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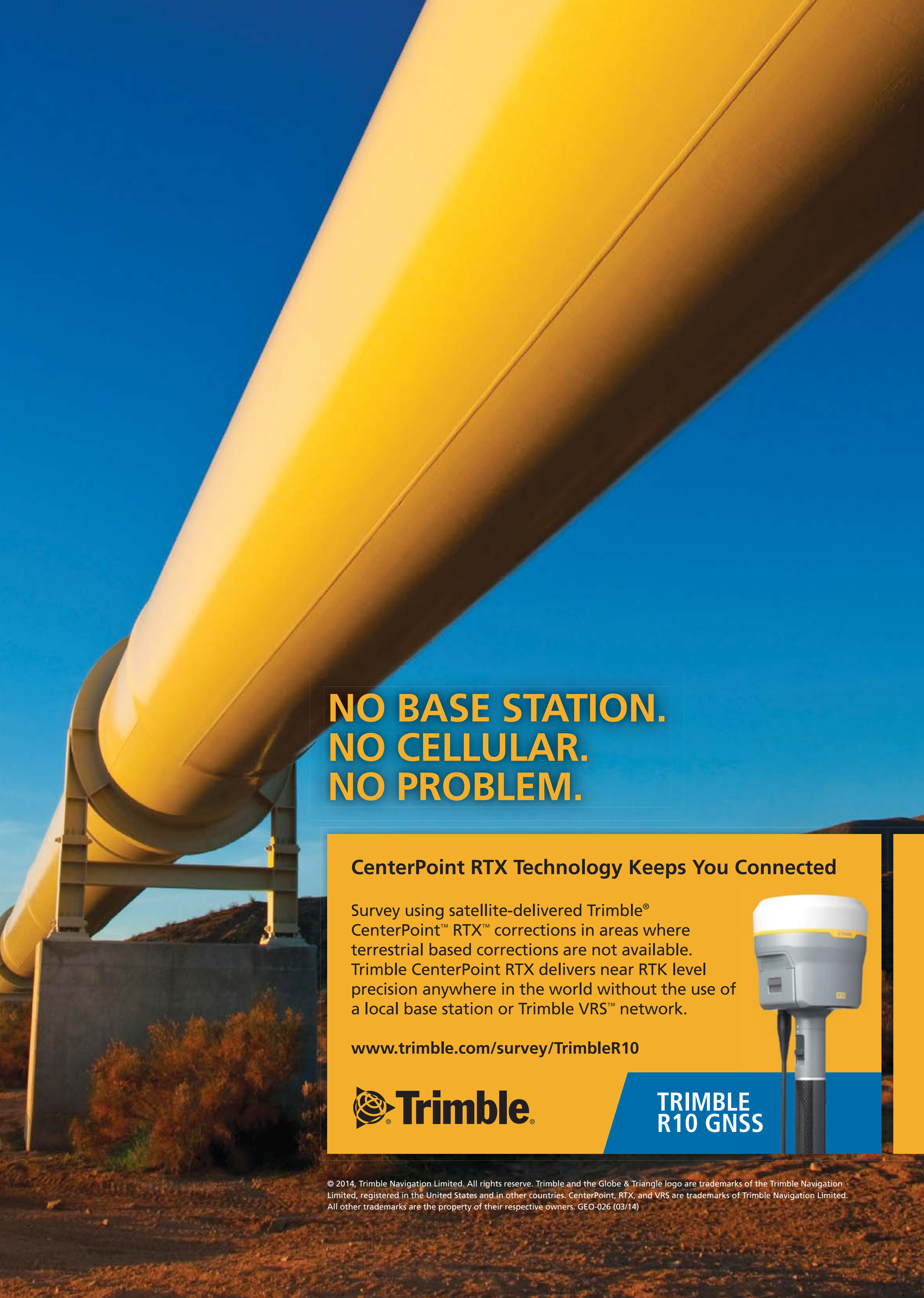
THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

Safe navigation for autonomous robot systems

Geodesy • SDI • Land Administration



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

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

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Editor Bal Krishna

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Spectra Precision Division
Rue Thomas Edison
ZAC de la Fleuriaye - CS 60433
44474 Carquefou (Nantes), France

+33 (0)2 28 09 38 00 Phone

ASIA-PACIFIC

Spectra Precision Division
80 Marine Parade Road
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SPECTRA PRECISION

IRNSS - IB: Another step forward

April 4, 2014.

ISRO's Polar Satellite Launch Vehicle, PSLV-C24, successfully launched IRNSS-1B.

The second satellite of the seven constituting the Indian Regional Navigation Satellite System (IRNSS).

The first one was successfully launched on July 02, 2013.

Two more satellites of this constellation, namely, IRNSS-1C and IRNSS-1D, are planned to be launched in the second half of 2014.

The entire IRNSS constellation of seven satellites is planned to be completed by 2015-16.

The project, initiated almost a decade back, had a long phase of lull.

But lull before the 'storm' was worth its while, in form of successful launches.

Kudos to the team ISRO!

Let the 'storm' continue.

Bal Krishna, Editor
bal@mycoordinates.org

Safe Navigation for autonomous Robot systems

The project SiNafaR (German acronym for "Sichere Navigation für autonome Robotikplattformen") aims for identifying requirements, legal aspects in Germany, and finding technological solutions for heterogeneous multiagent systems in the civilian sector, especially in the domain of security services covering large areas

Oliver Kurz
Fraunhofer IIS, Germany

Manuel Stahl
Fraunhofer IIS, Germany

Doris Aschenbrenner
Zentrum für Telematik, Germany

Michael Fritscher
Zentrum für Telematik, Germany

Robin Hess
Julius Maximilian University of Wuerzburg, Germany

Klaus Schilling
Julius Maximilian University of Wuerzburg, Germany

The project SiNafaR concentrates on surveilling big areas like container harbors with autonomous and heterogonous robots supporting the security staff. A combined network of heterogeneous agents takes advantage of the different capabilities to solve complex problems like surveillance. On the one hand, the high maximum velocity of an UAVs and the absence of obstacles in greater heights allow a fast approach of a single point. UGVs, on the other hand, offer a higher operation time, and therefore allow constant patrolling. But they can only provide video stream of a frog-perspective und suffer from connection loss due to ground structures. Therefore a combination of both advantages is beneficial.

Despite the system concept of a heterogeneous surveillance system, its information and data flow, special attention is drawn to the precise and reliable positioning, by means of local and global navigation. For setting up such a system in the civil domain, precise determination of the location of each node is essential. In order to avoid accidents with persons or collision with infrastructure elements, a robot device must have knowledge about its own position and the surrounding environment. A commonly used position determination system for outdoor applications is Global Navigation Satellite System (GNSS) with the currently available systems Global Positioning System (GPS) and GLONASS. GNSS systems suffer from unpredictable errors caused by atmospheric noise, satellite failures or multipath effects, which could lead to invalid position information. For the project SiNafaR, a new system has been developed to detect noise, multipath conditions or faulty GPS-data.

Fraunhofer IIS has developed a GPS receiver solution based on real-time-kinematic (RTK), enabling a conservative quality evaluation of the current localization data. Using a base station and more than one low-cost GPS receiver on the robots, the system can judge whether the data is valid or degraded by undesired effects. The solution includes a consideration of noise within the GPS pseudoranges as well as a special channel detecting multipath effects, and the fault detection and identification (FDI) algorithm *FIBSI* [10] developed by Fraunhofer IIS. In case of unreliable position information, the robot can switch to fallback solutions instead of using the potentially wrong GPS data.

Moving autonomously from A to B requires several technical capabilities such as automatic control, path tracking, and collision avoidance. Those tasks have been solved by the robot MERLIN developed by the University of Wuerzburg. Besides the GPS localization information, navigation can be supported by several additional ambiance sensors. For the movement of the robots themselves, certain restrictions such as the Ackermann steering model, environmental constraints (e.g. moving obstacles) etc. must be taken into account.

Another mission-critical part of this project is a stable and high-performance

Acronyms used in this document with explanation:	
COTS	Commercial off-the-shelf
FDI	fault detection and identification
GNSS	Global Navigation Satellite System, generic term for a system like GPS, GLONASS, Galileo, Beidou
GPS	Global Positioning System, full name NAVSTAR-GPS, a space-based satellite navigation system
GUI	graphical user interface
HIL	hardware-in-the-loop
HMI	human-machine interface
INS	inertial navigation system
JSON	JavaScript Object Notation, a text-based open standard designed for human-readable data interchange
MERLIN	Mobile Experimental Robot for Locomotion and Intelligent Navigation
MOS	Merlin Operating System
MTC	multi tap correlator
OFDM	Orthogonal Frequency Domain Multiplexing
ROS	Robot Operating System, an open source robotics platform by Willow Garage and Stanford AI Labs [1]
RTK	real-time-kinematic, a technique for precise positioning using GNSS
UAV	unmanned aerial vehicle
UGV	unmanned ground vehicle
UTM	Universal Transverse Mercator coordinate system, a grid-based method of mapping locations on the surface of the Earth
ZfT	Zentrum für Telematik e.V.

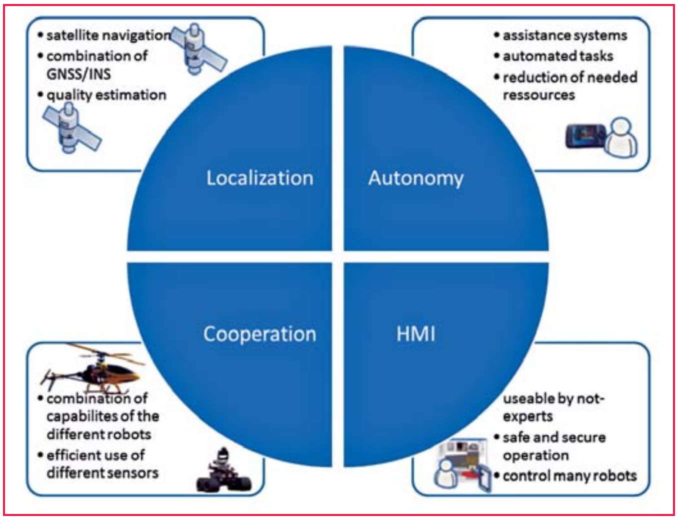

Figure 1: Schematical overview of important project components and contributions

radio-link between the entities. Therefore, the communications research department of EADS Innovation Works has developed a wireless communication system fulfilling these requirements based on Orthogonal Frequency Domain Multiplexing (OFDM) channels. The data is split in two categories, commands and video streams. The commands need low bandwidth but high reliability. The video streams need much more bandwidth, but a few lost packets might be acceptable. To benefit from this factor, these two streams are modulated with different degrees of robustness against disturbance.

On top of this physical layer, a generic network-based data infrastructure which synchronizes the data among all components has been developed by the ZfT. The infrastructure consists of the base station, which is the main server handling all data, and a library package, which contains the client and commonly used functionalities. To ease the development, this package can be imported in every Java or even Android project enabling them access to the data. The infrastructure is liable to synchronize the data of all components without any manual intervention of other program parts, and to inform the other program parts of changes like changed robot positions and emerged events. The communication is based on the TCP/IP protocol, so the components can be distributed world-wide. The messages are packaged using JavaScript Object Notation (JSON), a human-readable data format to ease the development and debugging while keeping them compact (compared to XML).

Furthermore, ZfT has developed a browser based human-machine interface following the expert knowledge of a professional surveillance provider from Wilkon e.K. to demonstrate the suitability of the GUI even for users who are not professionally trained in robot systems. This system considers heterogeneous agents to profit from the special advantages of each robot type. Additionally, a scheduler was created to allow automated tasks, which are time-driven, and interventions, which are eventdriven.

For testing scenarios, navigation algorithms and especially video camera positions, a simulation framework was build based on USARSim [12], which can be easily integrated in the graphical user interface (GUI) to augment real video information. Using this simulation as source for sensor data and as sink for control inputs of the used middleware Robot Operating System (ROS) a transparent transition between simulation, hardware-in-the-loop (HIL) simulations and operation with real hardware, based on the same ROS-modules is possible.

Besides developing a demonstrator study for the surveillance scenario described above consisting of an unmanned helicopter and an unmanned ground vehicle, the project has achieved many results, which can be used for future projects in different kinds of application areas (also see Figure 1).

UAV/UGV Platform

UAV Platform

For the UAV demonstrator platform a fuel powered helicopter was selected. It provides relatively easy maintenance and consists of inexpensive components but delivers a satisfying payload capability. Also, legal concerns are far easier compared to heavier UAV alternatives.

The UAV features a Commercial off-the-shelf (COTS) autopilot which is commanded by a list of waypoints. Figure 2 shows the hardware components in a schematic.

The live video was transferred using a 5 GHz WLAN connection delivering a MJPEG video stream to the ground station. The range of the WLAN was shown to be 100 m with simple antennas which was sufficient for the planned demonstration locations. Additionally the UAV features a pan-tilt-camera controllable by the user from the ground station, e.g. to search the vicinity of the UGV for obstacles. Using this, the navigation of the UGV can be further supported. Telecommand and position information are transmitted using separate data links.

The UAV has an onboard computer that handles route planning, marker detection and communication. Therefore the UAV has all necessary functionality onboard to follow the UGV autonomously.

UGV Platform

In order to meet the requirements made with respect to robustness, payload, and size, a small car-like robot was chosen as UGV demonstrator platform. The Mobile Experimental Robot for Locomotion and Intelligent Navigation (MERLIN) has been selected as foundation and was adapted and extended to fulfill the requirements.

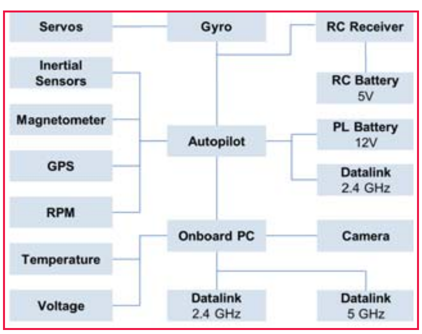

Figure 2: Schematics of hardware of the UAV

UGV Hardware (Figure 3): The MERLIN robot is a small car-like robot, developed since the early 90's [8] and used in teaching and different different research projects. The chassis is built from highly durable off-theshelf components taken from the RC-Racing sector, accompanied by in-house developed electronics and power systems, sensors and a powerful, yet energy efficient computer. For the proposed application, a laser range finder is used for obstacle detection and the built-in pantilt-zoom camera delivers the video stream important for the surveillance task. The built-in dead reckoning system, based on information of a gyroscope and an odometer, allows locomotion based on local information. A standard WIFI connection was used as data link for the further work.

UGV Software: The software of the MERLIN robots consists of two different parts, a real-time operating system and modules for the micro electronics as well as a standard operating system, a middle-ware and modules for the on board PC. The real-time operating system Merlin Operating System (MOS) is an in-house development, which implements the connection to the actuators and the on board sensors. The real-time capabilities enable the integration of short control loops and low-level drive assistance functions, as well as processing of the internal sensor data. [9]

The software responsible for high-level tasks is based on the middleware ROS [1] in its version *fuerte*. For the aforementioned framework modules have been developed to allow connection between the main processing platform and the microelectronics of the UGV and therefore providing full control of the robot to the ROS layer. Footing on this middleware the development and integration of the necessary position controller, the obstacle avoidance, the positioning system and the connection to the application network could be easily handled in a distributed manner.

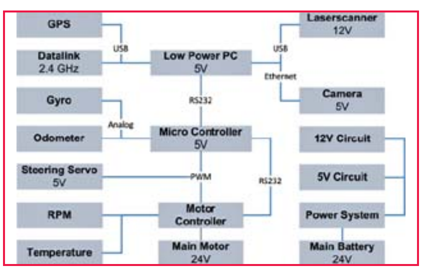

Figure 3: schematics of hardware of the UGV

UGV Simulation: To simplify development the existing UGV was modeled in the simulation environment and integrated into ROS which allowed transparent switching between simulated components and real hardware in HIL simulation as well as in the complete live system.

Localization and navigation

Fraunhofer IIS mainly contributed to the following topics: Localization, methods for estimating the GNSS delivered positioning quality, the GNSS/inertial navigation system (INS) coupling, evaluation of sensors for distance control and collision avoidance.

GNSS localization

One goal was to develop a robust and precise solution for localization based on GNSS that conforms to the requirements of autonomous or partially autonomous mobile robotics. Thereby it is especially important to detect anomalous or faulty GNSS-signals and subsequently discard position solution output with inadequate accuracy.

Multiple possibilities to detect disturbances in the GNSS have been discussed:

- Signal-to-noise ratio (SNR) observations: The classical investigation, weighting and subsequent exclusion of individual GNSS signals based on measured or derived signal strength values and their comparison with appropriate expected values
- FDI: The detection and unambiguous identification of

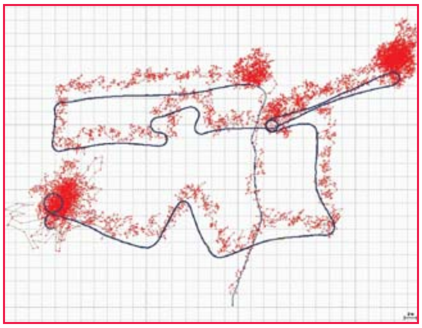

Figure 4: Comparison standard GPS (red) with the developed low-cost RTK-GPS solution (blue). Gridsize 2 m.

anomalies in individual GNSS signals as a base for exclusion of these signals from further processing multi tap correlator (MTC): A new approach for the detection and mitigation of multipath effects using high resolution in the correlation module of the digital signal processing parts of the GNSS receiver system

- A combination of the above mentioned methods in a novel system design to detect errors early and suppress or limit their impact on the position calculation

For this project a GPS-RTK solution with its own base station was selected. Therefore, many error sources in the GNSS can already be corrected by the use of a base station. Also for effects like multipath methods are presented to detect these at the rover location whereas the base station must be placed in a suitable location where no multipath is present.

