UNITED
NATIONS

E

Economic and Social Council

Distr.
LIMITED

E/CONF.89/INF/16
14 January 1997

ORIGINAL: ENGLISH

FOURTEENTH UNITED NATIONS REGIONAL
CARTOGRAPHIC CONFERENCE FOR ASIA
AND THE PACIFIC
Bangkok, 3-7 February 1997
Item 6 (h) of the provisional agenda*

REPORTS ON THE CONTRIBUTION OF SURVEYING, MAPPING AND
CHARTING TO SUPPORT THE IMPLEMENTATION OF AGENDA 21:
OTHER APPLICATIONS OF SURVEYING AND MAPPING TO SUPPORT
THE IMPLEMENTATION OF AGENDA 21

Integration of 3S Technologies; Remote Sensing, GIS and GPS**

(Submitted by the Secretariat)

---

* E/CONF.89/1.

** Prepared by Mr. Shunji Murai, First Vice-President, International Society for Photogrammetry and Remote Sensing (ISPRS), Institute of Industrial Science, University of Tokyo and Mr. Lawrence W. Fritz, President, International Society for Photogrammetry and Remote Sensing (ISPRS), Lockhead Martin Corporation, Rockville, MD.

97-01068 (E) 200197 210197

/...

Integration of 3S Technologies; Remote Sensing, GIS and GPS

Shunji Murai and Lawrence W. Fritz***
**First Vice President, International Society for Photogrammetry and Remote Sensing (ISPRS)*
Institute of Industrial Science, University of Tokyo
7-22-1 Roppongi, Minatoku,Tokyo 106 Japan
***President, International Society for Photogrammetry and Remote Sensing (ISPRS)*
Lockhead Martin Corporation
14833 Lake Terrace, Rockville MD 20853-3632, USA

ABSTRACT

So called 3S technologies of remote sensing (RS), geographic information system (GIS) and global positioning system (GPS) are being highlighted in geoinformatics, multi-disciplinary science that replaces the conventional disciplines such as surveying, photogrammetry, cartography, geodesy etc.

The paper demonstrates the present and future applicability of integrated system derived from combination of two or all 3S technologies.

INTRODUCTION

Geoinformatics is defined as multi-disciplinary science to measure, record, process, analyse and represent geospatial data. Geoinformatics is well supported by 3S technologies; remote sensing, GIS and GPS. Any two combinations of 3S technologies; remote sensing and GIS, remote sensing and GPS, and GIS and GPS will create a new technology or market. All combinations of 3S technologies will also create new technologies. Remote Sensing provides with multi-spectral, multi-resolution, multi-temporal and multi-sensor imagery of latest condition of environmental and natural resources. GPS/INS (inertia navigation system) provides positioning/orientation (or called attitude) of remote sensors used. GIS refers to information technology or information system of geospatial database or its utilization for decision support.

The concept of integrated 3S technology system is shown in Figure 1.

1. Integration of Remote Sensing and GIS

a. Integration of Satellite Imagery and GIS

In Asia, GIS for natural resources management is a key issue, in which remote sensing with satellite imagery plays an important role to provide with latest information about the land conditions in the form of land use map, soil map, forest map etc. However, information extracted from satellite imagery is only a part of many information requested in GIS. Nevertheless remote sensing is recognized as an essential data source, because there is no map available sometimes or the existing maps are out of date.

/...

