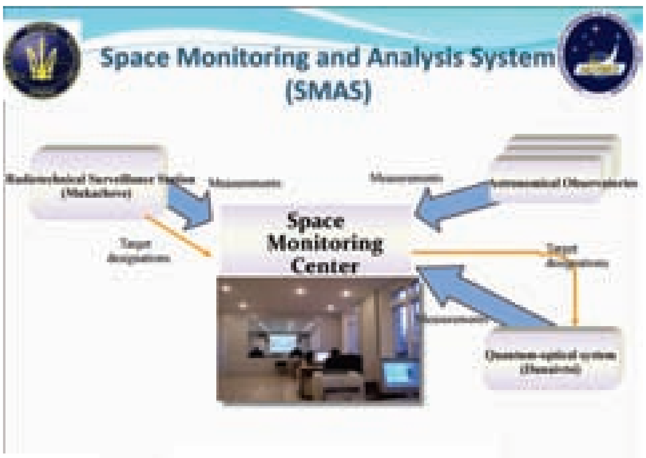


Figure 13

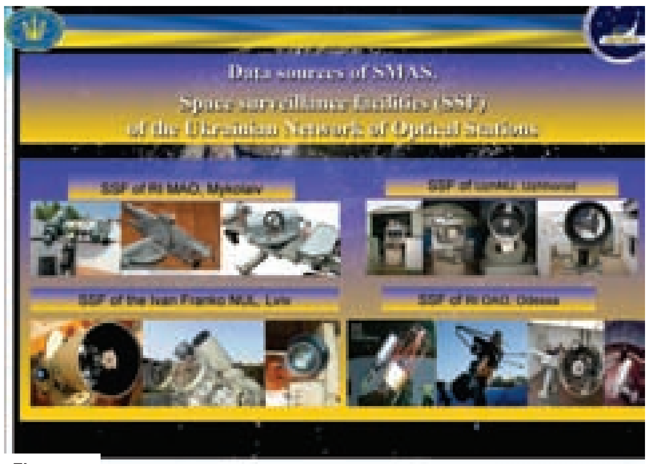


Figure 15


Figure 14

Figure 16

Urban sprawl predicition using cellular automata

A case study of Ahmedabad city

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Human population continues to accumulate in urban centers. This inevitably increases the urban footprint with significant consequences for biodiversity, climate, and environmental resources. Urban growth prediction models have been extensively studied with the overarching goal to assist in sustainable management of urban centers. There are various existing models, which have their own advantages and limitation. Here by using cellular automata, the prevailing modeling technique to obtain sustainable result.

The study is based on the data availability from LISS III. This model assesses developer and user perceptions and critically discusses existing urban growth prediction models, acting as a reference for future model development.

The potential of the use of satellite images for Ahmedabad, Gujarat, the assessment of urban growth on which future work should focus as the key factors of economic-environmental sustainability based on parameters taken into considerations that directly influence the land use.

Introduction

Urban sprawl: Definition

Urban sprawl or suburban sprawl describes the extension of human being populations away from inner built-up patches into previously out-of-the-way and rural regions, basically which results in low-density communities. Urban sprawl is a versatile concept of community planning particularly relevant to developed nations concerning topics that series from the external spreading of a city and it's suburban, to low-density and development on rural territory, assessment of impact of high separation between residential and commercial uses. Urban sprawling has happen to incredibly chief issue of learning to deal with city expansion and financial system

Cellular Automata

Cellular automata (henceforth: CA) are discrete, abstract computational systems that have proved useful both as general models of complexity and as more specific representations of non-linear dynamics in a variety of scientific fields. Firstly, CA is (typically) spatially and temporally discrete: they are composed of a finite or denumerable set of homogeneous, simple units, the atoms or cells. At each time unit, the cells instantiate one of a finite set of states. They evolve in parallel at discrete time steps, following state update functions or dynamical transition rules: the update of a cell state obtains by taking into account the states of cells in its local neighbourhood (there are, therefore, no actions at a distance). Secondly, CA is abstract, as they can be specified in purely mathematical terms and implemented in physical structures. Thirdly, CA are computational systems: they can compute functions and solve algorithmic problems. Despite functioning in a different way from traditional, Turing machine-like devices, CA with suitable rules can emulate a universal Turing machine, and therefore compute, given Turing's Thesis, anything computable.

The mark of CA consists in their displaying complex emergent behaviour, starting from simple atoms deterministically following simple local rules. Because of this, CA attracts a growing number of researchers willing to study pattern formation and complexity in a pure, abstract setting. This entry provides an introduction to CA focusing on some of their philosophical applications: this range from the philosophy of computation and information processing, to philosophical accounts of reduction and emergence in metaphysics, and debates in fundamental physics.

About the study area: Ahmedabad city

Human population continues to cumulate in urban centers. This inevitably increases the urban footprint with significant consequences for biodiversity, climate, and environmental resources. Urban growth prediction models have been extensively studied with the overarching goal to assist in sustainable management of urban centers. There are various existing models, which have their own advantages and limitation. Here I will be using cellular automata the prevailing modeling technique. The study is based on the data availability from LISS III and LandSat. This model assesses developer and user perceptions and critically discusses existing urban growth prediction models, acting as a reference for future model development.

City of Ahmedabad

The city of Ahmedabad is ranking on top among the largest metropolis in India. It is the first largest city in the State of Gujarat. According to Census of India 2011, the population of urban agglomeration reached to 7.2 million. The city is situated on 23°00’N Latitude and 72° 00’E Longitude. The city remained as a capital for the State till the year 1970. Currently it is a district headquarters. River Sabarmati is passing through the city divides into two parts, East and West. The western part of the city is comparatively newly developed. Therefore it is planned and sparsely built in comparison to the eastern part.

Infrastructure Services

The city of Ahmedabad provides mandatory services to the citizen. Those are water supply, sewerage, solid waste etc. are the physical infrastructure the city government provides and maintains

Objectives of the study

- Map the extent of urban growth for the largest city and former capital of the Indian state of Gujarat, Ahmedabad.
- Develop and calibrate an urban growth simulation model based on historical urban growth to predict future urban growth.
- The potential of the use of satellite images for the assessment of urban growth on which future work should focus as the key factors of economic-environmental sustainability based on parameters taken into considerations that directly influence the land use.