Due to restrictions in the selection of the GNSS receiver for the UGV not all proposed methods could be realized on the complete system demonstrator. For the base station and rover the same low cost COTS receiver [2] was used. A proper antenna with low phase center variation proved to be essential on both sides. In this project the Fraunhofer IIS 3G+C antenna [7] was used. The receiver itself is not able to calculate RTK solutions, so the open source software RTKLIB [3] was integrated as a ROS node. The RTK base station was connected to

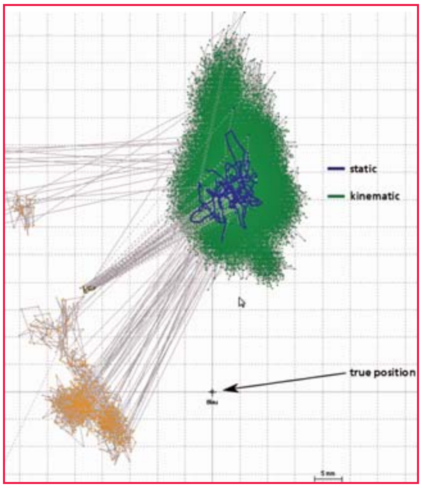

Figure 5: Comparison static/kinematic RTK positioning vs. true position, grid size 5 mm. The measurement was done with a static roof antenna with known position. Yellow points show false positions which are correctly excluded by the positiong algorithm.

the ground control station (see section IV) and correction measurements were sent via TCP to the rover.

The RTK ROS node contains a filter to exclude positions when a threshold for the confidence value of the over-determined equation systems of the RTK solution was exceeded. This approach allowed in virtually all cases a very convincing and a sufficiently accurate localization information regarding the absolute position of the UGV.

Figure 4 shows the route driven during the final demonstration event. The red line shows the result of the standalone, single frequency GPS algorithm, the blue line illustrates the result yielded by the developed RTK system. What can be seen is that the selected method generates positions with much higher precision. The movement of the UGV is easily discernible. Furthermore, periods with dark yellow color instead of blue indicate that the calculated position did not meet the safety margins. Figure 5 shows a computed solutions of static and kinematic RTK positioning in comparison to the known true position.

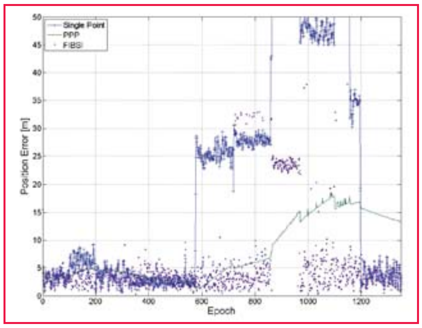

Figure 6: Comparison RTKLIB vs. FDI (FIBSI) processed position error in a strong multipath affected environment yielding good performance.

The mentioned FDI approach was implemented based on [10]. Figure 6 shows the performance in comparison to the standard RTKLIB positioning in a multipath effected environment. Using RTKLIB some errors can not be corrected. The FDI method *FIBSI* can detect these errors, identify the faulty sources and exclude them, yielding sufficient positioning performance even under strong multipath influence.

Sensors for distance control

In order to enable the UGV to fulfill the task of autonomous patrolling, a planned path, a position controller and an obstacle avoidance are necessary features. Based on the currently available sensors which are also used in present projects regarding robotics a set usable for obstacle detection should be found by conducting a multitude of tests according to the requirements which have been set for the project. Three current systems for detection of the local environment of a robot system have been compared: the CamCube 3.0 [4], the Microsoft Kinect [5] and a laser scanner by Hokuyo [6].

While the first two have the advantage of generating a 3D image which potentially includes higher detail, the laser scanner only measures the range in slices. Theoretically the 3D images would also allow to also detect negative obstacles, however these sensors mainly suffer from limited range, field of view, and problems in direct sunlight. Especially, the

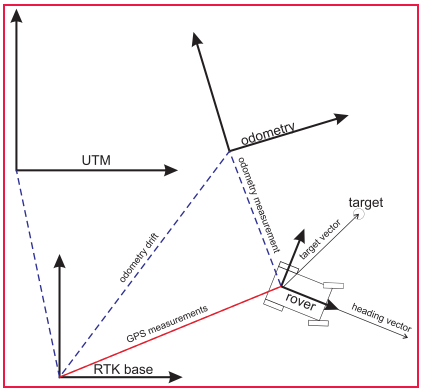

Figure 7: ROS frames depicting path tracking and drift compensation of the UGV. Blue dotted lines are published as ROS frame transformations.

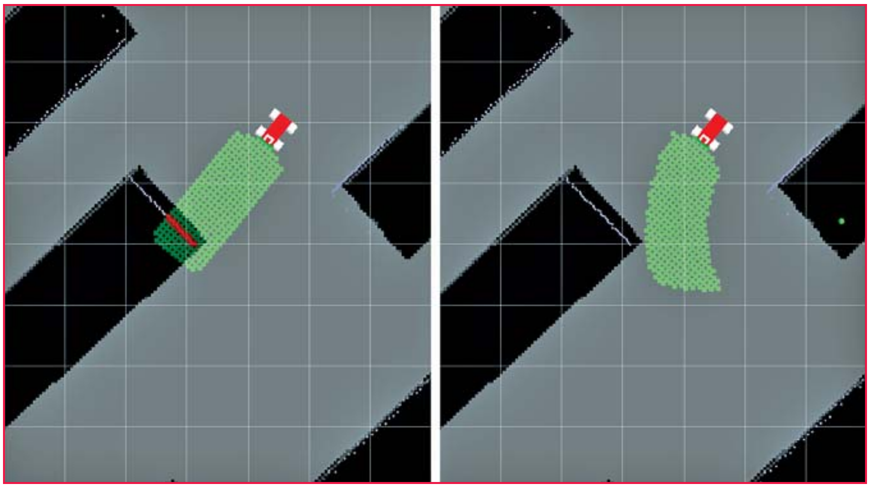

Figure 8: Visualization of the obstacle detection algorithm based on simulated and real laser scanner data (blue/red dots) using rviz from ROS. Left picture showing a blocked corridor (red dots show laser scanner targets in the corridor), right picture a free corridor.

Kinect can be regarded as an indoor sensor for short ranges. Therefore, with respect to range and robustness in outdoor, the laser scanner is by far superior to the available 3D cameras.

GPS/odometry coupling

The navigation of the UGV uses local position information based on dead reckoning. This source suffers from errors caused by wheel slipping and the drift of the gyroscope. Hence, the proposed GNSS positioning solution is used as a global reference, correcting the drift of the local odometry system by use of this so called domain based localization approach, calculating the relation between the GPS frame and the local odometry frame. To get a robust and predictable behavior the data from GNSS and odometry were not combined in a filter (most robot systems use a Kalman filter), but presented in hierarchical coordinate systems (see Figure 7). The outermost system was the world coordinate frame fixed to the global geo coordinates expressed in the Universal Transverse Mercator coordinate system (UTM) frame. The next system represented the location of the RTK base station and provided a cartesian coordinate system with east, north and up axes aligned to the local earth surface. Within the RTK base system lies a GNSS correction frame with no actual physical meaning. It contains the odometry frame and serves just to represent the accumulated drift of the odometry. This approach features smooth and gap-less trajectories without jumps yielded by GNSS position updates. Waypoints for the UGV (target points) where given in the RTK base frame by the control center and transformed to the local odometry frame using the previously mentioned relationship. This technique allows an implicit correction of the drift, as long as the distance between the target points is short enough which is sufficient to ignore the drift error along the traverse between two targets (see Figure 7).

To bridge gaps where no sufficient availability of the GNSS-signal is assured, some relative positioning should be realized. Obviously, for some of the relevant perturbations on the GNSS only a detection but no correction is possible. So there are situations where no sufficient accurate enough position can be gained even though satellites are visible. However, odometry data of the used UGV platform is good enough to drive several meters with a deviation of only a few centimeters.

Obstacle avoidance

As stated above a laser scanner was used as base for the obstacle avoidance. Using these data an algorithm was developed for obstacle detection and avoidance. The main idea behind this approach is to analyze the planned route based on the steering angle of the ground vehicle in a safety corridor for possible obstacles which are detectable in the laser scanner data. Based on this identification and categorization of obstacles a decision is made to either interrupt the movement or execute automatic re-planning with an avoid and detour maneuver.

The implementation of these algorithms was achieved using the simulation environment as a development and visualization help as well as verification on the UGV. The simulation environment cannot only be used to support the development but also to provide abstract visualization of the autonomous functions of the system during operation (see Figure 8).

UGV path tracking

Since the proposed scenario does not require dynamically created routes, a preplanned path was favored instead of on board planning. Therefore the navigation problem for the UGV can be reduced to accurate path tracking, defined by a number of target points. For this purpose a geometric algorithm has been developed, based

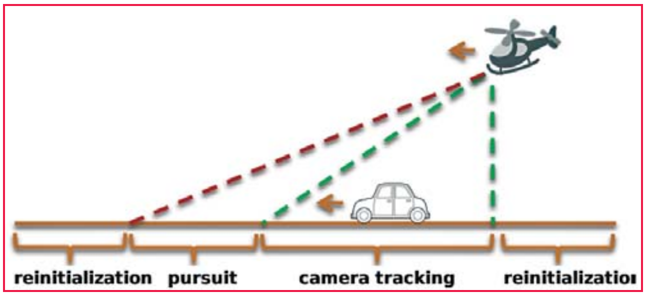

Figure 9: Tasks of the mission set for the UAV

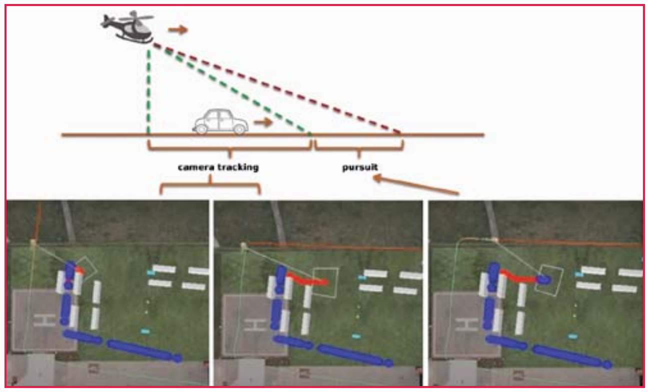

Figure 10: Visualization of the simulation environment showing UAV (dark yellow) HIL-simulation, obstacle detection and following the path of the UGV (red)

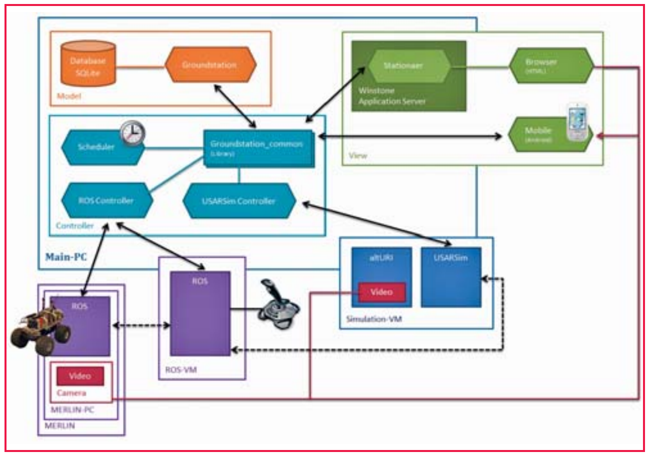

Figure 11: A schematic overview of the SiNafaR components and their communication

on local information of the UGV only. In every controller iteration, the relative vector between the robot frame and the next target point, the target vector, is calculated within the local robot coordinate frame. The length of the vector is equivalent to the distance to the target and is therefore used to calculate the target velocity of the robot. The target steering angle of the car-like robot is determined from the angle between the target vector and the heading vector of the robot (see Figure 7).

On the one hand this approach is capable of reaching target points and on the other hand can compensate inaccuracies in the mechanics of the robot. The vector approach also allows an easy integration of the obstacle avoidance. In presence of an obstacle, the target vector can be rotated according to the size of the obstacle, which allows an easy obstacle by-passing.

Since the proposed method is not capable of reaching targets within the turning radius of the robot, the approach has been extended by maneuver capabilities. Once a target is situated in the circle centered by the instantaneous center of curvature and with the radius defined by the minimal turning radius of the robot, a backwards maneuver is conducted using the opposite steering angle.

UAV route planning and UGV camera tracking

A route planning for the UAV was developed to support the demonstration foreseen in the project. This planning is based on waypoints to assure a continuous tracking of a moving target, i.e. the UGV, based on image based marker detection. The coordinates in the image frame are transformed into geo-coordinates based on the attitude, the GPS coordinates and camera information. If the detection fails, e.g. if the UGV is obstructed, the UAV automatically reinitializes itself and tries to reacquire the UGV.

On this mission the UAV starts to search for the UGV from a defined position. As soon as the target is acquired the camera will be steered to keep the target centered in sight. The camera will automatically track the target as long as possible. If the UGV moves out of camera range, the UAV will follow the UGV thereby ensuring the availability of a video transmission showing the UGV as well as providing a possibly optimal data relay from the ground station to the UGV.

Figure 10 depicts the stationary UAV in the top left corner (dark yellow) tracking the UGV (red dots) with the camera (camera footprint can be seen as a square projected on the surface). The right picture shows the pursuit of the vehicle when it is going to leave the tracking area to keep the target in sight.

Groundstation and Human-Machine Interface (HMI)

The ZfT contributed its knowledge and expertise in teleoperation, communication, simulation and human machine interfaces (HMI).

Framework

Figure 11 shows a diagram of the SiNafaR architecture. The left upper box is the main PC where the Java-written *groundstation software* runs structured by the model-view-controller pattern:

- The *model* is a SQLite database which is connected to the central library *groundstation*___ *common*.

Figure 12: A view of the simulation environment with two camera perspectives showing the UGV in bird view and UGV front camera.

- The *view* is the human machine interface described later.
- The *controller* part consists of the central library, a scheduler, which takes care of the different tasks (patrols, interventions and actions) and controllers for tethering the mobile agents (ROS Controller) and the simulation (USARSim Controller).

The *mobile agents* are displayed at the bottom left corner: The first one is for the robot MERLIN with its operation system ROS and its camera. The next box depicts a virtual Ubuntu PC where ROS is also installed. It is used to teleoperate either the real robot or the virtual agent which only runs in the simulation. The *simulation* is also a virtual machine with the software USARSim, which will be described later. In a second program the simulation environment is displayed and a video stream is generated. So, both the robot camera and the simulation environment can create a video stream which can be displayed in the HMI.

The ZfT has developed a special communication framework responsible for exchanging data with a userdefined number of agents. Hereby the main concern was robustness and easy reusability. The client library can be used as a java packet in every other java project and is also compatible to Android. Of course, communication is a critical part in this framework. To illustrate that, a short example is given: If e.g. one of the robots reached its desired position, the controller of the robot issues an update command to the groundstation, which in turn distributes the command to all the other connected components. The scheduler can start the next action while the HMIs displays this event to the user.

Another important part of the SiNafaR project was the integration of a simulation environment. For this purpose the team chose USARSim (Unified System for Automation and Robot Simulation [12]), a high-fidelity simulation of robots and environments based on the Unreal Tournament game engine. After configuring USARSim for the SiNafaR purpose, arbitrary mobile agents (UGVs and UAVs) can be modeled in freely configurable settings close to reality. That enables testing algorithms for path planning, mapping and obstacle avoidance. Furthermore, it helps to determine a perfect video setting for the surveillance scenario by simulating virtual easy configurable cameras, which is shown in figure 12 as an

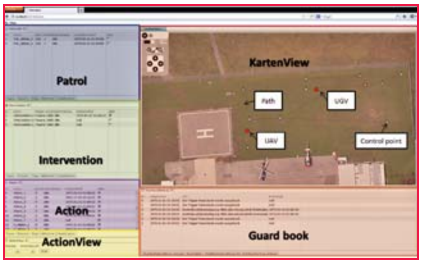

Figure 13: The main perspective of the SiNafaR HMI

Figure 14: Scenario of the final demonstration

example. Here the flying perspective of an UAV is shown together with the view of a mobile agent. This facilitates and accelerates development.

Human-machine interface (HMI)

Human machine interaction describes the whole clash of humans with machines from a simple on-off-switch to a complex steering mechanism. It is a complex research field, especially if an untrained user needs to control several heterogeneous autonomous agents as it is the case in the project SiNafaR. Of course software ergonomics is very important. But crucial for the user who controls one or several robots is his *situation awareness*. That means wether the user realizes the actual situation, interprets it correctly and projects it to the near future. The ZfT had already done a lot of research on this topic (e.g. [14]). Along with the described general criterias, the other main target was meeting the requirements profile of the civil defense industry. Interviews with the prospective user group, realized in the collaboration with the project partner Wilkon e.K., showed that security and easy usability had absolute priority. The user interface was redesigned in several iterations of an evaluation circle where partners contributed their practical experiences.

Figure 15: UAV and UGV during the final demonstration event

In figure 13 the main view of the HMI is shown. The largest space is reserved for a map in the right upper corner, in which the positions of all entities and their planned paths are clearly visible. This ensures a high level of situation awareness, because future behavior can be predicted. Clicked entities are also marked in the table views and vice versa. On the left side, the possible patrols, interventions and actions are shown to ensure quick access to them. This apportionment was one key result of the interviews with the Wilkon specialists. The last window part is the guard book, where all important events are shown. Technically, the HMI which is used in the SiNafaR project [13] is based on RAP (Rich Ajax Platform) and kept strictly modular, so many different scenarios can be covered. To show its practicability the appealing GUI for planning and supervising multi-robot systems was adapted for different kinds of interfaces (computers, mobile phones and tablets). The users can change the arrangement to their personal and operational needs, by simply changing the sizes and opening/closing tabs. Also a set of predefined perspectives is available, so the user can switch them depending on which display he uses. If he uses a mobile device, a smaller amount of windows is selected. Another example is to use a second monitor where the different camera perspectives are displayed.