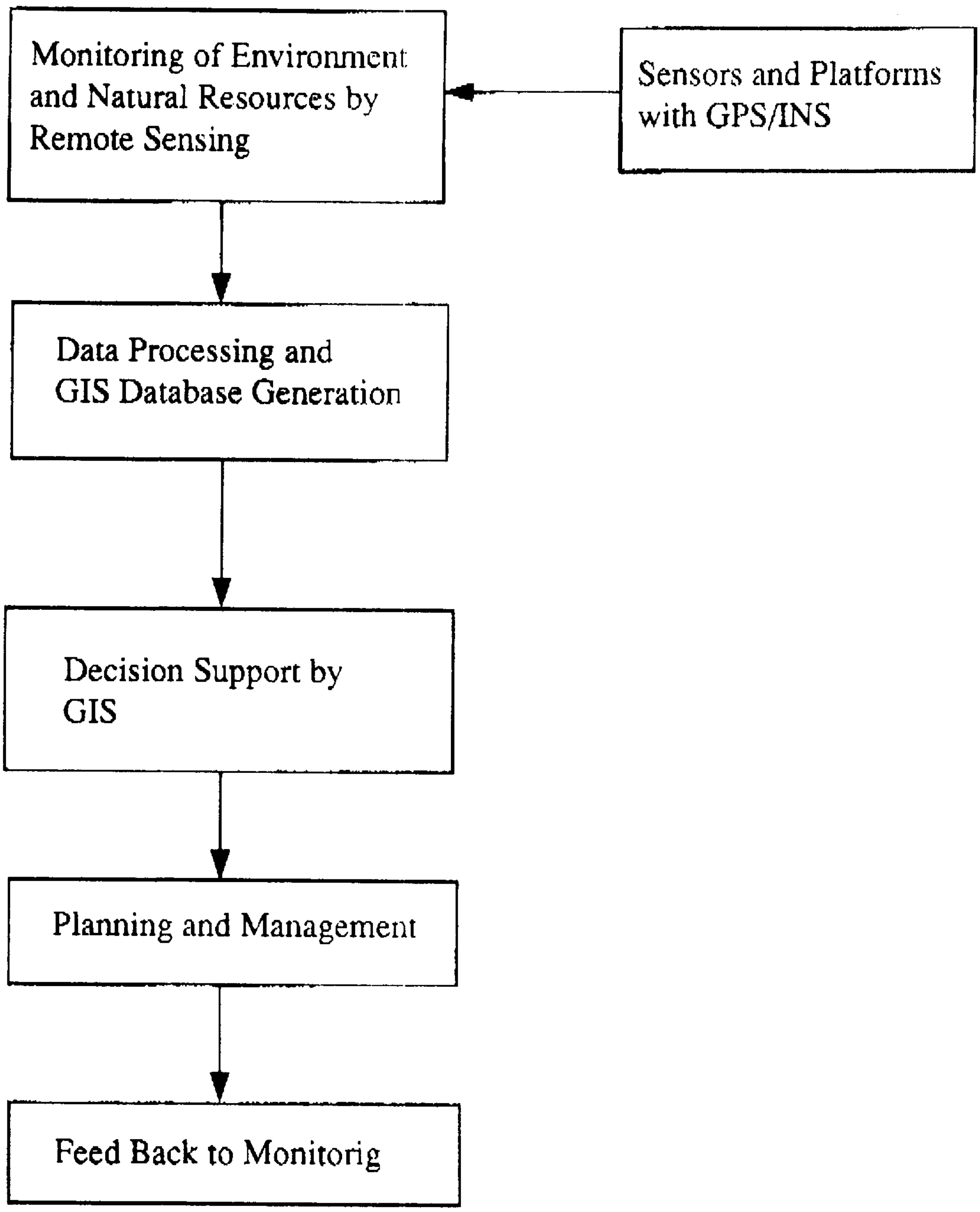

Figure 1 The Concept of Intergrated 3S Technology System

/...

Up to now, the resolution of satellite images is limited to provide the map scale to 1:100,000 as shown in Table 1. However as high resolution satellite data with 1 m resolution will be available in 1997 as shown in Table 2, the map scale up to 1:10,000 at most will become possible. Stereo function of high resolution will enable map makers to produce 1:25,000 topographic map with 10 meter contour interval.

GIS for natural resources management using remote sensing includes the following applications.

- Suitability study on landuse and agricultural development
- Watershed management
- Disaster analysis including soil erosion, flood, drought and other natural disasters
- Crop acreage monitoring and prediction of crop yield
- Urban environmental change detection and urban planning

Table 1 Requirement of Resolution and Accuracy for Map Production

Scale	Pixel Size	Height Accuracy/Contour	Planimetric Accuracy
1:250,000	25.0	±33.3 /100	±75.0
1:100,000	10.0	±13.3 / 40	±30.0
1:50,000	5.0	± 6.7 / 20	±15.0
1:25,000	2.5	± 3.3 / 10	± 7.5
1:10,000	1.0	± 1.3 / 4	±3.0

b. Integration of digital photogrammetry and GIS

If remote sensing can be defined as a technique to extract information from images, digital photogrammetry will be a part of remote sensing, because it provides automatically or semi-automatically information with about digital elevation model (DEM) as well as man made features such as roads and buildings. Automated DEM generation by digital photogrammetry has almost completed the algorithm. However automated extraction of man made features, for example, of roads and building has not yet accomplished, though many algorithms using advanced image understanding techniques are being developed in combination with CAD or reverse engineering by many scientists.Therefore automated interpretation, that is image understanding to extract meaningful information from digital images would be a breakthrough for digital photogrammetry.

2. Integration of Remote Sensing and GPS

Positioning and orientation of a remote sensor or the platform are most important parameters to reconstruct the geometry of a ray connecting between an object on the ground, sensor and the corresponding image. In particular, line scanner such as pushbroom or mechanical scanner has time-constrained function of the position and attitude, which makes difficult to determine analytically the orientation parameters with ground control points. In this regard, an integrated system with GPS for positioning and INS for orientation will be a strong tool to support remote sensing for both topographic and thematic mapping. GPS/INS supported remote sensing is generally useful for any type airborne or vehicle borne sensors such as digital camera, laser scanner, three line scanner and so on.