Study area: former capital of the Indian state of Gujarat, Ahmedabad.
Latitude: 23.0300^0 N | **Longitude:** 72.5800^0 E

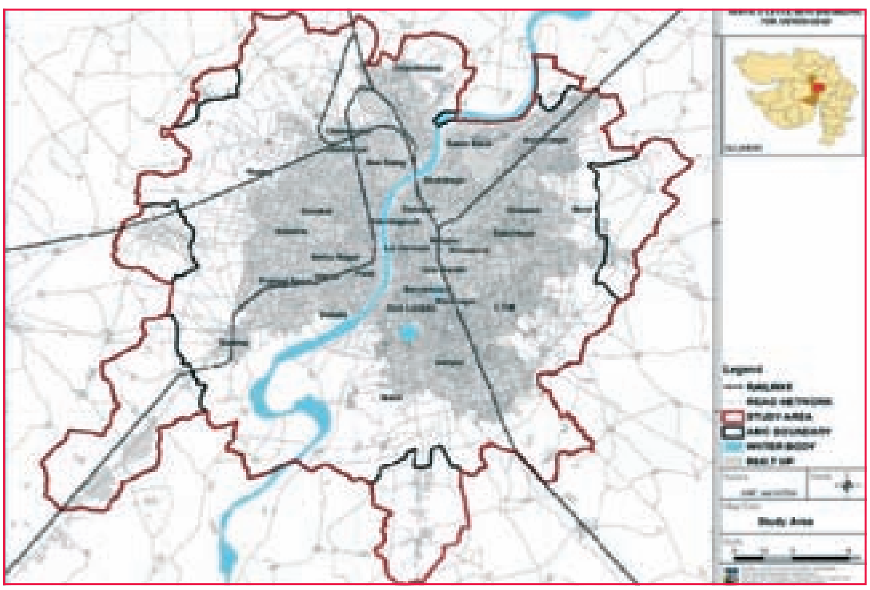


Figure 1: Ahmedabad City Area Limit Map [Ref.] Ministry of Urban Development, Government of India Center for Excellence (CoE) in Urban Transport, CEPT University, Ahmedabad

Data & software used for study

Satellite Data Used

IRS P6/Resourcesat-1

The IRS (Indian Remote sensing) satellites form a large family of Earth observations satellites operated by the Indian space agency.

IRS P6/Resourcesat-1 & Resourcesat-2 provides data of medium and high resolution by the twin satellites IRS-2C and IRS-1D.These two, launched in 1995 and 1997 respectively. Resourcesat satellites carries a LISS-III sensor as well a wide field AWiFS sensor ,but the high resolution(5.8 m) LISS-IV sensor replaces the panchromatic sensor. The high resolution data are useful for applications such as urban planning and mapping, while the average resolution is used for vegetation discrimination, land mapping, and natural resources management.

Figure 2: Location Map of India

LISS-III

The LISS-III (Linear Imaging Self Scanning Sensor) sensor is an optical sensor working in 4 spectral bands (Green, red, near infrared and short wave infrared). The Linear Imaging Self Scanning Sensor (LISS-III) is a multi-spectral camera operating in four spectral bands, three in the visible and near infrared and one in the SWIR region, as in the case of IRS-1C/1D. The new feature in LISS-III camera is the SWIR band (1.55 to 1.7 microns), which provides data with a spatial resolution of 23.5 m unlike in IRS-1C/1D (where the spatial resolution is 70.5 m).

The Data products are categorized as Standard and have a system level accuracy.

LISS-III Standard Products comprise Path/Row Based products, Shift Along Track product, Quadrant products and Georeferenced products. Path/Row Based products are generated based on the referencing scheme of each sensor. Shift Along Track applies to those products covering a user's area of interest which falls in between two successive scenes of the same path, then the data can be supplied by sliding the scene in the along track direction. LISS-III full scene is divided into four nominal and eight derived quadrants. LISS-III photographic quadrant products are generated on 1:125,000 scale. Georeferenced products are true north oriented products. These products are supplied on digital media only.

Standard Path/Row Based products cover an area of 141 x 141 km and are characterised by 3 Bands. Path/Row Based products comprise Raw, Radiometrically corrected and Geo referenced levels of corrections. Quadrant products cover an area of 70 x 70 km and are characterised by 3 or 4 Bands (Geo Referenced). Quadrant products comprise Standard and Geo referenced levels of corrections.

Software Used

i. ArcMap 10.1
ii. Erdas Imagine 2011
iii. IDRISI Selva 17.02
iv. Microsoft Excel 2007

Table 1: Satellite Image Used Information

Sr. No.	Satellite	Sensor	Date of Pass	Path/Row	Source
1	IRS Resourcesat-1	LISS-III	1-Nov-2008	093/056	NRSC/ISRO
2	IRS Resourcesat-1	LISS-III	16-Dec-2011	093/056	NRSC/ISRO

Table 2: IRS-P6 Radiometric Characteristics (micron) or Specifications

Sr. No.	Band	Spectral Band	Resolution
1	Band 2(Green)	0.52-0.59µm	23.5*23.5m
2	Band 3(Red)	0.62-0.68 µm	23.5*23.5m
3	Band 4(NIR)	0.77-0.86µm	23.5*23.5m
4	Band 5(SWIR)	1.55-1.70µm	23.5*23.5m

Methodology for study

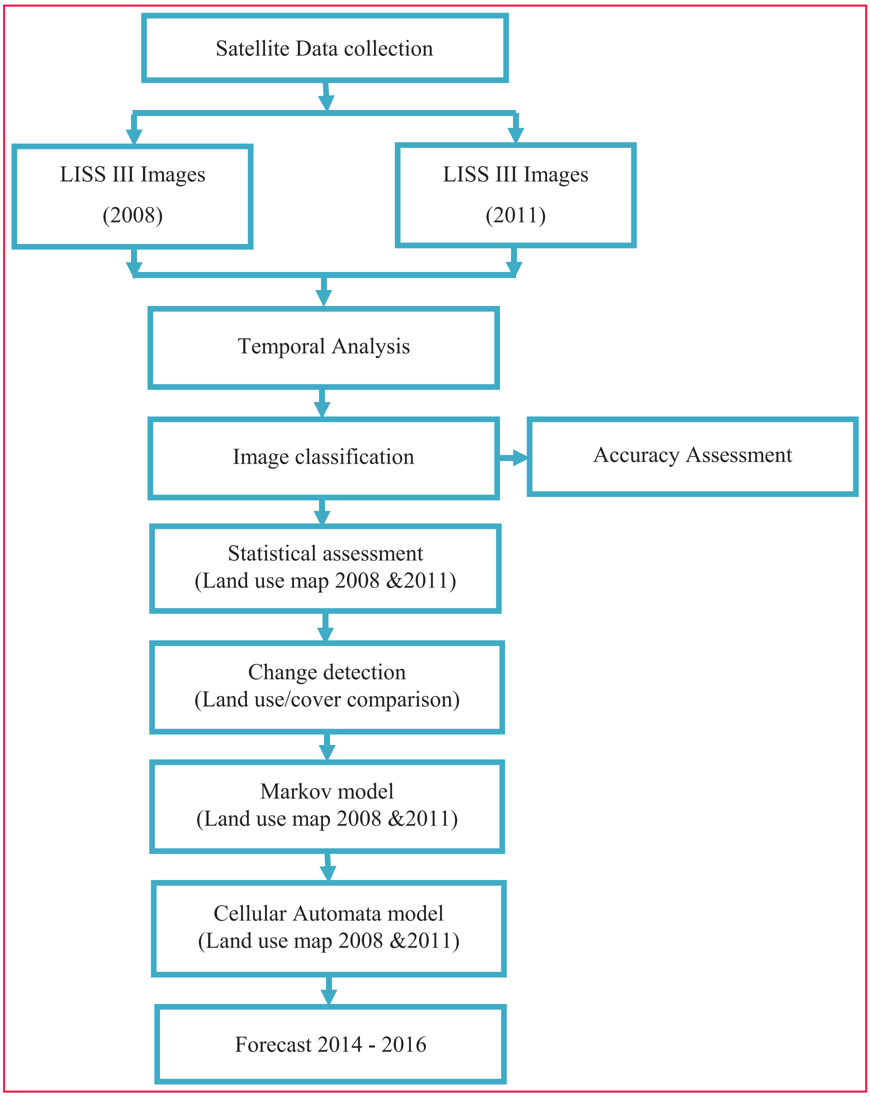
In this module, the main components of the urban growth model applied on Ahmedabad, an overview of the workflow as shown in flow chart. Which is comprised of various stages: a) Classification of satellite images and b) computation of transition probability maps? These maps, in combination with the land use maps, were required for Markov Change detection and cellular automata simulation model to predict future urban growth (for 2014).