Final demonstration event

At the end of the project a final demonstration event was planned and conducted.

The final demonstration event contained typical elements of a surveillance scenario (Figure 14). The routes between control points are pre-defined. The static control route for the UGV can be paused at any time to divert to additional control points of interest. The UAV is able to follow to the UGV autonomously to provide an additional bird view or can also be used separately.

1) The UAV is ordered by the ground station to patrol at point 3 and search for the UGV. The UGV is identified by the matrix marker.
2) The UAV is ordered to follow the UGV autonomously. The UGV is ordered to follow the pre-planned control route. Obstacles are detected and avoided
3) Pausing the control route at point 4. Tracking and pursuit by UAV is stopped. UGV and UAV can check individual POI. After that, both are ordered to return to point 4.
4) UAV re-aquires the UGV and the control route is continued.

The ground station coordinates all actions between UGV and UAV. The pose of each autonomous robot can be tracked on the control center as well as with mobile devices like tablet computers. Additionally, the video streams of both robots are supplied to the users. For the demonstration two tablet computers have been used to visualize the overview map with the moving robots or the transmitted video view.

Conclusion

In the project a GPS-RTK solution with moderate costs for mobile robotics has been integrated, various methods for GNSS fault detection and quality

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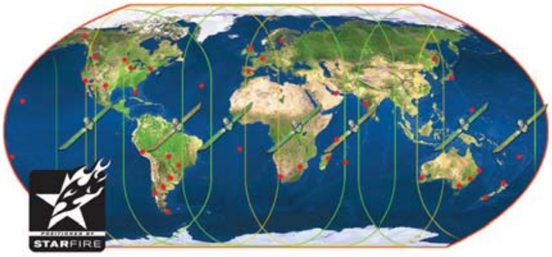

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monitoring have been proposed and partially implemented. A GPS/odometry coupling has been successfully introduced into the navigation stack of the UGV. A highperformance radio-link has been developed by project contributor EADS Innovation Works. ZfT developed a browser based HMI interlinked with both UGV and UAV providing application centric control of the autonomous systems for non-professional human controller. The components of the system are available in a simulation environment including simulated video streams and ROS based HIL operations.

Besides developing a demonstrator study for the surveillance scenario described above, the project has achieved many results, which can be used for future projects in different kinds of application areas:

- The project showed possibilities to reduce ressources and training costs for controlling and coordinating heterogeneous multi-agent systems
- Realisation of an HMI which can be extended to further fields of teleoperation
- Identification of requirements and technologies for the future admission and certification of small cooperating multi-agent systems in the civil sector
- Combination of existing technologies to increase robustness and security of the systems to enable a future admission

Hereby many different applications are possible, e.g. surveillance of grounds or objects, measuring and revising parameters in large areas and mobile exploration systems.

Based on the loadout capability and the closedness of the used helicopter platform (especially regarding the autopilot) it was not possible to demonstrate the localization approach as well as the obstacle avoidance on the UAV. However, the results of the GNSS localization are transferable to UAVs in general To provide reliable detection of obstacles in all possible movement directions of a UAV improvements in the miniaturization of sensors are essential. Camera based systems cover a wider range of view than laser scanner and have already reached the proper dimensions. But like most optical systems they suffer from interferences due to the environment, e.g. sun glare, rain, snow, fog, smoke, etc.

The initial goal to include the detection of faulty GNSS signals in the demonstrator could not be achieved because of restrictions in the COTS receiver hardware. Innovative extensions in advanced GNSS receiver hardware should be possible in this field and should be investigated in a further project. Also, the robustness should be further extended and increased to reach the goal of a safe navigation. This would ease control for the user and allow new applications.

Acknowledgment

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TUSAGA-Aktif and WEB-based online PPP Services: A case study in ÇORUM

The results show that Network-RTK provides cm level accuracy, whilst PPP-derived coordinates converge to the results evaluated by relative technique with cm to dm level of accuracy

Reha Metin ALKAN
Hitit University, Çorum, Turkey & Istanbul Technical University, Istanbul, Turkey

İ Murat OZULU
Hitit University, Çorum, Turkey

Veli İLÇİ
Hitit University, Çorum, Turkey

F Engin TOMBUŞ
Hitit University, Çorum, Turkey

Murat ŞAHİN
Hitit University, Çorum, Turkey

Positioning with GPS can be categorized into two broad groups: absolute (single point positioning) and relative (or differential) positioning. In 2000s, the Selective Availability was turned off and their users could obtain his/her position within a few meters level of accuracy with a GPS receiver in stand-alone mode. However, this accuracy is not sufficient for applications that require higher accuracy level. The most common way to increase the accuracy is to use differential methods which require at least two GPS receivers, one is reference and the other is rover. This approach requires relatively long occupation time/time-cost field and office work. Furthermore, users need to be familiar with post-processing software in order to process the collected GPS data, and in general the software is not free and processing requires knowledge of complex background about GPS techniques.

Depending on the improvements in the world of technology, different algorithms and some new approaches have been developed to obtain more accurate positioning, either absolute or relative positioning. One of them is Network RTK and it was established and used extensively in several countries, while producing economical and rapid solutions. All differential methods including network-based RTK need additional data from reference stations. Although the technique has several advantages with respect to conventional differential and RTK methods, it has some drawbacks as given below:

- The distance between the rover and its reference (base) station should be about 50-100 km (max.),
- Expensive GPS receivers with Network RTK capability are required,
- Data communication is essential (Zhizhao et al. 2013; Rizos, 2008; El-Rabbany, 2006).

Nowadays, Continuously Operating Reference Station (CORS) is the most widely applied method in Network-RTK (Rizos et al., 2012). In CORS Networks, the errors occurred in measurements were counted and current coordinate corrections were broadcast in real time to the users (Rizos, 2008). Users of the system can obtain real-time coordinates with a few centimeters level of accuracy (Weston and Schweiger, 2010).

Over the past decade, a number of techniques have been discussed in the literature to improve the positioning accuracy by using a single GPS receiver. One of the commonly used methods is Precise Point Positioning (PPP). Using the precise orbit and satellite clock corrections, the PPP method provides cm to dm positional accuracy without the use of base station(s) in both static and kinematic modes (Junping et al., 2013; Zhizhao et al., 2013; Martin et al., 2011; Huber et al., 2010; Alkan, 2008; Kouba and Heroux, 2001). With the advent of real-time precise products from the IGS Real-time Pilot Project, the PPP is started using real-time kinematic application (Junping et al., 2013). In this method, users only require a single GPS receiver to obtain his/her position at any location in a global datum. Although the PPP has become more popular, it has still some drawbacks including necessity of long occupation time for the carrier phase ambiguities to converge and unavailability of PPP evaluation mode in commercial GPS processing software. In addition to the PPP-technique being used in a variety of scientific and in-house software, there are also various internet-based online processing services.

In this study, geodetic points with different characteristics in the province of Çorum, Turkey were employed in a comparative study when coordinates were determined with Network GPS (i.e., TUSAGA-Aktif), and with commonly used online PPP services (i.e., CSRS-PPP, *magicGNSS*/PPP and APPS). The Network GPS-derived and PPP-derived coordinates were compared with those of relative (differential) technique results and an accuracy analysis was conducted.

TUSAGA-Aktif and web-based online PPP services

TUSAGA-Aktif

Continuously Operating Reference Station (CORS) networks have been set up to provide data collection, processing and transmission to users in many countries and regions. In Turkey, CORS network became active in 2009. The CORS-TR Network, later named as TUSAGA-Aktif Network, was established in cooperation with Istanbul Kültür University, the General Directorate of Land Registration, the Cadastre of Turkey and the General Command of Mapping of Turkey and sponsored by the Turkish Scientific and Technical Research Agency (TUBITAK) (Mekik et al., 2011a). The users determine the position fast and economically with a few cm accuracy within minutes, even seconds with TUSAGA-Aktif network. The network can be also used for modelling the atmosphere, predicting weather, monitoring plate tectonics and determining datum transformation parameters (Mekik et al., 2011b). Achievements provided by these networks are as follows (Kahveci 2009):

- The personnel and instrument need for reference station(s) is eliminated,
- Prior to the execution of surveying task, it eliminates the finding of known- coordinate points and thus saves time, personnel and money,
- Three-dimensional precise coordinates can be obtained in real time in the desired datum, including National Reference System,
- Points are continuously monitored and coordinates are updated in the event of any deformation.

As of today, TUSAGA-Aktif system consists of 146 Reference Stations and 2 Control Stations (master and auxiliary) (Figure 1). The software used in this system can calculate corrections in the ionosphere, troposphere, reflection and orbital corrections. The system reference stations collect GPS data at 1s and 30s interval and upload them to the Control Stations via Internet. The continuously collected static data can also be downloaded for post-processing with a limited fee.

The system server collects satellite observations and sends RTK corrections to the rover. Several RTK correction techniques are used: FKP, VRS and MAC. Communication between users and the control center is provided by NTRIP protocol via GSM, GPRS/EDGE using RTCM 3.0 and other protocols (Mekik et al. 2011b).

Figure 1: TUSAGA-Aktif Reference Points (URL-1)

The user of the TUSAGA-Aktif has been increasing day by day and the number has reached to over 3,600 as of April 2011 (Mekik et al., 2011b). More detailed information about Turkish RTK CORS Network, (i.e., TUSAGA-Aktif Network) can be found in Mekik et al., (2011a and 2011b), Yildirim et al., (2011).

Web-based online-PPP services

The PPP technique provides precise positioning using single GNSS receiver considering precise satellite orbit and clock corrections without any reference station (Zumberge et al., 1997). With technological advancements, precise satellite orbit and satellite clock corrections have been served by some institutions such as International GNSS Service (IGS), Center for Orbit Determination in Europe (CODE) and Jet Propolsion Laboratory (JPL) (Kouba and Heroux, 2001). The accuracy of satellite orbit and satellite clock corrections has increased day by day and reaching this data has become easier (Martin et al., 2011). It is now possible to obtain decimetre to centimeter level accuracy in both static and kinematic modes using only a single GPS receiver with PPP (Alkan and Öcalan, 2013; van Bree and Tiberius, 2012; Geng et al., 2010; Choy et al., 2007; Kouba, 2003; Gao and Shen, 2002; Kouba and Héroux, 2001; Zumberge et al., 1997). With the advent of the IGS Real-time Pilot Project, the availability, reliability and precision of real-time products will be improved upon and the Real-time PPP applications would have increased (Junping et al. 2013).

Various GNSS processing software (scientific, in-house, and online) have been used for PPP-derived coordinates and the usage of web-based online processing services have become widely popular in recent years (Alcay et al., 2013; Alkan, 2008). Because of the fact that post-processing GPS software need expertise and usually requires license fee; users tend to use web-based solutions which are easy to use (Alkan and Öcalan, 2013). In these services, users can upload GPS observation files and select the processing mode with a few clicks through the service's interactive web page, and they will be processed automatically. After completing the process, the results were sent to the users by e-mail or retrieved from ftp site. Together with the position, a detailed report including input data quality, used configuration, positioning quality, statistics, graphics, tables and some other information were also provided.

Although there are several web-based online GPS-PPP processing services, the most known and used online services, i.e., CSRS-PPP, *magicGNSS*/PPP and APPS were used in this study. Some brief information of these services are given as follows:

Canadian Spatial Reference System - Precise Point Positioning (CSRS-PPP):

CSRS-PPP is an online application for GNSS data post-processing that allows users to compute higher accuracy positions from their raw observation data. The service can accept single or dual frequency RINEX data collected in static or kinematic modes. The coordinates of the point(s) can be estimated based on two different datum - Canadian Spatial Reference System (CSRS) and International Terrestrial Reference Frame (ITRF). It should be pointed out that membership is required to access the service (URL-2).

magicGNSS/PPP :

This web-based service permits GNSS users to determine their position or trajectory with centimeter-level accuracy. Users can submit their collected data in standart RINEX format and the service also supports binary formats recorded by most receivers. Users can either upload raw data files in the web-based workspace or send them via e-mail. It has two processing modes; static and kinematic (URL-3).

Automatic Precise Positioning Service (APPS):

The service operated by NASA's Jet Propulsion Laboratory and users estimate their position in static, in motion, on the ground or in air. This service is capable of processing the GPS data in both static and kinematic modes. The users may send their measurements in files via e-mail, ftp server and service web page (URL-4).

Main features of the CSRS-PPP, *magicGNSS*/PPP and APPS services are given in Table 1. More detailed information about the services can be found in their web page that has been provided in the table.

Field trial

In order to compare Network-RTK and Online-PPP techniques with respect to positional accuracy, two field trials were conducted in Çorum District in March and August 2013 (Figure 2).

During the test measurements, 4 points with different land use/cover characteristics were established (Table 2).

Table 1. General Information about Commonly Used Online-PPP Services

	CSRS-PPP	*magicGNSS/PPP*	APPS
Service Name	Canadian Spatial Reference System-Precise Point Positioning	*magicGNSS*/PPP/Precise Point Positioning Solution	Automatic Precise Positioning Service
Organization	Natural Resources Canada (NRCan)	GMV Innovating Solution	Jet Propulsion Laboratory (JPL)
Web Page	http://webapp.geod.nrcan.gc.ca/geod/tools-outils/ppp.php	http://magicgnss.gmv.com/ppp	http://apps.gdgps.net
Reference Frame	NAD83 (CSRS) / ITRF	ITRF08 / ETRS89	ITRF08
Coordinate Format	LLH/XYZ/UTM	LLH/XYZ	LLH/XYZ
Quality Information	standard deviations	-	covariance matrix
Antenna Correction	IGS	IGS	IGS
Satellite Orbits and Clocks	IGS Final/Rapid/Ultra Rapid	IGS Final/Rapid/Ultra Rapid	JPL Final/Rapid
Elevation Mask	minimal 100	minimal 100	minimal 7.50
GNSS System	GPS, GLONASS	GPS, GLONASS, Galileo-ready	GPS
Used Software	CSRS_PPP	Magic GNSS 5.3	GIPSY v.6.2
File Number for Upload Allowed	Max. 1 file	Max. 2 files of 10 MB	5 MB is allowed for unregistered users
Processing Mode & Frequency	Static/Kinematic Single/Dual frequency	Static/Kinematic Dual frequency	Static/Kinematic Dual frequency
Data Transfer	e-mail (need to register)	e-mail/service's web interface	e-mail/ftp/service's web interface
Data Format	RINEX 2.0 or 2.11 or Hatanaka	RINEX 2.0 or 2.11 or Hatanaka	RINEX 2.0 or 2.11
Solution Type Static Processing	All epochs/Forward only	All epochs/Batch Solution	5-min epochs/Smoothed
Solution Type Kinematic Processing	All epochs/Smoothed	All epochs/Batch Solution	5-min epochs/Smoothed
Output Data Format	*.pdf, *.pos, *.csv, *.sum	*.pdf, *.snx, *.kml, *.clk	*.sum, *.ninjalog, *.pfs, *.stacov, *.xps


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Figure 2: The Study Area

Figure 3: Field Test Measurement with TUSAGA-Aktif System

Table 2. Characteristics of Selected Points

Point No.	Point Characteristic
1	Highly Urban Area
2	Sub-urban Area
3	Near Road
4	Water Environment

As a first step, the selected point's coordinates were estimated with CORS network by using Network-RTK technique via the GSM connection in ITRF datum. During data collection, fixed solutions were obtained only within a few minutes and CORS-derived coordinates were determined in the field in real-time (Figure 3).

After the CORS measurements, static sessions were started and 2-hour GPS data was collected. All the test measurements were carried out with Spectra Precision (Ashtech) Epoch 50 GNSS dual frequency GPS receivers. Some of the technical specifications of the receiver are given in Table 3.

To obtain known coordinates of the selected points with differential method, one of the CORS station CORU (40° 34' 13.5" N, 34° 58' 55.9" E, 922.1 m - in WGS84), were used as a reference station. The data of reference station, CORU, were downloaded from the related internet site. The collected data by dual frequency geodetic-grade receivers, both on occupied points in static sessions and reference station data, were processed by GPS processing software of Leica Geosystems Leica Geo Office (LGO), to obtain known coordinates of those 4-points. The baseline from the reference station is about:

- 2.2 km away from Point 1,
- 4.4 km away from Point 2,
- 34.9 km away from Point 3,
- 46.0 km away from Point 4.

Table 3. Technical Specifications of Epoch 50 GNSS Receiver (URL-5)

Features	- 220 Channels for multi-constellation GNSS support - Integrated transmit/receive UHF radio - Compact and lightweight design - RTK, Post-processed, Kinematic and Static - Network RTK Positioning - GPS : L1/L2/L2C/L5 - GLONASS: L1/L2 signals - SBAS (WAAS/EGNOS/GAGAN/MSAS): L1C/A, L5		
Accuracy	Static GNSS Surveying High-accuracy Static	Horizontal Vertical	: 3 mm + 0.1 ppm RMS : 3.5 mm + 0.4 ppm RMS
	Static & Fast Static	Horizontal Vertical	: 3 mm + 0.5 ppm RMS : 5 mm + 0.5 ppm RMS
	Real-Time Kinematic GNSS Surveying	Horizontal Vertical	: 10 mm + 1 ppm RMS : 20 mm + 1 ppm RMS
	Code Differential GPS Positioning	Horizontal Vertical SBAS Diff. Pos.	: 0.25 m + 1 ppm RMS : 0.50 m + 1 ppm RMS : Typically <5 m 3DRMS
Physical	Dimensions (W x H x D) Weight (with battery)	: 19.0 cm x 10.7 cm x 20.0 cm : 1.34 kg	

Some processing parameters used in the evaluation stage are given in Table 4.