Table 2 Super High Resolution Satellite Imagery

Earth Watch	Orbital Sciences	Space Imaging
July 1997	Dec. 1997	Dec. 1997
Quick Bird	Orb View-1	CRSS
PAN:1m/2m 11bit 3.5GB 36x36km MSS:4m 4bands 11bit 14.2GB 36x36km	PAN:1m/2m 8bit 128MB 8x8km MSS:4m 4bands 8 bit 128MB 8x8km	PAN:1m 11bit TBA 60x60km MSS:4m 4bands 11bit TBA 60x60km
σ xy(GCP) 02m without GCP - σ z(GCP) 03m without GCP -	02m 12m 03m 08m	02m 12m 03m 08m
In track $\pm 30^\circ$ Star Trackers 100scenes/orbit	In track $\pm 45^\circ$ Star Trackers 535scenes/day	In&Cross track $\pm 45^\circ$ Star Trackers 600scenes/day

/...

Table 3 shows the specification of a GPS/INS supported airborne three line scanner that is being developed by Core Co., Ltd, Japand and the author.

Air borne laser scanner is now available to measure the height between an aircraft and the ground or water surface. This sensor will be useful to measure the ground surface of a coast as well as buildings.

Airborne profiler is also used to measure the sea/water depth with use of two different wavelengths of laser beam near infrared and green, one of which will be reflected from the water surface, while the other will be reflected from the bottom.

Spaceborne laser altimeter will provide $\pm$ 10cm accuracy of DEM of the ocean, by which the geoid can be estimated. Auto-tracking of targets on a floating platform on the sea is possible using laser total station with a digital camera. This system can be reverse, that is, laser total station set up on a floating platform on the sea can track two fixed reflecting mirrors on the ground, which can determine the positioning of the platform in real time.

Synthetic aperture radar imagery will give various information of the surface such as roughness by means of texture of radar images and wind direction and speed to be estimated from intensity of back scattering. SAR image also delineates clearly the distribution of boats/ ships in a bay or harbor area. SAR is also used to identify sea ice/icebery.

SAR interferometry (called In SAR) is a new technology to produce DEM as well as to detect height deformation occured by earthquakes or volcanic eruptions.

3. Integration of GIS and GPS

A lot of field works are conducted with topomaps and satellite images for environmental investigation, land use survey, ground truth survey, disaster damage survey etc. However positioning of the current points is sometimes missing. Even many photographs taken at the sites are not well identified the location and direction of the photography. In such case GPS will be very useful to support the field works with the precise location (latitude and longitude) as well as the exact time.

Table 3 Specification of Airborne Three Line Scanner

Devices	Performance
Camera	70 mm Camera
Lens	64 mm Focal length
CCD	3 lines by 7,500 elements
Stereo angle	$\pm$22.5 degree
Positioning	Kinematic GPS
Orientation	INS
Data Recorder	30 M bytes per second
Gray Scale	10 bits

/...

Konica Co.,Ltd, a Japanese camera maker has recently developed a GPS camera called Landmaster by which date, time, latitude, longitude and the bearing from the north in which direction the picture was taken will be recorded at the upper of a frame. It would be remarkably useful to collect GIS data at the site. When such a GPS camera becomes digital camera type in future, a simplified mapping system will be developed, which is expected to replace the plane table mapping.

Car or ship navigation with GPS and electronic map or chart is one of the integrated systems of GIS and GPS. It can be combined with real time vehicle or ship information so that the users will get a better choice for optimum paths.

In Japan, the following GPS combined technologies have been already operationalized.
- Car navigation system with GPS
- Total station with GPS
- GPS camera
- Mobile mapping system with GPS/INS
- Navigation by electronic chart with GPS
- Airborne imaging with GPS/INS
- Continuous geodetic measurement with electronic GPS control towers.

4. Integration of 3S Technologies

3S technologies of remote sensing, GIS and GPS can be integrated for creating more powerful system for real time mapping or data collection.

A mobile mapping system is a good example of the integrated 3S technologies, in which digital cameras (remote sensing), GPS/INS, a computer system with electronic maps (GIS) and telecommunication devices such as mobile telephone to connect GIS database at the headquarters are equipped in a vehicle.

The mobile mapping system will allow the field operators in a car to collect geospatial data in almost real time or near real time, which will be input to GIS database. Two way communication between the site and the headquarters will be tremendous improvement for maintaining data quality as well as saving time and manpower.

CONCLUSIONS

Advanced technologies of remote sensing GIS and GPS will play a lot of roles for environmental and natural resources management. However the conventional systems will have to be modified, transfered or replaced by these new technologies smoothly. Otherwise advanced technologies will not be effectively operationalizd.

Remote sensing should be integrated with GIS and GPS, which will form so called 3S technology (RS, GIS and GPS) or geoinformatics. The authors judge that remote sensing has entered the third generation, when more variety of advanced technologies will be developed with multi-sensors, multi-functions and multi-clients.