Extraction of Land Use Map

Spatiotemporal mapping includes quantitative time series analysis and transformation of land cover classes. Because land use maps are a fundamental prerequisite for modeling future growth, individual land use classes were extracted from the remotely sensed images for each timestamp. After geometric corrections, the land use maps were initially classified based on the maximum likelihood algorithm and further accuracy assessment is observed onto classified images.

Table 3: IRS-P6 – Resourcesat-1 Technical Characteristics

Sr. No.	Space Vehicle Name	IRS-P6 (ResourceSat-1)
1	Country	India
2	Designers	ISRO
3	Operator	ISRO
4	Booster	PSLV C5
5	Launch Date	October 17th 2003
6	Orbit:	Sun-Synchronous Polar
	a) Altitude - km	817
	b) Inclination - deg	98.7
	c) Revisiting Period - min	101
7	Platform:	IRS-1
	a) Survey Equipment	LISS-4, LISS-3, AWiFS
	b) Declination Angles - deg	+-26°
8	Survey Repeatability - days	5
9	Active Life - years	5
10	Space Vehicle Dimensions - m x m	-
11	Space Vehicle Mass - kg	1360
12	Applications	Agriculture (Afforestation/ Reforestation Protection), Land (Soil, Vegetation, Landscape Topography), Solid Earth (Tectonics), Water (Water Management) and etc.,



Flow Chart 1: Methodology Flow Chart

Urban Growth Model

Urban Growth Prediction Models (UGPMs) are tasked to capture intrinsic and complex relationships in space and time. The spatial complexity reflects the impact of numerous biophysical and socioeconomic factors and as a result heterogeneous patterns appear across location and scale thus making urban development a dynamic and non-linear process.

The IDRISI Selva version 17.02 has been used for the analysis of images. Markov chain model has been applied to find the future change of LU/LC in the study. The land use information of the year 2014 is predicted according to the land use classification using supervised approach with maximum likelihood.

Markov Chain

Markov chain models have been used to model landscape changes in understanding and predicting the behaviour of complex systems using discrete state spaces. All landscape spatial transition models can be expressed in a simple matrix equation as follows:

$$N_{t+1} = N_t * P$$

where Nt + 1 and Nt are vectors composed of the fractions of each landscape type at time t + 1 and time t, respectively; P is a square matrix, whose cell Pij is the transition probability from landscape i to j during times t and t + 1.The transition probabilities P are derived from the landscape transitions occurring during some time interval.

Theoretically, the Markov chain model assumes that the transition probability is spatially independent (Brown et al. 2000). However, the future trend of a pixel to change is not a simple function of its current state, but is often affected by it neighbouring cells. The resulting probabilities were summarized in a transition probability matrix, not directly transferable to spatial representations. Therefore, additional steps are needed to incorporate both spatial and temporal information using CA.

Cellular Automata

Cellular automata (CA) were introduced by Ulan and Neumann in 1940 and since 1980 numerous models have been developed for simulating urban growth CA is defined as discrete dynamics systems, represented by a grid of cells, in which local interconnected relationships exhibit global changes.

Generally, the state of each cell depends on the value of the cell on its previous state as well as the values of its neighbours according to some transition rules and there are two possible values for each cell (0 or 1). As a rule-based model, its topological grid characteristics make CA an appropriate model for incorporating spatial interactions between a cell and its neighbourhood. For example, assuming a 3*3 cell neighbourhood, a cell's state is influenced by its eight adjacent cells. These models are typically calibrated using training data (i.e., past land use maps), which are then compared with an actual land use map, although the quantity of change is neglected. If statistical evaluation, using the kappa index for example, provides valid results, the calibrated model can be applied to the prediction of future urban spatial patterns.

Analysis and results of study

Supervised Land Use/ Cover Classifications

The 2 successive supervised land use/ cover classifications images for the

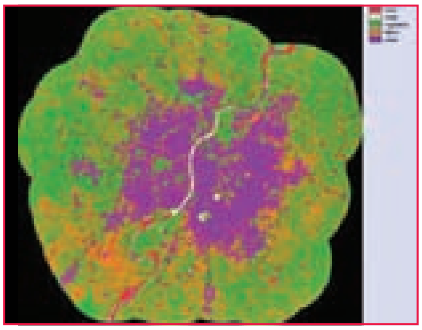


Figure 3: Land Use/Land Cover Change Detection – 2008

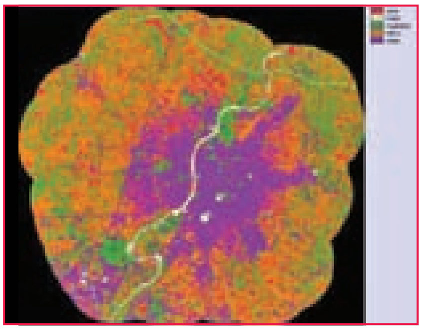


Figure 4: Land Use/Land Cover Change Detection – 2011

Figure 5: Gain and Losses between 2008 & 2011

year 2008 & 2011 discriminated in 5 classes using maximum likelihood are:

Change Detection using LCM in IDRISI:

Land Change Modeler (LCM) was used to analyze the land use/cover changes between various classes during the period of 2008 to 2011 in order to predict future urban.

Here it is observed that there is change in ratio of vegetation, urban and other classes as well, which can be seen graphically using change analysis in IDRISI.