All collected data with dual frequency geodetic-grade GPS receivers in the static sessions were converted to the RINEX format and then submitted to the web-based online-PPP GPS Processing Services, and through the e-mail for *magicGNSS*/PPP and APPS. After the submission of the RINEX data to the PPP service, the results were taken from online services.

The PPP-derived coordinates from online services and TUSAGA-Aktif Real-time, Network RTK-derived coordinates were compared with those of relative (differential) technique results and differences in position and ellipsoidal height are given in Figure 4.

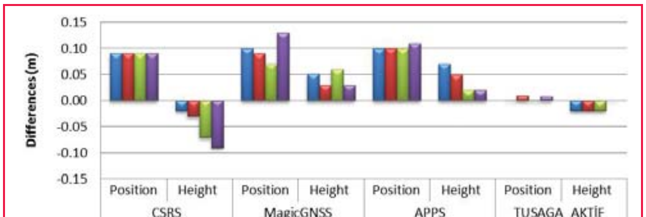
Table 4. Processing Parameters with LGO

Processing Parameters	
Cutoff angle	10^0
Ephemeris type (GPS)	Precise
Tropospheric model	Hopfield
Ionospheric model	Computed

As it can be seen from Figure 4, each of the three online services gives similar accuracy results both in position and height, and in general, sub-decimeter level of accuracy was obtained with PPP technique. However, exceptionally *magicGNSS*/PPP service provides 13 cm difference at Point-4 (water environment) for position. In terms of TUSAGA-Aktif, results showed that Network RTK-derived coordinates agreed with the relative positioning solution of a few cm level accuracy in both position and height.

Conclusion

This study aimed to assess the accuracy performance of the Network-RTK technique and web-based online PPP services. The test measurements showed that Network RTK-derived fixed coordinates agreed with the relative positioning solution at a few cm level accuracy in both position and height with a very short occupation time, i.e., couple of minutes. In addition, this study shows that TUSAGA-Aktif system can be used in most surveying applications that require high precision and strong alternative to the conventional differential methods that require expensive and time-cost processes. The results also showed that PPP technique provided decimeter positional accuracy and height as well for 2 hours collected GPS data.



	CSRS Position	CSRS Height	MagicGNSS Position	MagicGNSS Height	APPS Position	APPS Height	TUSAGA_AKTİF Position	TUSAGA_AKTİF Height
POINT_1	0.09	-0.02	0.10	0.05	0.10	0.07	0.00	-0.02
POINT_2	0.09	-0.03	0.09	0.03	0.10	0.05	0.01	-0.02
POINT_3	0.09	-0.07	0.07	0.06	0.10	0.02	0.00	-0.02
POINT_4	0.09	-0.09	0.13	0.03	0.11	0.02	0.01	0.00

Figure 4: Differences between Online-PPP Services, TUSAGA-Aktif and Known Coordinates

Based on the results, it can be concluded that the online-PPP services can fulfill the needs of GNSS users for applications requiring decimeter level of accuracy.

TUSAGA-Aktif system does not require conventional differential GPS measurements and post-processing. It provides instantaneous, real-time positioning within centimeter-level accuracy with fast, economically and effectively, and that is why CORS networks like TUSAGA-Aktif have become more popular almost all over the world. Distance limitation and data communication requirement between the rover and its base station and need of GPS receivers with RTK capability are some of the disadvantage of the technique. In some countries, as in Turkey, usage of CORS network requires membership and fee for measurements.

The PPP provides GNSS users to determine their position within cm to dm level accuracy at any location in a global datum without the need of additional data from any reference station and it is an ideal system for precise positioning over long distances and/or where no full CORS coverage is available. In this method, to obtain high accuracy, long occupation time is needed to converge. The long convergence time in PPP restricts its usability in many cases where rapid GPS surveying is required and surveying efficiency is concerned (Zhizhao et al., 2013). The PPP technique overcomes the distance limitation between reference and rover in RTK technique. The PPP method has become popular with its unique advantages and increasingly used in research and surveying applications. The web-based online PPP services have been applied with the advantages of user-friendly interface, being free-of charge and not requiring license fee or knowledge of GPS processing software or a deep GNSS knowledge (Alkan and Öcalan, 2013).

Acknowledgement

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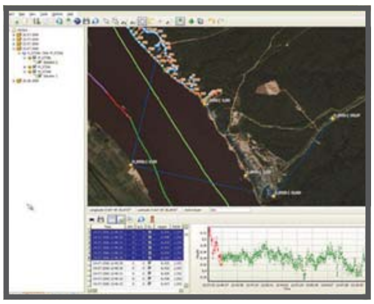

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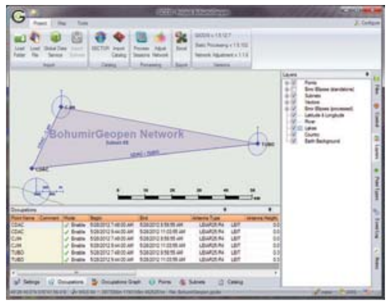

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Up-to-dateness in Land Administration: Setting the Record Straight

This paper is the first attempt to synthesize and clarify the various explanations of up-to-datedness in land administration systematically. The findings prompt the initiation of viewing up-to-datedness in land administration from the temporal perspective

PhD Candidate Ying Jing
Faculty of Geo-Information Science and Earth Observation (ITC), Twente University, The Netherlands

Ass Prof Rohan Bennett
Faculty of Geo-Information Science and Earth Observation (ITC), Twente University The Netherlands

Prof Jaap Zevenbergen
Faculty of Geo-Information Science and Earth Observation (ITC), Twente University The Netherlands

Up-to-dateness is a contemporary problem in the realm of cadastres, land registration, and land administration. It is argued that up-to-dateness is closely related to or determining the efficacy of land administration functions (Effenberg,Williamson, 1996; Enemark, 1998; Henssen, 2002; Hesse,Benwell et al., 1990; Karnes, 2004; Larsson, 1991; Zevenbergen, 2009). However, what is exactly meant by up-to-dateness is often left ill-explained in land administration science. In this context, it is necessary to make a clarification. Whilst it may appear a trivial point, the implications are important.

Normally, up-to-dateness in land administration is understood as occurring between land information system establishment and maintenance phases. Donors who fund land-related projects in developing countries tend to be project-oriented. The establishment of a land information system fits comfortably with this management approach - a project team can be created and managed until completion with a fixed amount of resources. System maintenance is less amenable - ongoing resources, impetus and skills are required. For these reasons, many establishment efforts are an initial success, yet many attempts fail in the end as they do not adequately consider the issues of up-to-dateness after the project is accomplished. In this view, it is believed that understanding up-to-dateness in land administration science will contribute to fit-for-purpose maintenance regimes design for land information system.

In land administration theories, up-to-dateness is interpreted from sporadic perspectives with various terms, involving 'up-to-date' and 'updating' (Scheu, Effenberg et al., 2000; Williamson, Enemark et al., 2009), 'upgrading' (Scheu, Effenberg et al., 2000), 'renewal' (Henssen, 2002), 'dynamism' (van der Molen, 2002; Zevenbergen, 2002), 'change' (Ding, 2003; Mattsson, 1999; Williamson, 2006; Williamson, Ting, 2001), 'maintenance' (Dale, McLaughlin, 1999; Scheu, Effenberg et al., 2000), and 'evolvement' (Kaufmann, 1999; Ting, L., Williamson, I., 1999; Ting, Williamson et al., 1999; Williamson, Grant, 1999; Williamson, Wallace et al., 2006). The preliminary synthesis is made by (Williamson, Enemark et al., 2009) to organize updating of dynamic components of land administration. Yet there still lacks a systematic synthesis of these diversified understandings on up-to-dateness. As such, 'up-to-dateness' needs re-evaluation as the first step. This paper aims to re-evaluate 'up- to-dateness' through literature synthesis. The subsequent sections of this paper are methodology, result, discussion and conclusion.

Methodology

A research synthesis is for analyzing and organizing literatures (Hart, 1999). Based on the problem formulated, the qualitative study involved literature selection, analysis, and presentation of results (i.e., synthesis modeling) (Cooper, 1998). This methodology was adopted to identify, compare and re-evaluate various interpretations of up-to-dateness among land administration theories.

The synthesis philosophy underpinning in this study is embedding Land Management Paradigm (LMP) into the Model of Economics of Institutions (EIM). LMP and EIM models were respectively developed by (Enemark, 2005) and (Williamson, 1998). LMP is the latest typical model representing the land administration domain. LMP provides the basis for classifications of land administration domain. EIM is the classical model of institutional changes. EIM provides temporal perspective to view interpretations of up-to-dateness in land administration.

Based on this philosophy, the synthesis process was implemented. Firstly, the selection process used prescribed channels - textbooks, journals, conference proceedings and publications of authorized organizations. Search terms included: updating, upgrading, dynamism, changes, renewal, maintenance and evolvement. These terms were considered to be covered by up-to-dateness in land administration. Then, categorization and analysis ensued.

In the end, a synthesis model was established to present a holistic view of up-to- dateness in land administration.

Result

This section attempts to synthesize all the existing interpretations of up-to-dateness in land administration. As discussed, LMP was the chosen model to classify these various interpretations. LMP is shown in Figure 1.

Seen from Figure 1, LMP consists of five components - sustainable development, land policy, land administration functions, land information infrastructures and country context. A wide range of literatures reveal that up-to-dateness occurs in any component of LMP. Up-to- dateness of each component can be equally understood as its dynamism with temporality. This temporality can be appropriately analyzed through EIM, as shown in Figure 2.

This well-known EIM suggests that institutional changes occur in four hierarchical epochs of time in the unit of a year. They are successively 10^2-10^3 (social theory), 10-10^2 (economics of property rights/positive political theory), 1-10 (transaction cost economics) and continuous (neoclassical economics/agency theory). This temporal hierarchy is applied to analyze up-to- dateness in land administration.

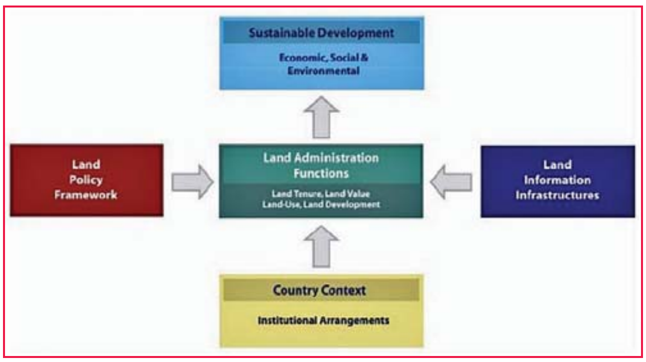

Figure 1: Land management paradigm (Enemark, 2005)

Table 1: Dynamic land administration system (Williamson, Enemark et al., 2009)

Dimension One	Evolution of human-to-land relationships.
Dimension Two	Evolving ICT and globalization, and their effect on the design and operation of LAS.
Dimension Three	The dynamic nature of information within LAS, such as changes in ownership, valuation, land use, and land parcel through subdivision.
Dimension Four	Changes in the use of land information.

Prior to holistic synthesis, Dynamic Land Administration System (DLAS) is worth mentioning, as shown in Table 1.

This table shows land administration dynamism. This could be regarded as the latest preliminary synthesis of up-to-dateness in land administration. However, we still argue a more holistic synthesis, based on pre-existing theories. That is, to provide a more complete view of up-to-dateness in land administration. Accordingly, the following starts this synthesis through the lens of embedding LMP into EIM.

Country context

Country context refers to institutional arrangements (Enemark, Williamson et al., 2005). Country context, namely institutions, needs up-to-dateness. Institutions are humanly-devised constraints for shaping human interaction; more broadly, the rules of societal rules for structuring incentives of human exchange in political, social, and economic (North, 1990).

Institutions should constantly evolve themselves due to the requirements of the community for becoming

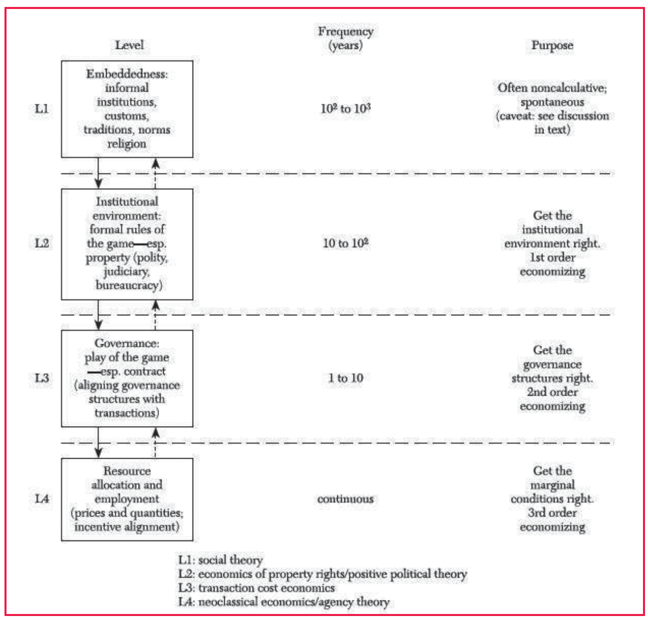

Figure 2: Economics of institutions (Williamson, 1998)

open, transparent and effective (Williamson, Grant, 1999), for better supporting land policies and good governance implementation (Enemark, Williamson et al., 2005) and as the key of understanding historical change due to shaping the way of societal evolvement (North, 1990). Institutions change incrementally, rather than discontinuously as a consequence of changes in rules, constraints and enforcement (North, 1990). Institutional changes or evolvement presents the significance of country context up-to-dateness.

Country context up-to-dateness is found concerning temporality. This temporality represents in certain epoch of time, fitting into level 1 (10^2-10^3 years) of EIM. The following two diagrams can make clear demonstration.

Seen from figure 3, a specific focus on land administration evolvement through western context specifically reflects into: 1) attitudes towards land shift: from wealth, commodity, and scarce resource to scarce community resource; 2) cadastral functions shift: from record, fiscal, land market, planning to multi-purpose. All these occurred fundamentally as a result from country context changes. All these evolvements match the epochs of time from up to late 1700's, late 1700's to WW II, post WW II & post-war reconstruction, to 1980's onwards. In Figure 2, epoch of time (10^2-10^3 years) could be preliminarily shown.

Figure 4 shows this epoch of time (10^2-10^3 years) more clearly and accurately: 1) changes from agricultural revolution to feudalism, industrial revolution to information revolution, in epoch of time 700 years, 100 years and more than 100 years; 2) changes from growth of city-states, to individual ownership, land markets, Torrens system, subdivision evolution, native title, agenda 21 and multi-purpose cadastres, in an epoch of time of around 100 years. As such, epoch of time for up-to-dateness of country context fits into Level 1 of EIM (10^2-10^3 years).

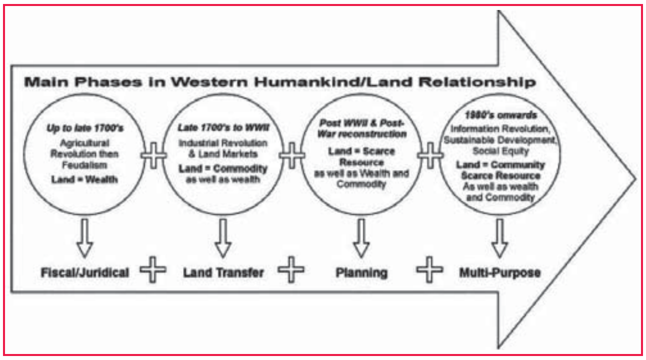

Figure 3: Main phases in the humankind/land relationship and cadastral evolution (Ting, L., Williamson, I., 1999; Ting, Williamson et al., 1999)

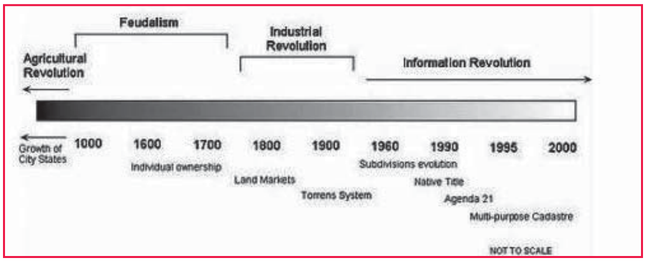

Figure 4: The evolution of modern cadastres (Williamson, 2001a)

Sustainable development

Sustainable development is deemed as the current overarching aim of land administration. This overarching aim of land administration is up-to-date as well. The initial aim of land administration originated from its initial establishment by Napoleon in France - land taxation (Williamson, 1983), shifted to land market (land as commodity) (Ting, L., Williamson, I., 1999; Ting, Williamson et al., 1999), to multi-purpose service (Dale, McLaughlin, 1988; Dueker, Kjerne, 1989; Ting, L., Williamson, I. P., 1999), to current sustainable development (Bennett, Wallace et al., 2008a; Enemark, 2001, 2007, 2009; van der Molen, 2001; Williamson, 2001b; Williamson, Enemark et al., 2009, 2010). This overarching aim is argued not static, and will continuously change in response to social evolvement.

The overarching aim underpins modern land administration design. Land administration design closely depends on the societal requirements in the country context. As such, epoch of time of this evolvement is argued to keep the same pace of country context. That is, its epoch of time is believed to fit into level 1 (10^2-10^3 years) of EIM.

Land policy

Land policy needs updating. Three cases can show the necessity of land policy up-to- dateness: 'land reform policy' published in world bank in 1975 should be updated considering changes of requirements of title types and land market efficiency after years (Deinlnger, Binswanger, 1999); China's land policy since 1978 has changed dramatically in response to land allocation systems adjustment (Ding, 2003); Chinese cultivated land use changes between 1999 and 2007 resulted in policy changes and evolving (Song, Ouyang et al., 2012). The above mentioned cases could also imply that the epoch of time for land policy up-to-dateness is decades of time.