Cellular Automata Markov Modelling

Based on land use conditions during the periods 2008 to 2011, transition potentials were computed using a Markovian process. The transition probability matrices of each land use type for both periods are produce. The diagonal elements represent probability values for self-replacement, referring to land use types that remain similar (Guan et al., 2011). In contrast, off-diagonal values indicate the probability of change from one land use category to another.

CA first input the transition probabilities for these years. The CA allocated the cells by means of a 5*5 or 3*3 matrix as per user requirements and iteration per year. Careful model validation was conducted to assure accuracy and to ensure an applicable simulation that predicts effectively.

Table 4: Supervised Land Use/Cover Classifications

Sr. No.	Classes	Year 2008 in sq.km.	Year 2011 in sq.km.	Difference in sq.km.
1	Urban	179.66592	254.648125	74.982205
2	Vegetation	481.992192	254.66255	-227.329642
3	Water	8.299008	24.358125	16.059117
4	Sand	16.9776	43.615	26.6374
5	Fallow	283.725504	475.95625	192.230746
	Total	**970.660224**	**1053.24005**	

Acknowledgements

We would like to acknowledge Dr. Anjana Vyas, Professor and Program Coordinator of Geomatics, CEPT University, Ahmedabad, and Mrs Shaily Gandhi, CEPT University, Ahmedabad for their assistance for providing relevant information and guidance for this study.

References

Hossein Shafizadeh Moghadam , Marco Helbich, (2013) .Spatiotemporal urbanization processes in the megacity of Mumbai, India: A Markov chains-cellular automata urban growth model. Applied Geography 40 140e149

Chanvoleak Ourng; Daniel S.R; Ligia T. Silva; Rui A.R. Ramos (2011), A proposed methodology for understanding urban growth pattern: a case study in Siem Reap, Cambodia. 16th WSEAS International Conference, Montreux, Switzerland.

Kumar, A., Pandey, A. C., Hoda, N., & Jeyaseelan, A. T. (2011). Evaluation of urban sprawl pattern in the tribal-dominated cities of Jharkhand state, India. International Journal of Remote Sensing, 32, 7651e7675.

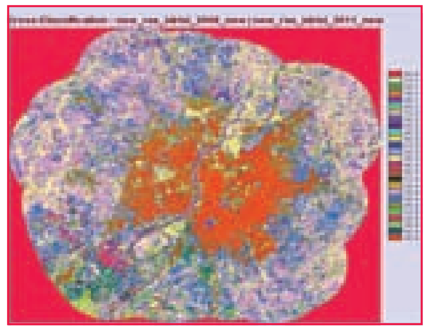


Figure 6: Cross Tab Classification for 2008 and 2011

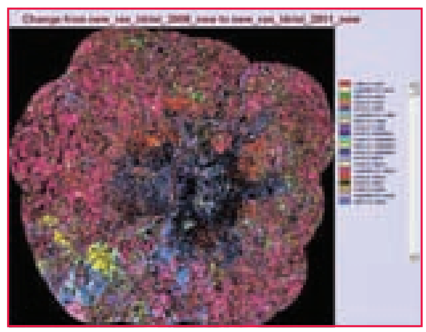


Figure 7: Change from 2008 and 2011

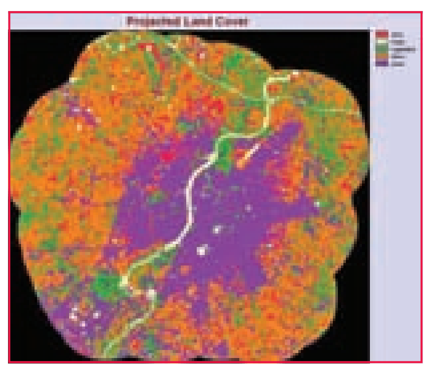


Figure 8: Predicted Land Cover for Ahmedabad City in 2016

The study is based on the data availability from LISS III. This model assesses developer and user perceptions and critically discusses existing urban growth prediction models, acting as a reference for future model development

Al-Ahmadi, K., See, L., Heppenstallm A,m & Hoggm J. (2009), Calibration of a fuzzy cellular automata model of urban dynamics in Saudi Arabia. Ecological Complexity, 6 (2), 80-101.

Heng Sun &Wayne Forsythe & Nigel Waters, (2007), Modelling Urban Land Use Change and Urban Sprawl: Calgary, Alberta, Canada, Netw Spat Econ 7:353–376 DOI 10.1007/s11067-007-9030-y

Czamanski, D., Benenson, I., Malkinson, D., Marinov, M., Roth, R., & Wittenberg, L. (2008). Urban sprawl and ecosystems e can nature survive? International Review of Environmental and Resource Economics, 2,321e366.

Sharaf Alkheder, Jun Wang and Jie Shan, (May 2006), Change detection - cellular automata Method for urban growth modelling,. ISPRS Commission VII Mid-term Symposium “Remote Sensing: From Pixels to Processes”, Enschede, the Netherlands, 8-11

M. Herold, H. Couclelis and K. C. Clarke, (2005), “The Role of Spatial Metrics in the Analysis and Modelling of Urban Land Use Change,” Computer, Environment and Urban Systems, Vol. 29, No. 4, pp. 369-399.

Clarke, K. C., and Dietzel C., (2004), A decade of SLEUT Hing: Lessons learned from applications of from applications of a cellular automaton land use change model. In: The Joint International Workshop on Integrated Assessment of the Land System: The Future of Land Use. Institute for Environmental Studies, Amsterdam.

H.S. Sudhira a, T.V. Ramachandra a, K.S.Jagadish, (2004) b. Urban sprawl: metrics, dynamics and modelling using GIS. International Journal of Applied Earth Observation and Geoinformation 5 29–39

Wu, F. (2002) Calibration of stochastic cellular automata: the application to rural-urban land conversions. International Journal of Geographical Information Science, 16 (8), 795-818.

Torrens, P.M., O’ Sullivan, D., (2001). Cellular automata and urban simulation: where do we go from here? Environ. Plann. B 28,163–168

Batty M., Xie Y., Sun Z. (1999), The dynamics of urban sprawl. Working Paper Series, Paper 15, Centre for Advanced Spatial Analysis, University College, London.

Eric De Noronha vaz, Mario Caetano & Peter NijKamp. Trapped between antiquity and urbanism- a multi-criteria assessment model of the greater Cario Metropolitian area. Journal of land use science vol.6, no.4

Antonia Mavroudi., Simulating city growth by using the Cellular Automata Algorithm. Bartlett School of Graduate Studies University College London.

Ministry of Urban Development, Government of India, Center for Excellence (CoE) in Urban Transport, CEPT University, Ahmedabad.