Land legislation, in this paper, is considered involving into land policy, because setting or refining of legal rules is the subsequent procedure to land policy updating. Similarly, land legislation needs up-to-dateness (Van der Molen, Österberg, 1999). This up-to-dateness could be presented in 'reforming' and 'strengthening' - land legislation needs reforming to become modern, standardized and simple through simplifying title nature (reduce to limit tenure types), enabling compulsory registration, introducing state guarantees in case of risks or integrating land-related laws into one systematic legislation (Dale, McLaughlin, 1999); legal principles should be strengthened for protecting land ownership and creating effective land markets; surging regulatory requirements drive the move to legalize almost all aspects of human behavior, especially for land administration issues (Bennett, Wallace et al., 2008b; Wallace, Williamson, 2006). Legal updating is closely related to or directly determined by land policy. As such, various channels to achieve legal updating is actually demonstrating the necessity of land policy updating.

Land policy up-to-dateness fits into level 2 (10-10^2 year) of EIM. From figure 5, we can see that land policy evolves keeping pace with economic, environmental, social, governmental and informatics development, for purposes of building instruments, building markets, supporting development and driving development. The temporal span is respectively from the Second World War, the year of 1975, 1990, and 2003 to 2010. As such, figure 5 provides a clear picture and proves that land policy evolvement is in 10-10^2 years.

Land administration functions

Land administration systems need updating inevitably and essentially for efficiency improvement or at least avoiding degradation due to dynamic human-to-land relationship (Smith, 1990; Williamson, 1990). This up-to-dateness can be presented in 'dynamic', 'evolvement' and 'reform' aspects - land administration systems contain dynamic component, reflecting in land tenure, land use and land value (van der Molen, 2002); due to land administration system evolvement, a modern framework is needed in response to the demands of sustainable development (Kaufmann, 1999); land administration system reform could be standardizing procedures, minimizing duplication, introducing risk management, developing 'one-stop shopping' facilities for the provision of public services or decentralizing selected operations to local community (Dale,McLaughlin, 1999). All these demonstrate the necessity of updating land administration systems through different channels for achieving sustainable development.

Up-to-dateness of land administration systems fit into Level 3 (1-10 year) of EIM, which can be shown in figure 6. Driven by technological development, land administration systems shift from paper records (1970), computerized systems (1980), and online land administration (1990), e-land administration (2005) to

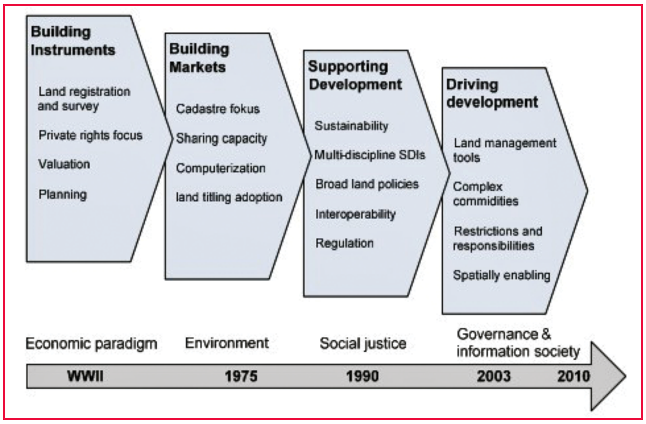

Figure 5: The policy focus on land administration has changed through time (Williamson, 2006)

Figure 6: Technical evolution of land administration (Williamson,Wallace et al., 2006)

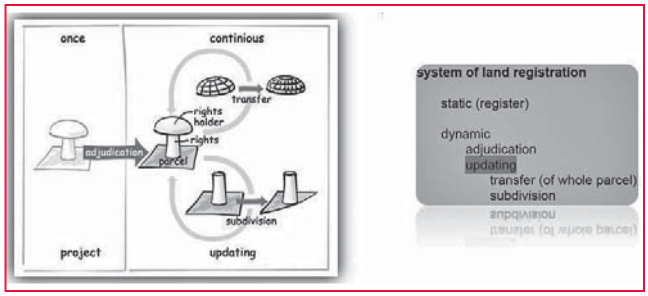

Figure 7: Dynamic model of land registration system (Zevenbergen, 2002)

iLand (2010). The epoch of time for land administration matches 1-10 years. It is believed that this epoch of time is also changing due to dynamic technological, political and economic development.

Land information infrastructures

Land information infrastructures, in this paper, refer to land information. A lot of scholars emphasized the necessity of land information - land information should be up-to-date due to inheritance, prescription, erosion or accretion along rivers, and calamities (Henssen, 2002); land information accuracy should be upgraded through the process of updating to achieve land administration maintenance (Scheu, Effenberg et al., 2000); cadastres are expected to be updated and accessed in real-time because of political, environmental, technological, social-economic drivers (Bennett, Rajabifard et al., 2010; Tambuwala, Bennett et al., 2010); land information up-to-dateness can be elaborated through the Dynamic Model of Land Registration System (DMLRS) in Figure 7 and three parameters for land information changes (transfer of property rights, property formation and alteration of land use) introduced by (Mattsson, 1999).

In Figure 7, two categories of land information up-to-dateness are reflected in the updating process of land registration. One is textual information changes through transfer. The other is graphical information changes through subdivision. Land information up-to-dateness should fit into level 4 of EIM (continuous). Even though cadastral information updating occurs in various epoch of time globally in reality. Considering the rapid growing demand for land information, continuous land information updating is extremely essential to keep conformity with reality for land-related services and geo-political decision makings.

Discussion

The findings of this study can be shown in Figure 8:

It is revealed that up-to-dateness occurs in any component of land administration, through literatures in terms of ‘up-to-date’, ‘updating’, ‘upgrading’, ‘renewal’, ‘dynamism’, ‘changes’, ‘maintenance’ and ‘evolvement’ in land administration. Furthermore, up-to-dateness is found to concern certain epochs of time in land administration: up-to-dateness of country context and sustainable development fits in the level 1 of EIM (10^2-10^3); up-to-dateness of land policy is in level 2 of EIM (10-10^2); up-to-dateness of land administration systems is in the level 3 of EIM (1-10); and up-to-dateness of land information is in the minimal epoch of time - level 4 of EIM (continuous).

Based on the main findings, further implications are argued that grasping principles with regard to the exact epochs of time of up-to-dateness in land administration will facilitate land administration activities, such as the followings:

Through mastering principles on epoch of time for country context up-to-dateness, institutional reform could be exactly predicted and relevant preparations could be made well in advance;

Through epoch of time for sustainable development up-to-dateness, the vision or overarching aim of land administration could be foreseen, and this will ultimately contribute to state development and stability due to considering the changing societal real requirements;

Through epoch of time for land policy up-to-dateness, proactive and reasonable land policy initiatives could be made by politicians;

According to epoch of time for up-to-dateness of land administration system, land administrators could make responses to enhance land administration in advance;

And the last but not the least, epoch of time for land information up-to-dateness is the core of up-to-dateness in land administration, influencing all other components within land administration domain. Accordingly, mastering principles on the exact epoch of time for up-to-dateness is believed to guide managerial activities in land administration.

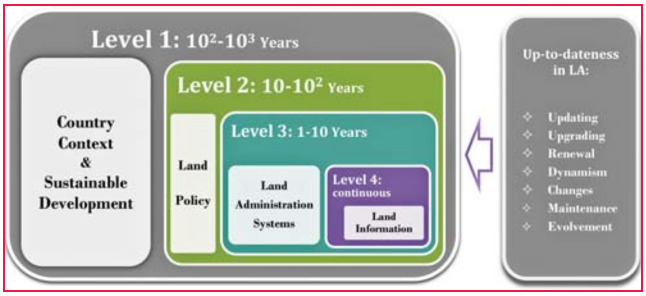

Figure 8: Epochs of time for up-to-dateness in land administration

Despite the main findings and further implications, the limitations of this study are worth mentioning: firstly, classification of LMP is probably limited - whether there is other components of land administration need probing or supplementing; secondly, hierarchies of EIM could be further reconsidered - whether the four levels need subdivision; thirdly, the synthesis model still needs further supplementing based on detailing epoch of time and supplementing components of land administration; fourthly, whether up-to-dateness of each component with certain epochs of time should be re-organized or not need reconsidering based on limited literatures. All in all, due to the limitations of LMP, EIM, limited literatures and inevitable environmental changes, the synthesis model itself still needs continuously updating in future. Yet, the synthesis model in this paper is accurate and complete in the present moment.

Conclusion

A wide range of literature reveals that up-to-dateness in land administration is presented in terms of 'up-to-date', 'updating', 'upgrading', 'renewal', 'dynamism', 'changes', 'maintenance', and 'evolvement'. All these diversified interpretations of up-to-dateness could be equally regarded as the dynamism of land administration. The established synthesis model shows that this dynamism occurs in any component of land administration (land information infrastructures, land administration systems, land policy, sustainable development and country context). It also shows that up-to-dateness or dynamism of each component of land administration is found to concern certain epochs of time. This paper is the first attempt to synthesize and clarify the various explanations of up-to- dateness in land administration systematically. This synthesis promotes the communication in up-to-dateness of land administration domain. It is also believed to facilitate land administration design and maintenance programs. Furthermore, the findings (the synthesis model) prompt the initiation of viewing up-to-dateness in land administration from the temporal perspective.

This synthesis model is a starting point for initiating research on up-to-dateness from temporal perspective in land administration science. What is the proper epoch of time for up-to- dateness of each component and how to evaluate the fitness-for-purpose of the current epoch of time could be the interesting directions for further probing.

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Spatial Data Infrastructure in the Sultanate of Oman

This article attempts to fill in the gaps in the Sultanate of Oman's National Spatial Data Infrastructure initiative project

Ahmed Hamood Mohammed
Al-Wardi "PHd Student Candidate", Faculty of Geoinformation and Real Estate (FKSG), Universiti Teknologi Malaysia

The Sultanate of Oman is located in the South-East of the Arabian Peninsula along the latitude (16˚40´ and 26˚ 20´) North, and longitude (51˚ 50´ and 59˚40´) East. It overlooks the Gulf outlet (Hurmuz Straight) in the North, Arab Sea on the East, with an estimated area of 309.500 square meter with a border line that stretches for 1,374 km shared with the Republic of Yemen to the South and South West, Kingdom of Saudi Arabia to the West and the UAE to the North West.

During the lapsed period of the 43 years of Oman's renaissance, a very rooted progress and wide development in the country's infrastructure occurred. This has great influence in lifting up and raising the level of living, and the oil sector played a prominent role in supporting and widening this development. The Sultanate took a great leap forward to support this sustainable development, and enlarge and develop the infrastructure in all fields and improve economic opportunities.

This wide construction development, which the Sultanate witnessed, was associated with imbalance in land usages, as the development was greatly focussed on some urban areas of great residential concentration, hence, causing a lot of problems in planning and construction expansion. As a result, it was a challenge for the country to deliver all its services to the entire region of the Sultanate, due to the varied geographic distribution between mountains, hills and deserts. Accordingly, the Sultanate has targeted itself to the importance of activating a national spatial strategy aiming at rectifying this path and finding clear visions, through which the country can develop remote rural areas to deliver the economic development effects and improve the various income resources in line with the sustainable development ambitions. Naturally, any strategic vision must be based on fully integrated information, where the idea of lifting the level of information that encourages participation and ideal use of spatial data as a starter to improve the government performance, disasters management, the strategic vision of raising the wheel of planning and construction to improve the various income resources as per well studied principles, has appeared.

This worldwide development witnessed by the technology of spatial data in operations such as (production, storage and use) has created a large sector of producers who deal with such data separately, where production process is done as per a solo vision, specifications and objectives. This has created financial and human burdens, waste of energy resources, and numerous problems such as data duplicity, weakness in participation and data integrity; not to mention the obstacles which have limited the achievement of common environment for the ideal usage of spatial data.
Since spatial data represents the major components, which the development of economic, social and disaster management is based on due to its direct influence on planning and correct decision taking, the government orientations should be based on correct spatial data in order to achieve requirements of the different sectors. With clear and thorough view for the Sultanate geographic data, its diversification and the extent of meeting the demanding requirements of the Sultanate's current development, this paper came to discuss the surrounding

Figure 1: Illustrates the location of the Sultanate of Oman

circumstances and its correspondence with the activation of the SDI and to what extent this current data would participate in the success of this initiative. The NSA's role as a major player in the success of this orientation has also been reviewed.

Spatial Data

The spatial data is known as that information which must answer questions of location, shape, and relation of particles in space, and it describes the distribution of matters (natural or man-made) on the land surface. The characteristics of spatial data are differing in nature than that in its geometric shape. Simply, the data is the raw material which information is derived from, and it represents the base and solid database for GIS which allows users to derive useful information based on precise and correct data.

The spatial data is stored and coordinated in geographic databases. This requires full understanding of operations such as additions, administration, handling the information (integrity, retrieval and showcasing), analysis and production of other styles, representation, and abstracting/producing information from the spatial data. Hence, such operations require special human skills, and special hardware and software. Data are represented in various forms - raster or vector symbols (points, line and area). Also, there is another type of data, the metadata which represents the spatial data's features and characteristics, and are stored on configurations and alphabets table. Qualitative data is represented in the form of letters and words, such as names of locations. As for the quantitative data, this is represented in a form of digits as for population consensus and humidity percentage (see figure 2).

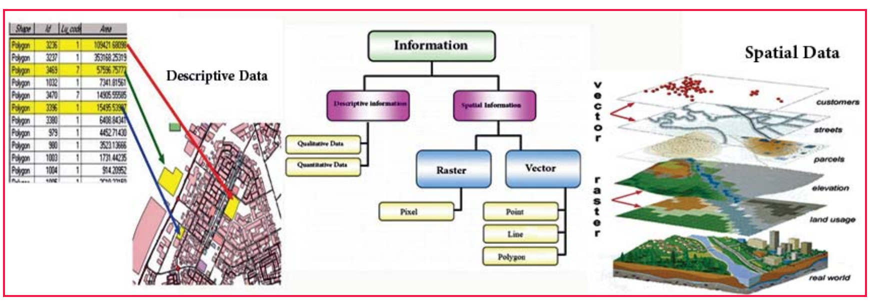

Figure 2: Shows types of Information

Spatial data Infrastructure – Initiative

One of the inevitable facts amid this information technology development is the ability of mankind to plan and deal with things that directly match with the information in hand. In the great nations, the information is owned and positively utilized for strategic planning, and this has formed a great quantitative leap towards supporting its economy and diversifying its income resources in many domains. The spatial data comes at the peak of the information pyramid with direct influence on decision-makers, and planning as 80% of the information used by decision-makers are spatial data (Klinkenberg, 2013).

With great advancement in the use of spatial data, the need was tangent to create a suitable method to review the availability of spatial data and reduce the increasing cost of data production due to the increasing demands for such data. The necessity was a driving force to create new and precise data to be ideally used to meet the needs of the country's establishments in a centralized form.

In early eighties, a what so-called (co-ownership under one umbrella) had emerged from within in every nation causing national geographic databases to be active and seek harmony with all levels in the country, starting from corporation level and then to local, national, regional and international levels. The Australian initiative in 1986 came as a starter for other nations to adopt this ideology, which began with the USA in 1987 and then the UK at the start of the '90s. According to Crompvoets, J., and A. Bregt (2003).), the number of states sought to activate the spatial data infrastructure initiative until 2002 was 120 countries.

The word infrastructure is used to promote the concept of supporting environment similar to a communications and roads network, whereas the word spatial data infrastructure is used to indicate access to and use of spatial data as per a common frame of agreements, practices and policies agreed upon for the ideal use of spatial data.

In line with the above, the expression 'Spatial Data Infrastructure (SDI)' is mostly used to point at the fundamental group of relevant, i.e., (technology, policies, arrangements and administrative matters) that facilitates availability and accessibility to spatial data. This forms a base to explore, evaluate the application of spatial data by users and producers at all levels. However, this entails us to say that, the SDI is more than a group of information or spatial databases. Actually, its concept extends to include features and characteristics of unified standards based data, user's ways of reaching to this data and data application supporting services within an environment governed by organizational agreements that facilitate data management on various levels. Furthermore, the group of information is the common fundamental data group which everybody seeks to obtain, to enable them to produce new data derived or based on this spatial data.

SDI Definition

The purpose and definition of the SDI differs from one country to another depending on that country's requirements and needs, as some countries at the time of adoption of this initiative, have focused on the production of data, or facilitate co-ownership or the use of standards. Therefore, there is no unified definition for the SDI initiative. The major definitions are:

a. Technologies, policies, standards and human resources necessary to acquire, process, store, distribute and improve utilization of geospatial data. (Executive Order of the White House 1994).
b. SDI as an umbrella of policies, standards and procedures under

which organizations and technologies interact to foster more efficient use, management and production of geospatial data. (US FGDC, 2008).

c. 'SDI is an initiative intended to create an environment in which all stakeholders can co-operate with each other and interact with technology, to better achieve their objectives at different political/administrative levels.' (Chan et. al., 2001).

d. 'The fundamental concept about facilitation and coordination of the exchange and sharing of spatial data between stakeholders from different jurisdictional levels in the spatial data community'. (Rajabifard Abbes, 2004).

The SDI Components

There is an active interaction between spatial data and the requirements of use by people through an existence of access medium to this produced data as per an agreed upon standards that achieve integrity between them. Hence, the initiative's components include the group of data, people, policies, standards, and access network as a major element to activate co-operation between these vital components for the success operations of storing, distributing, data improving, maximum usefulness and achievement of integrity and co-ownership (Rajabifard & Williamson (2003).