The paper was presented at Asian Conference on Remote Sensing (ACRS), Colombo, Sri Lanka 17-21 October 2016

NEWS - UAV

Insitu™ announces high accuracy photogrammetry payload

Insitu has announced the successful integration of a 50-megapixel camera into its ScanEagle™ Unmanned Aerial Vehicle (UAV) for delivering High Accuracy Photogrammetric (HAP) aerial imagery. The HAP-equipped ScanEagle remotely surveys broad areas quickly, accurately, and safely — due to ScanEagle’s proven Beyond Visual Line of Sight performance and Insitu’s specialized direct georeferencing system, combined with the accuracy of the carefully selected, purpose-built 50-megapixel aerial camera. *www.insitu.com*

China launches record-breaking drone swarm

China has launched a record-breaking swarm of 119 fixed-wing unmanned aerial vehicles, authorities said on Sunday. The feat broke the previous record of a swarm of 67 drones, the China Electronics Technology Group Corporation (CETC) said.

The 119 drones performed catapult-assisted take-offs and formations in the sky. According to the CETC, “swarm intelligence” is regarded as the core of artificial intelligence of unmanned systems and the future of intelligent unmanned systems.

Zhao Yanjie, an engineer with CETC, said that since drones were invented in 1917, intelligent swarms have become a disruptive force to “change rules of the game”. http://timesofindia.indiatimes.com/

Frontier Precision brings Microdrones UAV western U.S.

Frontier Precision has announced they are now offering Microdrones unmanned aerial mapping solutions. To accomplish this, Frontier Precision hired experienced UAS Specialist and certified pilot, Jack Wilcox, who will focus strictly on getting users started with unmanned systems. Frontier Precision recently completed Microdrones’ mdAcademy training.

Teledyne CARIS reacts to IHO request to support latest ENC Validation Standard

CARIS™ has announced the adoption of Edition 6.0 of IHO Publication S-58 for ENC validation checks, in the latest release of CARIS S-57 Composer™ 3.1.Its internal and customized quality control tests have been reorganized, rewritten and extended to match the standard. New messages have been added to the tests and the descriptions have been re-worded to add clarity. New test collections have been created to quickly determine if an ENC passes the mandatory Error and Warning checks. *caris-info@teledyne.com*

CompassTrac Enterprise Mobile Resource Management Solution

CompassCom Software has unveiled Version 7.1 of its industry leading mobile resource management (MRM) solution. It is an on-premise platform that receives location and status data from any GPS-equipped vehicle, hand-held device or high-value asset and serves that information in real-time to a digital map app. Deployed extensively by public works, public safety, DOT, utility, and local government agencies to manage and dispatch fleets and field personnel, the CompassCom MRM solution integrates with the Esri environment.*www.compasscom.com*

Plan to deliver authoritative pan-European open data services unveiled

Members of EuroGeographics have unveiled plans for pan-European open data services underpinned by geospatial information from official sources. The Open European Location Services (ELS) project aims to improve the availability of geospatial information from the public authorities responsible for mapping, cadastre and land registries. Funded by the European Commission, it builds upon the European Location Framework (ELF) project, which developed the standards, specifications, tools and technical infrastructure to deliver pan-European geospatial content. *www.eurogeographics.org*

China launches remote-sensing micro-nano satellites

China has launched two remote-sensing micro-nano satellites on a Long March-4B rocket from Jiuquan Satellite Launch Center in northwest China's Gobi Desert. The OVS-1A and the OVS-1B, the first two satellites of Zhuhai-I remote-sensing micro-nano satellite constellation, are expected to improve the monitoring of geographical, environmental, and geological changes across the country. *http://news.xinhuanet.com/*

Cartosat-2 and 30 other satellites placed into orbit successfully

On 23 June, Indian Space Research Organisation (ISRO) has successfully launched the 712 kg Cartosat-2 series satellite for earth observation in Cartosat-2 series - a dedicated satellite for defence forces - from the Sriharikota spaceport. The PSLV-C38 carried 712 kg Cartosat-2 series satellite for earth observation and 30 co-passenger nano satellites, weighing about 243 kg, the total weight of all these satellites was about 955 kg. The co-passenger nano satellites belong from 14 different nations, including countries like-Austria, Belgium, Chile, Czech Republic, Finland, France, Germany, Italy, Japan, Latvia, Lithuania, Slovakia, the United Kingdom, the United States of America and India. Cartosat-2 is a remote sensing satellite and its major objective is to provide high-resolution scene specific spot imagery

Amul signs MoU with ISRO

Gujarat Cooperative Milk Marketing Federation (GCMMF) in India recently signed an agreement with Indian Space Research Organisation (ISRO) for fodder acreage assessment using satellite observation and space technology. GCMMF markets its products under the brand name of Amul. Currently, Amul procures around 150 lakh litres of milk daily from around 35 lakh milk producer members from over 18,500 villages. The milk producer farmers of Gujarat will get benefit of fodder cultivation by using this technology. *http://indiatoday.intoday.in*

INR 7L cr to be spent on highways in 5 yrs

In the next five years, approximately INR 7 lakh crore will be spent in building and expanding highways and constructing expressways across the country. While barely 15% of this investment will come from the private sector, the remaining 85% will come from fuel cess and toll, monetisation of completed highway stretches and National Highways Authority of India (NHAI) raising funds from the market.

Road construction is coonsidered a major employment generator. Sources said around 40,000 km of highways will be expanded till 2022, which includes about 24,800km covered under Bharatmala in programme. According to government estimates, construction of 10,000 km of highways annually has the potential of generating four crore mandays. The inter-ministerial panel for approving government investment known as Public Investment Board (PIB) has approved the Bharatmala programme and the entire financing plan for highways development for five years in set to be cleared. It is also learnt that the NHAI Board, which will have representatives from ministries and Niti Aayog, will get the authority to appraise and approve proects up to INR 2,000 crore.

Officials admitted that private investment was likely to be much less than the desired level of at least 30% and hence government has to invest in a big way to push infrastructure growth. With the government making it clear that user charge or toll will be collected on viable stretches, NHAI will recover the investment. It can even auction completed highways projects to private players to get money upfront for fresh projects. For construction and widening of identrified projects. For construction and widening of identified projects, the government aims to generate INR 34,000 crore by monetising some of the completed stretches. The PMO has asked the highways ministry to accelerate monetisation of completed projects.

Japan launches Michibiki 2

Japan launched an H-2A rocket which carries the satellite called "Michibiki No.2" from a space center in Tanegashima, southern Japan.

The first Michibiki satellite was launched into space in 2010 on a trial basis and two more satellites will be sent later this year, according to the Cabinet Office.