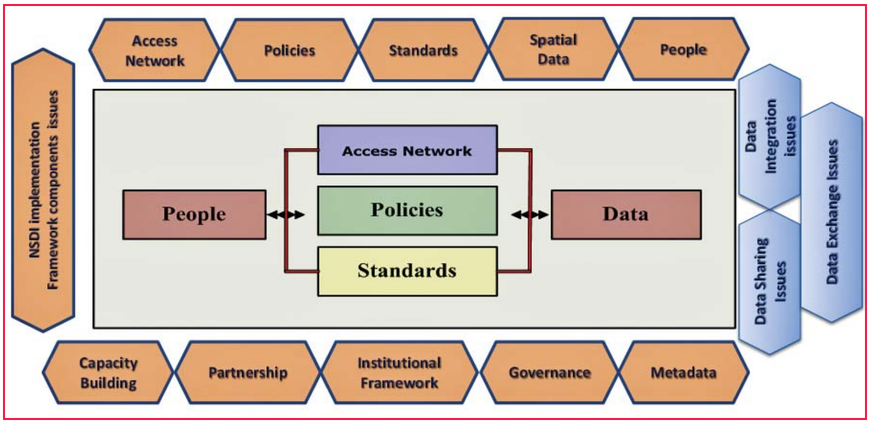

Figure 3: Shows NSDI Initiative's Components Surrounded by Obstacles

The Executive Office of the President of the United States of America (2002) introduced 5 components for the American initiative, which included fundamental data, metadata, data clearance house, standards, and co-ownership. Whereas Kennedy's initiative comprised 5 major components including technology, policy, frames, standards and accessibility (GeoConnections, 2008). In recent years, researchers have realized the role of influence of other components, such as capacity building, spatial data sharing, partnership and governance in the success and failure of spatial data initiative.

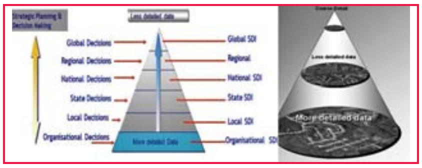

Figure 4: Illustrates SDI levels

SDI Levels

The spatial data infrastructure is divided into many levels based on the functional level of this data and the extent of its services to different sectors. The precision and density of this data depends on the pyramid level shown in the figure (4). The data found in the organizational level is characterized by great density and large scale, which coincides with the company's requirements in these operational stages, and it adversely lessens whenever we move to the upper level. As for data of the national level, it is determined according to partnership agreements between all establishments in service to their mutual interest, where data is upgraded to strategic planning operations and data management as well.

Spatial Data activities in the Sultanate of Oman

In the Sultanate, there are many organizations and agencies that produce spatial data and provide it to users, especially decision-makers. However, with the increasing demand for this data and the expansion of GIS applications in the Sultanate, the case of data production considered to be an obstacle which helped to create work duplicity, waste of the country's resources and create more complications to obtain new correct information on time. Therefore, necessity entails finding an idea of a common effort and forming a framework for better utilization of such data.

With many government establishments entering the digital world and their persistence to activate their services digitally, such establishments involved separately in producing data that achieve their requirements. This diversity has brought into existence many important characters such as standards, policies, and organizational arrangements which differ from one establishment to another. Mohammadi H, (2008), indicated that this discrepancy in the point of view between stakeholders and information producers, in any country, is considered as an obstacle towards achieving data integrity from various resources, and this is shown in the common information group produced by different producers who do not adhere to common standards, technical specifications and other associated policies. This has caused each establishment to be dependent on its budget in providing the data, which in turn leads this data to be engulfed with secret and administrative complications. This makes this data inaccessible to users and creates lack of common co-operation between the producers and users establishments.

Outlining Co-Work of Major Data Activities

In the national level, common data is usually identified by a special committee which outlines the information type on basis of the country's interests and needs. This data is identified by the word 'frame' or 'fundamental' for the NSDI initiative, which provides services to all civilian and private sectors to fulfill their duties. Accordingly, there must be a 'frame' for a common work to create a common data source for the production of more commonly basic geographic data with respect to requirements and usage, further to the provision of supporting environment for development and data usage. The feature of this 'frame' is distinguished by existence of procedures, technology, and instructions to help achieve data exchange and participation, with the existence of solid ground of data of unified standards to achieve integrity between them from different sources. The process of organizing and managing this frame must be done through finding common relations between establishments, so as to encourage building cooperation and help in maintaining, developing and improving this data.

Every year, thousands of Omani Rials are spent by many establishments in the country just to obtain data from data-making companies, which allocate budgets for certain projects. Most of this data is of a single format and single purpose. However, despite the large availability of data with these establishments, a large number of it is mostly used to solve problems faced by the establishment, or not being managed and newly maintained because that establishment does not have the suitable upgrading means and it's outside of its work frame. On the other hand, some organizations can deal with the data, but with different techniques and use different databases and standards, where a certain geographic area may be covered by a number of these organizations. This makes us realize that there is a big problem related to the harmony and integrity of this data with one another. Accordingly, many obstacles have arisen that must be gradually solved in line with the existence of driving force for the country's higher interest.

Many countries have strived to activate the NSDI initiative. While some succeeded in introducing facilities for the data to be used by all users, and others failed. Moreover, some countries kept their initiatives without any tangible advancement. Therefore, the success of such orientation should be built on the basis of understanding, cooperation and trust among all participated parties, and is *not limited to one else.* Furthermore, there must be a gradual advancement in changing the hazy picture about the concept of participation, its nature and boundaries. Accordingly, involvement in the activation of Oman NSDI initiative must be supported by information awareness to include all sections in the spatial data group, starting from the technician level up to the level of decision-makers with clear visions for the nature and type of information and standards that must be created and followed to achieve the required integration, as well as the policies helping to activate this participation and data exchange in harmonious environment protected by suitable legal frames.

Obstacles of Common Work

There are many obstacles that limit the common work between GI community in the Sultanate. This paper outlines some of the main constraints that can hinder Oman SDI implementation. These constraints include:

Absence of awareness about the concept of NSDI initiative

One of the prime driving concerns for the Sultanate's spatial data activities is the lack of informational awareness of matters pertaining to the initiative and acknowledgement of its major components. Realizing the data groups, the initiative's benefits and the nature of cooperation is considered to be an enticing forefront for the country's advancement, with confidence, towards the activation of the SDI initiative. In line with this, there must be awareness to prepare the ground from which this initiative will be launched, and go in parallel with its activation to include all levels in the organization from technicians to decision-makers. Currently, there is unsteady realization for the purpose of activating the NSDI initiative or may be unknown to some establishments, which reflected negatively on the harmony of views and extending hands of cooperation between participants.

Basic Data Availability

Naturally, the NSDI initiative would be built on the basis of the availability of new precise data covering the national orientation requirements as per scales range between medium and large, to meet the country's needs at all (organizational, local and national) levels. This data provides the backbone for this initiative to achieve the intentions of ideal usability, exchange and participation. Whoever deeply penetrates to understand the nature of the Sultanate SDI would realize that there is shortage in the availability of basic maps, not to mention the availability of different data with different scales, which are hard to predict its precision and conformity of its standards with the common work. This is due to the absence of proper documentation and the activation role of the metadata. Combining this data in an environment for purpose of integrity is a waste of time leaves nothing but numerous legal and organizational problems, besides the initiative's outcomes do not serve the organization's environment.

Metadata- Lack of Documentation

The use of data in the Sultanate is embraced by informational weakness on the characteristics of the spatial data and lack of documentation. The existence of metadata is a demanding requirement to identify the place and evaluate the available data. With the change in the nature of forming and documenting the metadata, the data of today becomes viable for use in the years to come, hence facilitating participation in a harmonious environment. The availability of metadata is a very important demand for the management of common data. With existence of this data, documentation and the metadata, access to data becomes easy and direct, and this would help in managing the assets available. Besides, the documented information would be more valuable than the data without documentation. In fact, the activation of metadata would assist the establishment in organizing and keeping its data organized without any duplicity, apart from the quick and easy access to data when urgently needed. The metadata will also participate directly in the improvement of data management procedures and its promotion within the user's requirements.

Co-operation & Coordination Between Public/private Sectors

As previously mentioned, the solo work in the production of spatial data does not lead to coordination and participation, and produces spatial data with different formations away from the concept of participation with no data integrity is achieved. Further to that, absence of the hosted establishment to organize and manage the data has greatly affected the spatial data activities in a solo and isolated form under the one establishment frame, in addition to the spread of technology and the activation of GIS applications. The reliance on varied digital data differs from one establishment to the other. The inexistence of a unified funding source for the production of spatial data has strongly deepened the participation gap and forced many establishments to create administrative complexity to protect their data, hence restricted users accessibility to the data, not to mention the inexistence of clarification for the type and venue of this data among the country's produced establishments.

Absence of Unified standards

Amid the technology development witnessed by the Sultanate in the early period of this current century and the simplicity of acquiring hardware and software to gather spatial data, many establishments sought to obtain this software and allocated a lot of money to acquire observation and drawing software. Accordingly, the GIS applications have expanded and with this increasing demand on data, these establishments adhered themselves to solitude in producing data as per specific standards that serve their duties and responsibilities. The variation of these standards in some establishments and its non availability with others had greatly influenced the process of finding data that serve certain purposes and for limited periods. Hence it left behind a lot of duplicity in effort, time and money. Since the unified standards are considered the backbone for the spatial data integration from different sources, countries which have succeeded in the activation of the NSDI initiative have oriented themselves to develop a number of unified standards as an engine base for the success of their initiative. This is to include many fields relevant to data exchange standards, GIS standards for data capture, metadata standards and geo-referencing standards, in addition to procedures followed to facilitate data accessibility. As a result, this entails the Sultanate to support the activation of available standards evaluation committee and establish new standards that coincide with the visions and objectives the NSDI, based on this evaluation.

NSA's Role in Activating Spatial Data Infrastructure's Initiative.

Since its inception in 1984, the National Survey Authority (NSA) was tasked with major responsibilities in the management of spatial data. Its mission was to setup and apply Oman's geographic policy, monitor topographic surveys of national criteria and mapping, maps review and air charts to support all civilian, military and private sectors in the country, further to establishing the national archive for geographic data. Therefore, the NSA is dealing with all spatial data sectors in the country in line with its bestowed responsibilities and duties as part of its major work reinforced with capabilities such as manpower, assisted software, and long service history of 30 years experience in this field to meet the consumers' requirements in the Sultanate. The NSA also supervises the production of spatial data projects for the country's establishments and possesses the capabilities to check the data specifications agreed upon in implementing these projects. Hence the NSA is the major driving engine in activating the national spatial infrastructure initiative.

The NSA strongly understands that achieving integration among the state establishments is a difficult matter, and the exchange of this data will face a lofty administrative complexity. It also realizes that subjecting this data under one environment may cause legal problems and may not correspond with many establishment's capabilities and usages. As a result, the NSA's interest during the last five years was in line with the necessity of moving the Sultanate from the umbrella of separate entity to the umbrella of collective work toward activating the national spatial data basic initiative. During the last period, the NSA's work was mainly focused on preparing its data to welcome this technology, and there were many implemented projects which still stand and coincide with this orientation. This includes:

Transferred from Paper to Digital Format

NSA transferred all hardcopy spatial data into digital format that was included in the National Database (NGDB) to go along with the requirements of future spatial data infrastructure. This database includes many spatial data such as aerial photographs, satellite imageries, heights data, ground control data and geographic names database, further to all various maps scales (raster), and all this represents an important source for the country's requirements.

Map production

Currently, the NSA is working on producing maps at scale 1:50.000, and renewing maps at scale 1:100.000 in seamless vector format in line with modern principles and unified data samples. By the end of 2015, these two scales will provide to feed the Sultanate's requirements and so, other establishments can use these two scales as a standard to produce new thematic data.

Projects Activations to Unify the Sultanate Coordinate System.

The NSA is currently seeking to activate a number of focal projects which are presented to unify the geo-referencing system in the Sultanate on the basis of an existence of a solid ground that enables the state's establishments to produce their data in a way that achieves the objective of data integrity among them in future. These projects presented in the following:

a. Establishment of Oman National CORS Network (ONCN).
b. Establishment of Oman National Geoid Model (ONGM).
c. Establishment of Oman National geodetic Datum (ONGD14).

Production Capacities Enhancement

In line with its progress, the NSA has enhanced its line of production with all the necessary equipment and modern software to include enhancement of field survey section, photogrammetry section and development of cartography drawing tools, further to introducing check and quality control cell which now has become capable of supervising and producing base maps at large scale for planning purposes. And should the financial funding for this cell become available, the ground referencing system would become totally complete and achieve the spatial data infrastructure initiative's purposes.

Conclusion

The case of spatial data management is considered an engine for nation's development and progress and achievement for the right decision, which participates in the management of planning and setting up successful future policies. As it is known, the world today has become blocks of different levels starting with the organization all the way to the local, national, regional and global levels. Therefore, data management has, during the last two decades, been given the required attention. Hence, countries oriented towards working under the collective umbrella of these different levels and "what so-called spatial data infrastructure initiative" has appeared. But, despite the differences that existed between one nation and another in terms of activating this initiative, the target was to achieve commonness and exchange of new and precise data among the country's establishments and foster integrity among them with the availability of technology environment to access this data. Achieving the objectives of this initiative is engulfed with many difficulties and technical, social, organizational and corporative obstacles. Finally, the success of any country's initiative is tied up with the country's ability to conquer these obstacles.

Oman is one of the countries, during recent years that sought to adopt the National Spatial Data Infrastructure initiative project due to its tangent need to organize its data within a common frame. This frame fulfills its future ambitions and provides the base from which its long term strategies in all fields of development and fulfillment of requirements for environment management were launched. However, there are gaps that need to be filled and obstacles that must be crossed to expedite the common work. This paper has presented a short clarification on Oman spatial data infrastructure activities and the effect of solo work toward achieving integrity among the common data and data exchange between organizations. This paper has also tackled a number of obstacles to include data availability, absence of information consciousness with regards to the concept of spatial data infrastructure, lack of metadata documentary, absence of unified criteria as a basis for data integrity, and the most important, the lack of cooperation and coordination between organizations in a local sector. The NSA's role as a custodian to Oman's spatial data has also been tackled, while bringing out the most hastily prominent projects that go in line with the way of activating Oman's spatial data infrastructure initiative.

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Georeferencing archive spy satellite images of Hungary

The Corona satellites were used for photographic surveillance beginning in June 1959 and ending in May 1972

Gábor Bakó
Member, Szent István University's Institute of Botany and Ecophysiology, Hungary

Eszter Góber
Manager, Interspect Aerial Image Archive, Hungary

The first successful spy satellite series

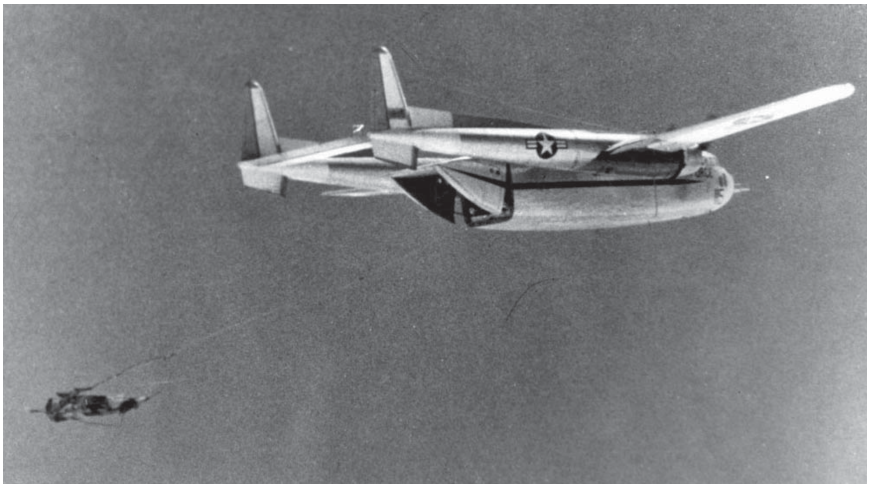
The Corona program was a series of American strategic reconnaissance satellites produced and operated by the Central Intelligence Agency Directorate of Science & Technology with substantial assistance from the U.S. Air Force. The Corona satellites were used for photographic surveillance beginning in June 1959 and ending in May 1972. The Corona program was officially declassified on February 22, 1995. The name of this program is "Corona" was a codeword, not an acronym. There were 144 Corona satellites launched, of which 102 returned usable photographs. The Corona satellites used special 70 millimeter film with a 24-inch (610 mm) focal length camera. Manufactured by Eastman Kodak, the film was initially 0.0003 inches (7.6 µm) thick, with a resolution of 170 lines per 0.04 inches (1.0 mm) of film. The contrast was 2-to-1 (Brown 1996). The cameras were manufactured by the Itek Corporation, the lens designed for the cameras was based on German Zeiss Tessar lenses (Lewis 2002). By digitizing the best quality standardized photographs, the achievable spatial resolution is 1.5 m. However, 0.91 m resolution was also applied, and during a test, 0.3 m spatial resolution photo was taken too (Chun 2006).

The resulting photo mosaic generated by the Interspect Research Group has 2.5 m spatial resolution.

Coronas were launched by a Thor-Agena rocket. The film was brought back by reentry capsule developed by the General Electric, which separated from the satellite and fell to earth, parachutes deployed at 18 km, and the capsule was caught in mid-air by a passing airplane towing an airborne claw.