Once the four satellites are in orbit, at least one satellite will be flying over Japan for eight hours per day. Combining with the U.S. GPS and the Japanese system will enhance the stability of receiving radio waves and increase the precision of position information. *www.usnews.com*

China launches satellite navigation positioning system

China has launched national satellite navigation and positioning system, which will provide positioning service to transportation, emergency medical rescue and city planning and management. It is the largest in the country and boasts the widest coverage, officials said. Li Weisen, deputy director of the National Administration of Surveying, Mapping and Geoinformation, said that the system consists of 2,700 base stations, a national database centre and 30 provincial level database centres.

The system, featuring faster speed, higher accuracy and wider coverage, will be compatible with other satellite navigation systems, such as the BeiDou and GPS, Li said. *http://indianexpress.com*

GPS III in full production

In a specialized cleanroom designed to streamline satellite production, Lockheed Martin is in full production building GPS III – the world's most powerful GPS satellites. The company's second GPS III satellite is now assembled and preparing for environmental testing, and the third satellite is close behind, having just received its navigation payload. In May, the U.S. Air Force's second GPS III satellite was fully assembled and entered into Space Vehicle (SV) single line flow when Lockheed Martin technicians successfully integrated its system module, propulsion core and antenna deck.
GPS III SV02 smoothly came together through a series of carefully-orchestrated manufacturing maneuvers utilizing a 10-ton crane. GPS III SV02 is part of the Air Force's next generation of GPS satellites, which have three times better accuracy and up to eight times improved anti-jamming capabilities. Spacecraft life will extend to 15 years, 25 percent longer than the newest GPS satellites on-orbit today. *www.lockheedmartin.com/gps.*

Report estimates cost of disruption to GPS in UK would be £1bn per day

The UK stands to lose £1bn per day in the event of a major disruption to the GPS, according to a government report. Emergency services would also be severely affected and struggle to cope with demand. Longer emergency calls, less efficient dispatch, navigation, and congested roads would mean a total estimated loss of £1.5bn. Besides navigation, many industries are reliant on GPS software for swathes of critical applications such as financial trading and precision docking of oil tankers.

The report, titled The economic impact to the UK of a disruption to GNSS and commissioned by quangos Innovate UK and Space UK, follows an incident last year where an error in the GPS network triggered by the decommissioning of a US satellite had knock-on effect across a number of British industries.

The report raises questions as to whether the government should invest in a national backup and what that should be, or if it ought to promote a commercially based backup that government and companies can use as needed. *https://www.theregister.co.uk*

Russia and Brazil may expand space cooperation

Russia and Brazil are studying the possibilities of expanding their cooperation in the space sphere, Russian President Vladimir Putin said after negotiations with President of Brazil Michel Temer.

"A possibility is being studied for joint launches from the Brazilian cosmodrome and the joint production of small- and medium-class carrier rockets," Putin said.

"An electro-optic complex has been opened on the territory of Brazil for detecting space debris and four ground-based stations of Russia's Glonass global navigation system are in operation," Putin said.

Temer expressed interest in expansion of the network of GLONASS stations on the territory of his country.

"We assessed positively the experience of creating the stations of the Russian GLONASS system in Brazil, and we, for our part, expressed interest in expanding the network of these stations," he said. *http://tass.com/science/952649*

Turkish Airlines to optimize navigation capabilities

Boeing has announced, through its subsidiary Jeppesen, a new 10-year service contract with Turkish Airlines, the national carrier of Turkey. The agreement includes both paper and digital Jeppesen charts, FliteDeck Pro, electronic flight bag (EFB) services, NavData digital navigation services, Airport Moving Map capabilities, e-Link digital chart library services and Receiver Autonomous Integrity Monitoring (RAIM) prediction technology. Jeppesen navigational data is provided to customers on a "changes-only" basis, which allows for data download speeds that are many times faster than comparative industry providers. Aiding Turkish Airlines navigation capabilities, Jeppesen RAIM technology assesses the integrity of GPS signals and the accuracy of airborne GPS navigation equipment. Its NavData is developed from a comprehensive aviation database, which is composed of more than one million records. To ensure accuracy, Jeppesen flight information analysts edit and verify approximately 150,000 database transactions generated from worldwide aviation data source documents during every 28-day revision cycle. *www.jeppesen.com*

CNES Offering two new Android Apps for GNSS

French Space Agency CNES – with support from its subcontractor C&S – has made available two Android applications on the Google Play store, compatible with Android Nougat and validated on a Nexus 5X device.

The two new apps are:

- RTCM Converter: this app converts the smartphone GNSS raw measurements to Radio Technical Commission for Maritime Services messages (RTCM message type 1077) and sends them to a caster for further use by third-party softwares.
- PPP WizLite: this app is a lite version of the CNES PPP-Wizard client, currently using only pseudorange and Doppler raw measurements. The app uses these measurements along with external RTCM streams for orbit and clock corrections and broadcasts, such as the ones available from the International GNSS Service Real-Time Service (IGS RTS), to compute the precise position of the phone in real time.

The new Android 7 (Nougat) operating system allows recovering raw measurements from the smartphone's GNSS receiver. *www.ppp-wizard.net*

Next Gen GLONASS Satellite to launch next year

The first of a new generation of GLONASS satellites will be launched next year says the satellite manufacturer, Reshetnev Information Satellite Systems.

The next gen satellite will launch from the Plesetsk spaceport in North Russia. Called Glonass-K2, the new satellites are distinguished by improved accuracy and longer ten-year operational lifespans compared to seven years for the previous generation. And at 1,800kgs they are twice as heavy as the previous K1 series. *tass.com*

First GNSS Integrated in Narrowband Cat-M1 and NB1 Cellular IOT Chipset

Altair Semiconductor has demonstrated GNSS functionality integrated in its new ALT1250 narrowband CAT-M1 and NB1 (NB-IoT) chipset. It is the only narrowband cellular IoT chipset in the market that incorporates GNSS/GPS functionality. In addition to GNSS functionality, its extreme level of integration eliminates the need for most external components required to design a cellular IoT module. Approximately the size of a shirt button and less than 100mm^2 in size, an ALT1250 module features support for both Release 13 standards - CAT-M1 and NB1, and includes a wideband RF front-end supporting unlimited combinations of LTE bands. *www.altair-semi.com*

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www.Trace.ME

RIEGL gets JALBTCX Technical Award for contribution in LiDAR bathymetry

The receipients of the Sebastian Sizgoric Technical Achievement Award has been announced. RIEGL has been chosen this year for its major contribution in the field of LiDAR bathymetry and airborne coastal mapping and charting. The trophy was presented to RIEGL during the 18th Annual JALBTCX Airborne Coastal Mapping and Charting Workshop. The event took place from June 6 to June 8 at Savannah International Trade and Convention Center, Georgia. JALBTCX is the Joint Airborne LiDAR Bathymetry Technical Center of Expertise whose mission is to perform operations, research, and development in airborne LiDAR bathymetry and complementary technologies.