Hungary at 2.5 m spatial resolution 60s images mosaic

The photographs digitized by the USGS arrived in four parts; the first task was



The Fairchild-C-119J-51-8037 recovers the Discoverer XIV capsule in flight (19 August 1960)

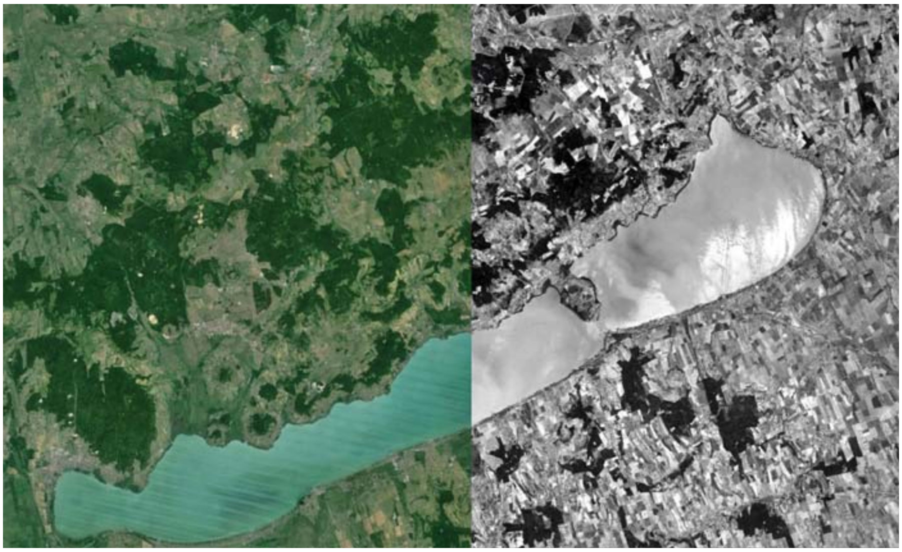


Figure 1: Landsat and CORONA image mosaic of Lake Balaton, Hungary

compiling the original unity. It required geometric reconstruction, during which the geometry of upturned edges of overlapping scanned film strips was restored leaving out the blurred sections. After the restoration of film strips, the screening for ground control points (GCPs) was launched. The image georeference was carried out by two methods.

With multipoint registration the less overlapping images have been synchronized by GCPs (40 – 170 GCPs/ image) measured in geodetic survey and transformation synchronized for image-pairs (6000 – 8000 points). Here Delaunay Triangulation was applied, because it is exactly preserve the location of each entered GCP.

Wherein the base-pairs have allowed stereo models were applied. Finally, in both cases the images were rectified onto surface model by bilinear interpolation resampling.

650 meters of the blurred edges of rectified images have been left out due to resolution reduction and image blur. Then cloud cover- and cloud shadow-free seamless mosaic was created for the 80% of the country. The resulting panchromatic photo map has 2.5 m spatial resolution; it is well- interpretable for land-cover.

The Interspect and the Global Mapper software were applied to perform the task. For collecting GCPs Topcon Hiper SR geodesy GPSs were used. As the adjustment quality depends on GCPs' quality, these measurements have been conducted particularly carefully. The

The works concerning the territory of Hungary were based on the following Corona missions of the 1960s:

Launch date	Mission No.	Cover name	Camera	International Designator
16 Jun 1967	1042	OPS 3559	Camera: KH-4A (Corona J-1)	1967-062A*
*This US Air Force photo surveillance satellite was launched from Vandenberg AFB aboard a Thor Agena D rocket. It was a KH-4A (Key Hole-4A) type spacecraft.				
07 Jul 1961	9019	Discoverer 26	KH-2	1961-016A
12 Sep 1961	9022	Discoverer 30	KH-3	1961-024A**
**These capsules were designed to be recovered by a specially equipped aircraft during parachute descent, but were also designed to float to permit recovery from the ocean. All film was black and white. With this launch, the film capsule was caught in mid-air after 33 orbits.				
30 Aug 1961	9023	Discoverer 29	KH-3	1961-023A
1 May 1968	1103	OPS 1419	KH-4B	1968-039A***
***This US Air Force photo surveillance satellite was launched from Vandenberg AFB aboard a Thor Agena D rocket. It was a KH-4B (Key Hole-4B) type spacecraft.				

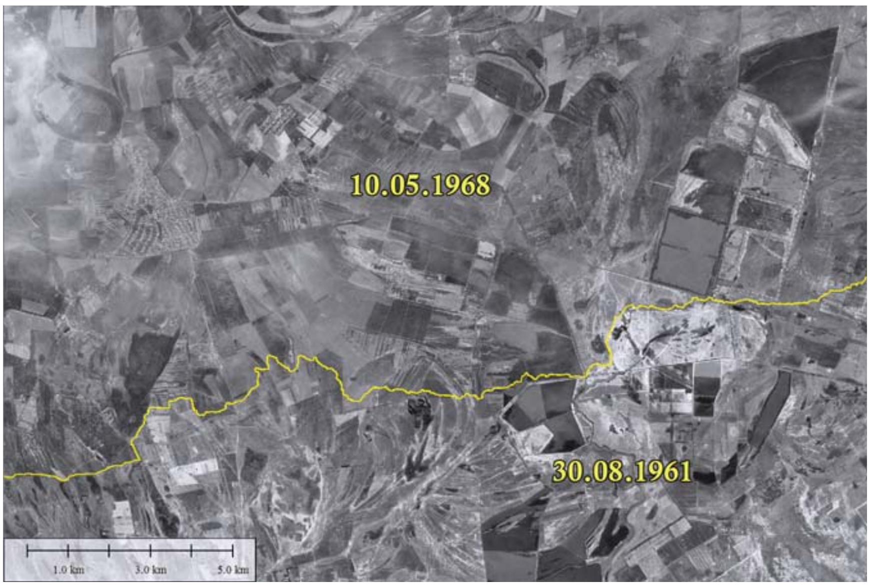


Figure 2: Vector layer including shooting date

location of used photographs which were taken on different days is represented within the mosaic by opening a vector layer with accuracy of 1 m (Figure 2). For easier handling the mosaic was cut into sections of 48 x 32 km (19200 x 12800 pixel).

The images will be used for land cover, climate change and biodiversity studies.

Participants of the image map production:
Project Manager: Gábor Bakó
Field team leader: Zsolt Molnár
Leader of the Archive: Eszter Góber

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SuperGIS Server for national development

Supergeo Technologies supports Taiwan National Development Council to integrate various geographic data and services collected by different divisions into one single platform, named Spatial Arrangement Supporting System, to provide timely spatial analyses and map data display by GIS. Being the core foundation of the System, SuperGIS Server 3.1a provides the system with various functions including spatial data processing, analyzing, displaying and editing. It is also equipped with SuperGIS Server Network Extension to provide advanced network analysis. Microsoft SQL Server 2008 is adopted for database management service. *www.supergeotek.com*

Zambezi valley mapping in Mozambique

South Korea will fund a cartographic survey of the Zambezi Valley region of Mozambique, costing US$4.5 million and taking an expected two years, the Korean International Cooperation agency (Koica) said.

The project is intended to produce digital topographical maps of the city of Tete, in the Zambezi valley region and covering round 286 square kilometres and the whole of the Zambezi Valley region. The maps will be produced to a scale of 1:2,500 and 1:50,000, respectively. *www.macauhub.com.mo*

Australian soil carbon map sets a baseline for future gains

A new CSIRO-developed map of Australia's stored soil carbon provides an important benchmark against which Australia can track future changes in soil carbon storage or carbon sequestration.

Providing the most detailed and accurate representation of soil organic carbon stocks, to a depth of 30 cm, at a national scale, the 2010 soil organic carbon map for Australia, draws on soil sampling data and innovative prediction methods.

The map includes an estimate of soil carbon stock and an estimate of the uncertainty for approximately two billion football-field-sized blocks (90m by 90m) across Australia. *www.csiro.au/en*

Abu Dhabi completes the development of i-TINS

In accordance with the Surface Transport Master Plan (STMP), the Department of Transport (DoT) in Abu Dhabi announced the completion of the Integrated Transport Information and Navigation System (i-TINS) and the launch of the first version of the “Darb Mobile” application for smart phones.

i-TINS works through the collection of real-time data from different sources – road side systems such as traffic counting systems and travel time measurement systems and central sub-systems such as Taxi and Buses GPS-based tracking systems. Data is then analysed and processed to ensure its accuracy and made available to the transport system users in the Emirate of Abu Dhabi. I-TINS also has the ability to provide public transport users with the exact locations of bus stations and stops, real-time bus schedules, ferry routes and timetables. *http://dot.abudhabi.ae*

Indoor maps in India by Google

Google has announced the availability of indoor maps in India giving access to the floor plans of 75 places in 22 Indian cities. Most of these 75 places are shopping malls but museums and convention halls also find a mention in the list. Similarly, while most of these places are located in big cities like Delhi and Mumbai, some buildings from Raipur and Ludhiana too are a part of the project. *http://timesofindia.indiatimes.com*

Low cost info to help China's geomatics industry

China plans to offer basic geographic information at low cost or even for free in the future so as to boost development of the geomatics industry. The policy will offer information support for companies and promote their value-added development based on this data, said the National Administration of Surveying, Mapping and Geoinformation. The government also plans to invest more to buy services from social sectors, take measures to encourage companies to compete internationally, boost growth in consumption of geographic information, and invigorate private investment in this sector. *www.shanghaidaily.com*

High-tech mapping at violence in Mexico

Chris Kyle, Ph.D., a University of Alabama at Birmingham associate professor of anthropology has been awarded a $40,000 research grant from The Harry Frank Guggenheim Foundation. The foundation sponsors scholarly research on problems of violence, aggression and dominance. The award will partially fund a yearlong sabbatical during which Kyle will write a book on the spatial analysis of criminal violence in Guerrero, Mexico. Using GIS mapping software, he is able to plot events on a map and to analyze spatial and temporal patterns in the incidence of violent crimes. *www.uab.edu/*

President's 2015 Budget Proposes $1.1 Billion for the USGS

The President's fiscal year (FY) 2015 budget request for the U.S. Geological Survey is $1.1 billion, an increase of $41.3 million above the FY 2014 enacted level.

The FY 2015 Budget reflects the President's ongoing commitment to scientific discovery and innovation to support decision making in addressing critical societal needs and to support a robust economy, while protecting the health and environment of the Nation. *www.usgs.gov*

TERI launches first-ever GIS tool to tap rooftop solar power

The Energy and Resources Institute (TERI) unveiled the first-ever cloud based open-source Web-GIS Tool for estimating Rooftop Solar Power potential for Indian Solar Cities. The main objective of this initiative is to develop a high performing and flexible Web-GIS tool to estimate the rooftop solar power potential for Indian cities. Chandigarh will be the first city where the tool will be launched. *http://indiaeducationdiary.in*

Galileo update

EGNOS capability enhanced with addition of new generation transponders

As part of the actions undertaken by the European Commission to upgrade and maintain the EGNOS system, on 22 March two geostationary transponders – GEO-2 - were successfully launched on board the SES ASTRA 5B satellite from the European Space Port in Kourou, French Guiana. The new generation transponders will provide higher accuracy positioning signals to both citizens and professionals using EGNOS enabled receivers and ensure the continuity and quality of the EGNOS open service and safety-of-life services for the next 15 years. Together with the previous transponder replenishment on the SES-5 satellite launched in July 2012, GEO-2 will soon be introduced in current EGNOS operations and will support the new EGNOS generation (EGNOS V3). EGNOS V3 will provide dual-frequency signals on L1 and L5 bands and augment both GPS and Galileo. *www.gsa.europa.eu*

ESA to Award Certificates For First Galileo Position Fixes

To mark the first anniversary of Galileo's historic first satnav positioning measurement, ESA plans to award certificates to groups who picked up signals from the four satellites in orbit to perform their own fixes.

In 2011 and 2012 the first four satellites were launched – the minimum number needed for navigation fixes.

On 12 March 2013, Galileo's space and ground elements came together for the first time to perform the historic first determination of a ground location – the Navigation Laboratory of ESA's Technical Centre in Noordwijk, the Netherlands.

From this point, generation of navigation messages enabled full testing of the entire Galileo system – not just by ESA and its industry and institutional partners but also by any entity with a customized satnav receiver.

ESA's Galileo team heard about position fixes carried out by organizations and companies all over Europe and beyond, including as far away as Vietnam.

A year on, ESA will recognize these Galileo pioneers with commemorative certificates to the first 50 entities who document their achievement of a past or present fix. *ESA*

Global Navigation Satellite Receiver From Galileo Satellite Navigation Now Available on Cadence Tensilica ConnX DSP IP Cores

Cadence Design Systems, Inc has announced that Galileo's software-based GNSS receiver is now available on Tensilica® ConnX DSP IP cores. The GSN GNSS receiver running on a Cadence ConnX BBE16 DSP consumes very little power - as low as 10mW of power on a 40nm process - and has the ability to work in lower rates, or "snap-shots" for ultra-low-power mobile scenarios. The solution delivers high sensitivity tracking, offering a seamless GNSS experience in challenging environments. *http://www.galileo-nav.com*

Hybrid cloud location services by Pitney Bowes and IBM

Pitney Bowes Inc. and IBM have announced collaboration on IBM's codename "BlueMix" platform-as-a-service to develop new hybrid cloud location services that help businesses unearth deeper connections between their customers, their geography, and their networks to deliver more personalized services and contextually relevant experiences. BlueMix provides DevOps in the cloud -- an open, integrated development experience that scales to any level. Pitney Bowes is among the first third-party solutions now available to developers and companies on the new IBM BlueMix Platform-as-a-Service (PaaS). *www.pb.com*

Garmin Xperia™ Smartphones

Garmin® International Inc has announced a new navigation app for Xperia™ smartphones1 with an extension for Sony SmartWatch 2. The new app seamlessly integrates with Sony SmartWatch 2 to display walking directions, providing users navigation information right on their wrist and without having to hold a phone. *www.garmin.com/pressroom*

High-tech surveillance data on China islands

China has collected detailed topographic information and images of all its islands using aerial remote sensing. The completion of the project marks the country's first "systematic and comprehensive" move to collect surveillance information on the more than 10,500 islands within its territory, said the State Oceanic Administration (SOA). It took three years of work by the aviation law enforcement forces with the China Marine Surveillance (CMS), according to an SOA statement. *http://news.xinhuanet.com*

Global location chip targets wearables

Broadcom Corporation offers the industry's first GNSS system-on-chip (SoC), designed for low-power, mass-market wearable devices such as fitness trackers and smart watches. The BCM4771 GNSS SoC with on-chip sensor hub enables consumers to more accurately track and manage their health and well being by delivering precision activity tracking and location data while consuming less power than traditional architectures. This enables location intelligence and the extended battery life needed by the growing wearable market. The chip constantly monitors user activity levels and location history to improve accuracy while adding advanced features such as location batching. *www.broadcom.com*

Pinpointing users where GPS doesn't work

Ruckus Wireless has unveiled the Ruckus Smart Positioning Technology (SPoT) service. This cloud-based service gives carriers, service providers and enterprises the ability to deliver location-based services using Wi-Fi in locations where GPS is not effective.

New and existing Ruckus Smart Wi-Fi access points are now capable of powerful and accurate client positioning for indoor or dense urban environments, where GPS doesn't always work. By knowing where clients are located, companies are able to help them get wherever they need to go, making the network experience better for them, or use data from their location to optimise their experience. *www.crn.com.au*

GPS devices in election campaign in India

Over 400 campaign vehicles and tempos of the Bharatiya Janata Party in Uttar Pradesh (UP) have been fitted with GPS devices to keep a check on any laxity from workers while campaigning in each assembly constituency in the state. Monitoring of these campaign vehicles will be done from a control room set up in state capital, Lucknow. According to a party leader, installation of GPS devices and monitoring from a control room would be done only to keep an eye on the workers so that the party is not misled by workers about the movement of vehicles. Monitoring at the control room would be done by volunteers of Citizens for Accountable Governance (CAG), a non-profit group supporting BJP prime ministerial candidate, Narendra Modi. *www.dnaindia.com*

RADARSAT-2 info for the Malaysia Remote Sensing Agency

MDA's Information Systems group (MDA) has signed a contract with the Malaysian Remote Sensing Agency (MRSA) to provide RADARSAT-2 information that will be used to support a number of applications, such as agriculture monitoring, and natural disaster response. MRSA has been utilizing the recent access to RADARSAT-2 information to aid in the search of the missing Malaysia Airlines Flight MH370. *www.mdacorporation.com*

European Parliament adopts Copernicus

Copernicus, the EU's Earth Observation Programme, will ensure the regular observation and monitoring of Earth sub-systems, the atmosphere, oceans, and continental surfaces, and will provide reliable, validated and guaranteed information in support of a broad range of environmental and security applications and decisions. The vote marks a major milestone for Copernicus. Indeed, the adoption of the Regulation paves the way for the continuous development of the programme. This text, which still needs to be adopted by the Council, defines Copernicus objectives, governance and funding (some € 4.3 billion euros) for the period 2014-2020. The Copernicus programme is entering the operational phase after years of preparation. The next step is the launch of the first Copernicus satellite, Sentinel-1, very soon. *http://copernicus.eu*

Integrated Digital Medium Format Aerial Camera

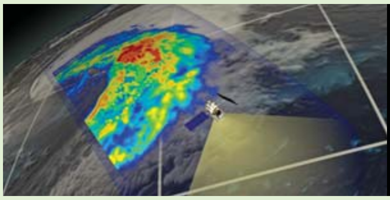
Phase One Industrial has announced the Phase One iXU 150 — the first CMOS-based medium format aerial camera. Its 50 MP CMOS sensor offers 8280 pixels cross-track coverage, which is 68 percent more capture area than the sensor in any full- frame 35mm DSLR. Quality captures are now possible across its full range from ISO 100 to 6400, at a capture rate of 0.8 second per frame. Its magnesium chassis is 30 percent lighter than an aluminum design, but built to be a tough workhorse, able to withstand the challenging physical conditions of aerial photography. *industrial.phaseone.com*

China mulls global satellite surveillance

China is considering massively increasing its network of surveillance and observation satellites so it can monitor the entire planet. The government is mulling building more than 50 orbiting probes, which Chinese researchers said would make the nation's satellite surveillance network on par with, or even larger than, that of the US. Frustration with the search for the missing Malaysia Airlines aircraft over the past three weeks had led the project to win strong backing from decision makers in Beijing, the researchers said. *www.scmp.com*

First Images Available from NASA-JAXA Global Rain and Snowfall Satellite

NASA and the Japan Aerospace Exploration Agency (JAXA) have released the first images captured by their newest Earth-observing satellite, the Global Precipitation Measurement (GPM) Core Observatory, which launched into space Feb. 27. The images show precipitation falling inside a March 10 cyclone over the northwest Pacific Ocean, approximately 1,000 miles east of Japan. The data were collected by the GPM Core Observatory's two instruments: JAXA's Dual-frequency Precipitation Radar (DPR), which imaged a three-dimensional cross-section of the storm; and, NASA's GPM Microwave Imager (GMI), which observed precipitation across a broad swath. *www.nasa.gov*



An extra-tropical cyclone seen off the coast of Japan, March 10, 2014, by the GPM Microwave Imager. The colors show the rain rate: red areas indicate heavy rainfall, while yellow and blue indicate less intense rainfall. The upper left blue areas indicate falling snow. Image Credit: NASA/JAXA

IRNSS-1B successfully launched

ISRO's Polar Satellite Launch Vehicle, PSLV-C24, successfully launched IRNSS-1B, the second satellite in the Indian Regional Navigation Satellite System (IRNSS) on April 04, 2014. After a flight of about 19 minutes, IRNSS-1B Satellite, weighing 1432 kg, was injected to an elliptical orbit of 283 km X 20,630 km, which is very close to the intended orbit.