Applanix and the University of Waterloo collaborate

Applanix, a Trimble Company, has announced that it is collaborating on advanced research for autonomous vehicle guidance and control systems with the University of Waterloo Centre in Ontario, Canada for Automotive Research (WatCAR). Applanix will provide WatCAR with its industry-leading Positioning and Orientation System (POS) for testing autonomous guidance and control systems in real-world conditions. Applanix will also provide the Trimble GNSS-Inertial board set for integration with car systems and sensors to enable precise positioning. *www.applanix.com*

Trimble launches VRS now correction service in France

Trimble has announced the availability of its Trimble® VRS Now™ GNSS correction service in France. The service is ideal for a variety of geospatial and construction applications including surveying, cadastral, land administration, and urban and rural construction that would benefit from easy access to high-accuracy, centimeter-level positioning. Trimble also recently announced Galileo support for its VRS Now correction service. Powered by the Trimble Pivot™ Platform, VRS Now in Europe fully supports GPS, GLONASS, BeiDou, QZSS and now, Galileo satellite systems. *www.trimble.com*

GPS M-Code receiver order for U.S. Air Force

Rockwell Collins delivered the last of a 770 Military-Code (M-Code) GPS receiver order to the U.S. Air Force Space and Missile Systems Center (USAF SMC). Committed to the Military GPS User Equipment (MGUE) program, the M-Code receiver operates using a more powerful signal, resistant to cyber threats. M-Code not only enhances traditional GPS for military use but coexists with existing signals without interfering with current or future civilian or military user equipment. It is also designed to be autonomous so users can calculate their positions solely using the M-Code signal compared to existing signals where more than one signal code is required. *www.rockwellcollins.com*

Leica Cyclone REGISTER 360

Hexagon has announced its new Leica Cyclone REGISTER 360 laser scanning software for simpler, automated registration, and its Cyclone Cloud Services platform for secure global collaboration through an on-demand software-as-a-service model. Together, the new products offer users smarter ways to register, visualise and collaborate around digital reality projects, delivering solutions into the architecture, engineering and construction (AEC), plant, survey and public safety markets through the connected Leica Cyclone family. *hexagon.com*

Spectra Precision's new GNSS receiver

Spectra Precision has introduced its new SP90m multi-frequency and multi-application GNSS receiver. The Spectra Precision® SP90m is a powerful, highly versatile, ultra-rugged and reliable GNSS positioning solution for a wide variety of real-time and post-processing applications. It features integrated communications options such as Bluetooth, WiFi, UHF radio, cellular modem as well as two MSS L-band channels to receive Trimble® RTX™ correction services. With a modular form factor, the SP90m is flexible and can be used as a base station, campaign receiver, continuously operating reference station (CORS), RTK or Trimble RTX rover, or integrated on-board a machine.

The state-of-the-art and patented Z-Blade™ GNSS-centric technology uses all available GNSS signals to deliver fast and reliable positions in real-time. The SP90m GNSS receiver also allows the connection of two GNSS antennas for precise heading or relative positioning determination without a secondary GNSS receiver. *www.spectraprecision.com*

Uttar Pradesh Police receives award

Hexagon Safety & Infrastructure presented Uttar Pradesh Police with an Icon Award for the police force's efforts to improve emergency response for 220 million citizens in the state of Uttar Pradesh, India. Announced at HxGN LIVE, Hexagon's annual conference, the Icon Awards are Hexagon Safety & Infrastructure's highest customer award, presented for visionary use of software to significantly benefit citizens and communities. Uttar Pradesh Police is the largest police force in India and among the largest in the world, with 250,000 police officers in 75 districts. Uttar Pradesh Police selected Hexagon's Intergraph® Computer-Aided Dispatch (I/CAD) suite for UP 100. Two hundred fifty call-takers, 150 dispatchers and thousands of field officers use I/CAD applications to respond to citizen needs. *hexagon.com*

IDS GeoRadar launches safety, stability monitoring radar for the underground mining industr

IDS GeoRadar has introduced HYDRA-U, a radar-based technology solution specifically designed and developed to support geotechnical engineers in the underground mining industry. HYDRA-U is a remote sensing monitoring system able to provide real time monitoring of surface deformations as well as management of ground fall hazards over large areas. The system is designed to trigger early-warning alerts based on specific velocity thresholds in case of impending collapses to evacuate people and machinery at-risk. It can fit narrow spaces typical of underground operations and is designed for quick and easy transport and deployment in critical areas by one single person. *http://idsgeoradar.com/*

Altair Semiconductor demonstrates GNSS functionality

Altair Semiconductor demonstrated GNSS functionality integrated in its new ALT1250 narrowband CAT-M1 and NB1 chipset. According to Altair, ALT1250 is the only narrowband cellular Internet of Things (IoT) chipset in the market today that incorporates GNSS and GPS functionality. In addition to GNSS functionality, the ALT1250's level of integration eliminates the need for most external components required to design a cellular IoT module. *www.satellitetoday.com/*

Microsemi updates TimeProvider 5000

Microsemi Corporation has updated the hardware on its TimeProvider 5000 IEEE 1588 Precision Time Protocol (PTP) grandmaster clock. The update enables the clock to support Internet Protocol version 6 (IPv6) and multi-GNSS constellations to ensure better reception and higher security in a wide variety of telecommunications network applications. The device offers multiple constellations in accordance with the directives in certain countries to remove their sole dependency on GPS. Having support for GLONASS and Galileo constellations also makes systems more robust and secure to certain GNSS vulnerabilities.

Tersus GNSS releases inertial navigation system

Tersus GNSS Inc. is now offering the INS-T-306, a GNSS-aided inertial navigation system. The INS-T-306 is the advanced module that combines GPS L1/L2, GLONASS, BDS navigation and a high-performance strap-down system. It is capable of determining position, velocity and absolute orientation (heading, pitch and roll) for any device on which it is mounted. The launch of the INS-T-306 aims at facilitating motionless and dynamic applications that need high accuracy, such as vessels, ships, helicopters, unmanned aerial vehicles (UAVs) and unmanned ground vehicles (UGVs).

Pulsar-Based Navigation System to get test on space station

An experiment that arrived on International Space Station on June 5 will test a celestial navigational system that one day may guide future spaceships to Jupiter as efficiently as GPS satellites get you to Starbucks. The Station Explorer for X-ray Timing and Navigation Technology (SEXTANT) experiment is among the projects planned for the world's first telescope dedicated to observing neutron stars, the densest known objects in the universe. Neutron stars form when a star roughly 10 to 30 times the mass of the sun runs out of fuel for nuclear fusion and collapses, crushing every proton and electron in its core. The result is a ball of neutrons about 12.5 miles (20 kilometers) across — roughly the size of a city — that contains as much mass as the sun. *Space.com*

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July 2017

United Nations/United States of America Workshop on the International Space Weather Initiative
31 July - 4 August
Boston College, Massachusetts, USA
www.unoosa.org

August 2017

SEASC 2017
15-17 August
Brunei Darussalam
www.seasc2017.org/

September 2017

INSPIRE 2017
4 - 5 September, Kehl Germany
6 - 8 September, Strasbourg France
http://inspire.ec.europa.eu/events/inspire-conference-2017

Interdrone 2017
6 - 8 September
Las Vegas, USA
www.interdrone.com

ESA-JRC Summer School on GNSS 2017
4 - 15 September
Svalbard-Spitsbergen, Norway
www.esa-jrc-summerschool.org

56th Photogrammetric Week '17
11-15 September
Stuttgart, Germany
www.ifp.uni-stuttgart.de/phowo

ION GNSS+ 2017
25 - 29 September
Portland, USA
www.ion.org

Intergeo 2017
26 - 28 September
Berlin, Germany
www.intergeo.de

October 2017

GIS Congress-2017
2 – 3 October
Vienna, Austria
http://gis-remotesensing.conferenceseries.com/europe/

Year in Infrastructure Conference
10 -12 October
Singapore
https://www.bentley.com/en/yii/home

INGEO2017
18 – 20 October
Lisbon, Portugal
http://ingeo2017.lnec.pt/index.html

ACRS 2017
23 - 27 October
New Delhi, India
www.acrs2017.org

6th International Colloquium – Scientific and Fundamental Aspects of GNSS/Galileo
25 – 27 October
Valencia, Spain
http://esaconferencebureau.com/2017-events/17a08/introduction

3D Australia Conference 2017
26 - 27 October
Melbourne, Australia
http://3dgeoinfo2017.com

ITS World Congress 2017
29 October – 2 November 2
Palais des congrès de Montréal, Quebec
itsworldcongress2017.org

November 2017

37th INCA INTERNATIONAL CONGRESS
1 – 3 November
Dehradun, India
http://incaindia.org/index.php/2016/12/10/37th-inca-international-conference-2017/

PECORA 20- 2017
14 – 16 November
South Dakota, USA
https://www.asprs.org/asprs-events/pecora-20-2017-sioux-falls-south-dakota.html

International Technical Symposium on Navigation and Timing (ITSNT)
14 – 17 November
Toulouse, France
http://www.itsnt.fr

Commercial UAV Show and GeoConnect Show 2017
15 - 16 November
London, UK
http://www.terrapinn.com/template/live/add2diary.aspx?e=9214

INC 2017
27 - 30 November 2017
Brighton, UK
http://www.internationalnavigationconference.org.uk

December 2017

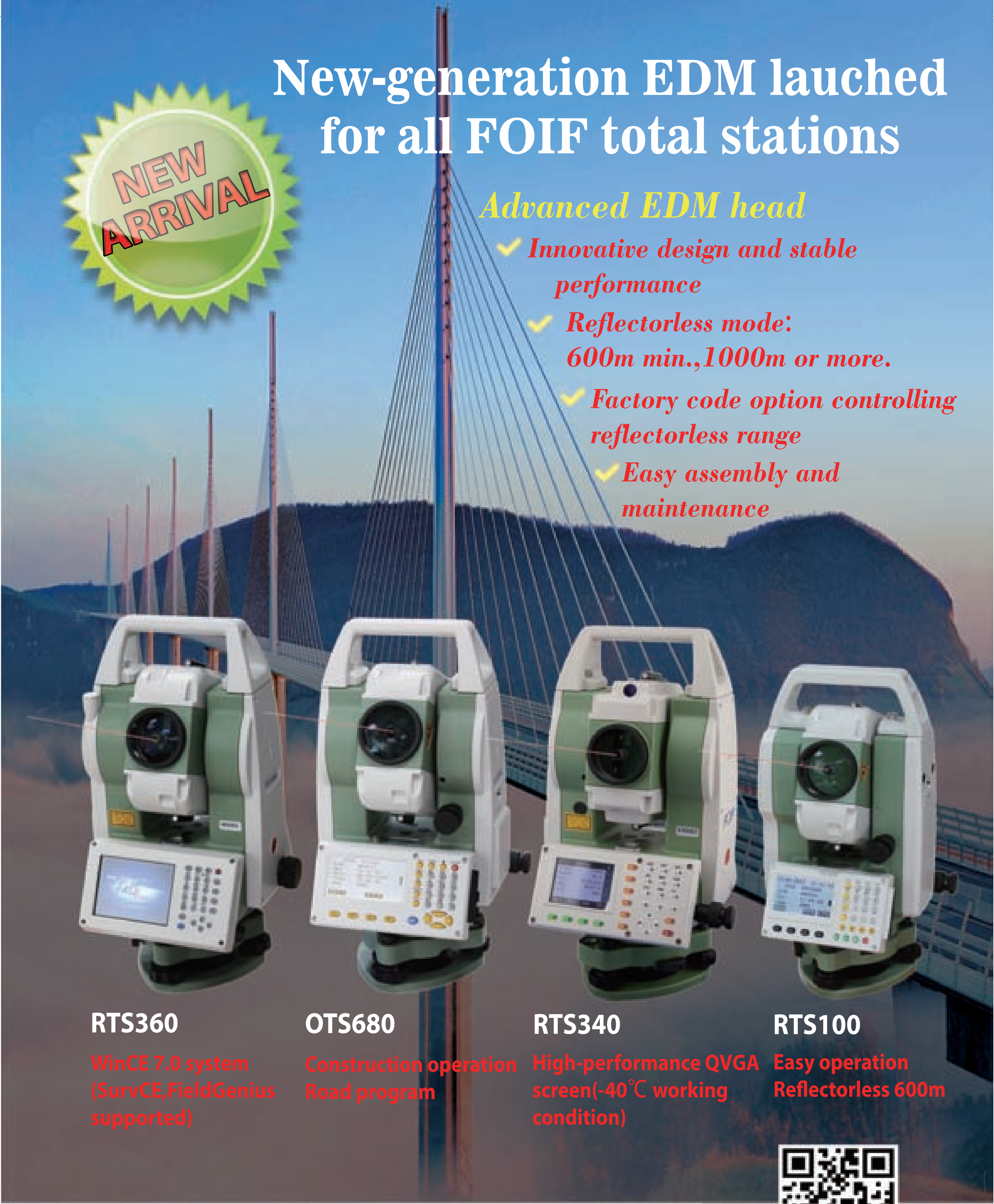
International Symposium on GNSS (ISGNSS 2017)
10-13 December
Hong Kong
www.lsgi.polyu.edu.hk

February 2018

GMA: Geodesy, Mine Survey and Aerial Topography
15 – 16 February
Moscow Novotel Center, Russia
http://www.con-fig.com/?lang=eng

April 2018

The 7th Digital Earth Summit 2018
17 – 19 April
El Jadida, Morocco
http://www.desummit2018.org/



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