IRNSS-1B is the second of the seven satellites constituting the space segment of the Indian Regional Navigation Satellite System. IRNSS-1A, the first satellite of the constellation, was successfully launched by PSLV on July 02, 2013. IRNSS-1A is functioning satisfactorily from its designated geosynchronous orbital position. IRNSS would provide two types of services, namely, Standard Positioning Services (SPS) - provided to all users - and Restricted Services (RS), provided only to authorised users. A number of ground stations responsible for the generation and transmission of navigation parameters, satellite control, satellite ranging and monitoring, etc., have been established in as many as 15 locations across the country.

Two more satellites of this constellation, namely, IRNSS-1C and IRNSS-1D, are planned to be launched in the second half of 2014. The entire IRNSS constellation of seven satellites is planned to be completed by 2015-16.

Russia's Glonass GPS system suffers major disruption

Users of satellite navigation systems around the world were experiencing problems recently after Russia's Glonass satellite positioning system was hit by a major disruption. So far, the cause of the problem is a mystery. Most of the 24 satellites that make up the Glonass constellation began broadcasting erroneous data about their locations. The ability of satellite positioning receivers to provide an accurate fix is tied to the accuracy of the signal from space, so the problem immediately affected users.

A status graph on the website of Russia's Federal Space Agency confirmed the error impacted all Glonass satellites at some point, with the system finally returning to full health around 11 hours after the trouble began. Despite the widespread disruption, the space agency has yet to provide details about what caused it. *www.pcworld.com*

Soyuz space rocket with Glonass-M navsat launched

The Soyuz-2.1b rocket with a Glonass-M navigation satellite has been launched from Plesetsk spaceport. The GLONASS system is intended for operational navigation-and-timing support to an unlimited number of land-, sea-, air-, and space-based users. *http://en.itar-tass.com/*

Precise monitoring of bad weather using unique GPS system onboard airplanes

GPS on-board airplanes will now help detect precise conditions in the atmosphere and better predict weather conditions and improve hurricane forecasting across the globe.

The new system, led by Scripps Institution of Oceanography geophysicist Jennifer Haase and her colleagues captures detailed meteorological readings at different elevations at targeted areas of interest, such as over the Atlantic Ocean in regions where hurricanes might develop. The instrumentation, which the scientists labelled "GISMOS" (Global Navigation Satellite System Instrument System for Multistatic and Occultation Sensing), increased the number of atmospheric profiles for studying the evolution of tropical storms by more than 50%.

GPS III program faces cuts, more delays in 2015 budget

The Air Force is planning to slow the development of the Global Positioning System III satellite program as a part of cuts detailed in the President's Fiscal Year 2015 budget request that was unveiled on March 5.

The Air Force originally planned to purchase two GPS III satellites next year, but now it is only planning on buying one. The GPS III satellites are expected to affordably replace current GPS satellites while providing additional capabilities. They are designed to be more accurate and more resistant to jamming techniques, while also having a longer lifespan. *http://defensesystems.com*

Rx Networks Launches BeiDou Services

Rx Networks Inc has completed the upgrade of its GPStream GRN™ (Global Reference Network) to include the BeiDou constellation. A top-tier GNSS semiconductor vendor has already incorporated this new feature so their platform can take advantage of the extra satellites now available in the BeiDou constellation.

Global real-time assistance and high accuracy long-term orbit and clock prediction products are now uniformly available across the GPS, GLONASS and BeiDou constellations. In Q2/2014, BeiDou support will also extend to GPStream PGPS™ - Rx Networks' popular synthetic A-GNSS software that has been deployed in over 100 million smartphones and personal navigation. *www.prweb.com*

Hemisphere GNSS announces Glonass functionality

All Professional level Vector products of Hemisphere GNSS, including the V103, V113, VS131, and VS330 now include the ability to utilize the GLONASS Satellite system, along with the GPS Satellite system in the navigation solution. Vector Technology uniquely processes L1 GPS and GLONASS signals to deliver precise heading, greater positioning reliability, and improved performance in challenging environments. Hemisphere GNSS' patented Vector technology computes the heading and pitch or roll angle while stationary or in motion allowing for heading accuracy of up to 0.01 degrees depending upon the product selected. A variety of differential correction methods also make it possible for Vector products to provide sub-meter to centimeter level RTK position accuracy. *www.HemisphereGNSS.com*

Indian aircraft would have to upgrade avionic systems soon

All Indian aircraft would have to upgrade their avionic systems soon to match with India's own satellite-based navigation system GAGAN. If the airlines can take advantage of GAGAN system by equipping their aircraft with matching avionics, almost USD 10 million worth of jet fuel could be saved annually, Civil Aviation Secretary Ashok Lavasa said.

He was indicating at the fact that a lot of fuel could be saved as the GAGAN system would help pilots navigate in all- weather conditions by an accuracy of up to three metres. It would enable an aircraft to fly on a specific path between two three-dimensional defined points, straighten routes and reduce fuel burn. Such a capability would also help in landing an aircraft in tough weather and terrain. The Secretary also said that air navigation service (ANS) providers and aircraft operators would be required to work together and co-ordinate investments in the GNSS technology. Maintaining that India was poised to become the third largest market in terms of air traffic growth, he said satellite navigation technology was the vision of future and GAGAN was an essential cornerstone to future safety. *http://articles.economictimes.indiatimes.com*

iXBlue launches octans nano

iXBlue has launched OCTANS NANO, a compact FOG-based (fiber optic gyroscope) gyrocompass and attitude sensor system for subsea use. It is optimized for lower total cost of ownership and ease of export (no ITAR components). It addresses closely the critical needs of market segments in ROV navigation and attitude monitoring of subsea structures. It is not only robust but smaller and lighter than any available product of its type. *www.ixblue.com*

CompassCom unveils CompassLDE Connector

CompassCom has introduced the CompassLDE Connector for the Esri ArcGIS GeoEvent Processor, allowing organizations to track the locations and status of their mobile resources – vehicles, smartphones, and other GPS-enabled assets – in real time on their Esri ArcGIS 10.2 platform. *www.compasscom.com*

VERIPOS upgrades its Global Network of Reference Stations

VERIPOS is concluding the upgrade of its entire global network of GNSS reference stations with high performance multi frequency GPS/GLONASS/Galileo/BeiDou receivers from Septentrio. It owns and operates a network of over 80 reference stations worldwide that is used to determine estimates of the orbit and clock errors of multiple GNSS satellite constellations. VERIPOS uses these estimates to calculate corrections which are then broadcast to end users to significantly improve the accuracy of positioning using Septentrio PolaRx4 reference receiver that provides high-quality tracking and measurement of all available and upcoming GNSS signals.

The upgrade of the VERIPOS global network of reference stations with the latest Septentrio reference receiver technology is another outcome of the multi-year collaboration between the two companies. *www.septentrio.com*

UoSAT-2 clocks up an outstanding 30 years of in-orbit operations

Surrey Satellite Technology Ltd and the Surrey Space Centre are celebrating a remarkable thirty years of in-orbit operations from one of its earliest satellites, UoSAT-2, which was launched on a Delta rocket on 1st March 1984 from the Vandenberg Air Force Base in the USA.

UoSAT-2, the second satellite in a long history of 41 missions launched by SSTL to date, has always held a special significance and has remained

Trimble News

New eCognition software

Trimble eCognition software is a powerful solution for the analysis and extraction of information from geospatial data collected via aerial, satellite and mobile mapping platforms. With eCognition 9, users can define objects graphically to streamline the template creation process. These templates are used to automatically identify objects of interest in imagery. In addition, Remote Sensing and GIS professionals can now integrate data layers more efficiently through improved GIS tools within eCognition 9.

Online information management platform launched

Trimble has introduced the InSphere™ platform for geospatial information management. An innovative approach for central management of geospatial operations, Trimble InSphere improves workflow, maximizes efficiency and transforms the way geospatial professionals work and access critical operational information. It is a cloud-based software platform for central management of geospatial applications, data and services. *www.trimble.com* a constant in the company's evolution from University spin-off to world-leading small satellite manufacturer. Today, UoSAT-2 still transmits its VHF telemetry on a regular 11-day cycle and the on-board real-time clock still tells the time – although running somewhat late! *www.sstl.co.uk/news-and-events*

The FARO® Laser Scanner Focus3D X 130

FARO Technologies has released new FARO Laser Scanner Focus3D X 130. It is the newest member of FARO Laser Scanner Focus3D X Series range of laser scanners delivers tremendous power, compact design, and the flexibility to perform laser scanning in both indoor and outdoor. With a scanning range of 130 meters, this laser scanner is ideal for mid-range scanning applications such as architecture, BIM, civil engineering, facility management, industrial manufacturing, forensics, and accident reconstruction. *www.faroasia.com/LaserScanner/in*

Leica News

ComGate10 launched

As integral part of Leica Geosystems' mobile communication solution M-Com, ComGate10 is the first plug and play router on the market that offers users fast and fail-safe wireless data transfer, with the added benefit of a secondary back-up communication type for total security. It is fully compatible with all Leica Geosystems monitoring sensors and software, and can enhance the functionality of Leica Nova sensors.

GeoMoS Adjustment v1.7

Leica GeoMoS Adjustment, the network adjustment add-on for the successful Leica GeoMoS monitoring software, is intended for use in projects where the most precise and reliable information on structural movement is required. The latest version now makes adjusted data available everywhere at any time on Leica GeoMoS Web. The computation processing time has also been significantly improved to provide movement analysis with adjusted data as quick as possible. *www.leica-geosystems.com*

GNSS Signal Simulator Supports a Wide Range Of PNT Testing

Spectracom announced its program to develop robust applications-specific testing solutions. The program fills the technology and expertise gap in providing customers in a variety of industries the tools to perform more comprehensive qualification of their mission-critical systems. Examples include: multi-constellation (GPS, GLONASS, Galileo, BeiDou) simulation; integrated MEMs/INS testing; Interference Detection and Mitigation (IDM) verification; assisted-GNSS (A-GPS) validation, HIL testing for automotive applications; high dynamic platform simulations for aerospace and defense (UAVs, UASs); and precision agriculture/surveying testing via RTK/differential measurements.

New HydroFusionTurbid Water Module for CZMIL by Optech

Optech released HydroFusion Turbid Water Module, a powerful new tool that enables the Optech CZMIL Coastal Zone Mapping and Imaging Lidar to collect bathymetry data in water conditions that were previously impossible to capture. The Turbid Water Module is an addition to the Optech CZMIL HydroFusion workflow specifically designed to detect and extract bathymetry measurements from turbid, shallow waters and muddy, less reflective seafloors, areas where previous lidar bathymeters could not extract depth measurements. Combined with the advanced hardware of the Optech CZMIL, it has successfully made seafloor measurements from very shallow waters (depth <1-2 m) in highly turbid conditions (Kd >0.5 m-1) with dark, muddy bottoms (reflectance = 3-5%). *www.optech.com*

F4 Tech releases SilvAssist Cloud

F4 Tech have released SilvAssist Cloud, an innovative cloud based business support system for reporting, analysis, growth & yield modeling, and management of forest inventory data. It allows users to easily share data throughout an organization, model growth & yield; simulate harvest, thinning and regeneration activities; create configurable reports and provide a centralized repository for all of your inventory documents and data. *www.thinkf4.com*

Spirent GSS9000 Simulator

Spirent Communications has announced the introduction of the Spirent GSS9000 Multi-Frequency, Multi-GNSS RF Constellation Simulator. The GSS9000 offers a new benchmark in performance, capability and flexibility that includes the ability to simulate signals from all GNSS and regional navigation systems.

The GSS9000 offers new levels of performance, enabled by a four-fold increase in system iteration rate (SIR) over Spirent's current GSS8000 product. The GSS9000 SIR is 1000Hz (1ms), enabling higher dynamic simulations with even more accuracy and fidelity. It also includes support for restricted and classified signals from the GPS and Galileo systems as well as advanced capabilities for ultra-high dynamics.

UK. Digital Yacht launches news sensor for PCs and MACs

Digital Yacht has introduced a new variant of their DualNav GPS and GLONASS positioning sensor which utilises a USB interface for both data and power allowing direct connection to a PC or MAC. Called the GPS150USB, it's designed for a growing group of boat owners who use a PC or MAC for electronic charting and navigation rather than a traditional plotter. *www.bymnews.com/news/*

TopNETlive Fastest Growing GNSS Network Service in North America

Topcon Positioning Group announces the expansion of its TopNETlive network service into nineteen states and five Canadian provinces, making it the fastest growing DGPS and RTK network service in North America.

TopNETlive utilizes a dense network of ground-based reference stations that are capable of supporting all major GNSS satellite constellations to provide the highest accuracy with the fastest initialization time. *topnetlive.com*

Antenna designed for high-precision GNSS

Imec and Septentrio have collaborated to the design of an antenna-RF integrated element of a multi-frequency GNSS antenna for GPS, GLONASS, BeiDou and GALILEO. Developed under the European Community's Seventh Framework Programme project HANDHELD, the compact antenna can be integrated in multi-frequency handheld GNSS devices for high precision location applications (up to 1 centimeter).

Carlson Software's MINI2

Carlson Software's newest data collector, the Carlson MINI2, packs a punch for its compact size. The new handheld computer is taking the place of its predecessor, the Carlson MINI.

With an IP68 rating, the MINI2 is waterproof and dustproof, and is tested to MIL-STD-810G to meet the environmental demands of the surveying industry. The MINI2 also has several advancements over the MINI, including a bright display, a custom battery that lasts 20+ hours on one charge, and a scratch-resistant capacitive touchscreen with glove-friendly numeric keypad, for faster and more accurate data entry.

Photo Science, Awarded NOAA Shoreline Mapping Contract

Photo Science, a Quantum Spatial company, was recently awarded a multi-million dollar, 5-year, Indefinite Delivery Contract to provide the National Oceanic and Atmospheric Administration (NOAA) with Shoreline Mapping Services. This contract is in support of the National Geodetic Survey's (NGS) Coastal Mapping Program, Aeronautical Survey Program, and Vertical Datum update (GRAV-D). *shoreline.noaa.gov*

MARK YOUR CALENDAR

May 2014

IEEE/ION Position Location and Navigation Symposium
5 – 8 May
Monterey, CA
www.ion.org

Annual Baska GNSS Conference
7 – 9 May
Baska, Krk Island, Croatia
renato.filjar@rin.org.uk

MundoGEO Connect 2014
7 – 9 May
Sao Paulo, Brazil
http://mundogeoconnect.com/2014/en/

AUVSI 2014
12-15 May
Orlando, Florida, USA
www.auvsishow.org/auvsi2014/public/enter.aspx

GNSS: Principles, Augmentations and Evolutions of EGNOS
12-23 May
Toulouse, France
sandrine.castiglioni@enac.fr

The 5th China Satellite Navigation Conference
21-23 May
Nanjing, China
http://www.beidou.org/english/index.asp

GEO Business
28 – 29 May
London, UK
www.geobusinessshow.com

June 2014

Hexagon Conference 2014
2 – 5 June
Las Vegas USA
http://hxgnlive.com/

5th International Conference on Cartography and GIS
15 – 21 June 2014
Riviera, Bulgari
http://iccgis2014.cartography-gis.com/Home.html

ION Joint Navigation Conference 2014
16 – 19 June
Orlando, United States
www.ion.org/jnc

INSPIRE Conference
16-20 June 2014
Aalborg, Denmark
http://inspire.jrc.ec.europa.eu/events/conferences/inspire_2014/

XXV FIG Congress
16 – 21 June
Kuala Lumpur, Malaysia
www.fig.net

International Congress on Remote Sensing and GIS
25-27 June 2014
Casablanca, Morocco
http://siggtcasablanca.univcasa.ma/

July 2014

AfricaGEO 2014
1 - 3 July
Cape Town, South Africa
www.africageo.org

GI Forum 2014
1 – 4 July 2014
Salzburg, Austria
www.gi-forum.org

Esri International User Conference
14 – 18 July 2014
San Diego, USA
www.esri.com

September 2014

ION GNSS+ 2014
8-12 September
Tampa, Florida, USA
www.ion.org

October 2014

Second symposium on service-oriented mapping
6 - 8 October
Hasso Plattner Institute at University of Potsdam, Germany
http://somap.cartography.at

INTERGEO 2014
7 - 9 October
Berlin, Germany
www.intergeo.de

ISGNSS2014
22 - 24 October
Jeju Island, Korea
www.isgnss2014.org

35th Asian Conference on Remote Sensing
27-31 October
Nay Pyi Taw, Myanmar
www.acrs2014.com

November 2014

Trimble Dimensions 2014
3 - 5, November
Las Vegas, USA
www.trimbledimensions.com

5th ISDE Digital Earth Summit
9 - 11 November
Nagoya, Japan,
www.isde-j.com/summit2014/

11th International Symposium on Location-based Services
26 -28 November
Vienna, Austria
www.lbs2014.org/