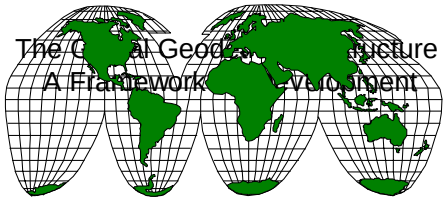
The Global Geodetic Infrastructure
A Framework for Development



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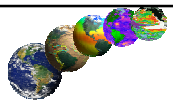
IGS - International GNSS Service
NASA/Jet Propulsion Laboratory, USA
19 April 2005
FIG Working Week, Commission 5
Cairo, Egypt

Introduction



- International GNSS Service (IGS) - formerly International GPS Service celebrates a decade - 1994-2004
- Services of International Association of Geodesy (IAG):
  - IGS, International Earth Rotation and Reference Sytem (IERS) International Laser Ranging Service (ILRS), International VLBI Service (IVS), International DORIS Service (IDS), International Gravity Field Service (IGFS)
  - International Terrestrial Reference System - part of IERS combines solutions of the Services for realizations of ITRF
- IAG initiates new program - Global Geodetic Observing System - GGOS approved by International Union of Geodesy and Geophysics 2003 (see Drewes et al.)
- GGOS official participant in ad-hoc Intergovernmental Group of Earth Observations (GEO), and actively engaged in defining the GEO System of Systems for long term Earth observations.

Introduction (2)

- Charter for the United Nations Office of Outer Space Affairs - Action Team on Global Navigations Satellite Systems:

"Using space applications for human security, development and welfare, action should be taken … to improve the efficiency and security of transport, search and rescue, geodesy, and other activities by promoting the enhancement of universal access to and compatibility of space-based navigation and positioning systems."

- Regional Workshops conducted - Lusaka July, 2002
  - AFREF directly discussed wth group of African experts
- UN GNSS Report and recommendations finalized December 2003
  - Report available from UN-OOSA
    - http://www.oosa.unvienna.org/SAP/gnss/index.html
- Recommendation - establish an International Committee on GNSS, ICG
  - Mechanism for coordination, see report
- Key project recommendation --> AFREF (next)
  - (See Wonnacott, and Kamamia)

UN-OOSA GNSS Action Team

Extract from Report:

Surveying, Mapping and Earth Science, Recommendation 1:

"Establish a continental reference for Africa, or African Reference Frame (AFREF), consistent with the International Terrestrial Reference Frame"

"A uniform coordinate reference system is fundamental to any project, application, service or product that requires some form of geo-referencing. Many developing countries, and particularly the African countries, would benefit greatly from a modern GNSS-based reference system that can be used for national surveying, mapping, photogrammetry, remote sensing, Spatial Data Infrastructure (SDI), Geographical Information Systems (GIS), development programs, and hazard mitigation (earthquake studies, fault motion, volcano monitoring, severe storms). Many existing national coordinate systems are based on reference figures of the Earth which are generally outdated and are restricted to a particular country, making cross-border or regional mapping, development, and project planning very difficult. ***A continental reference system for Africa should be organized through an international project, known as AFREF, with common goals and objectives throughout Africa, and with the commitment of African countries and the support of international partners***. The benefits of GNSS technology cut across applications and across countries. It is further emphasized that the importance of simultaneous development of information and communications technology (ICT) and related infrastructure is necessary for sustainable use of GNSS. Policy and decision-makers should be made aware of the ***critical importance of ICT*** to the successful utilization of GNSS."

GEOSS 10 Year Implementation Plan - Extracts

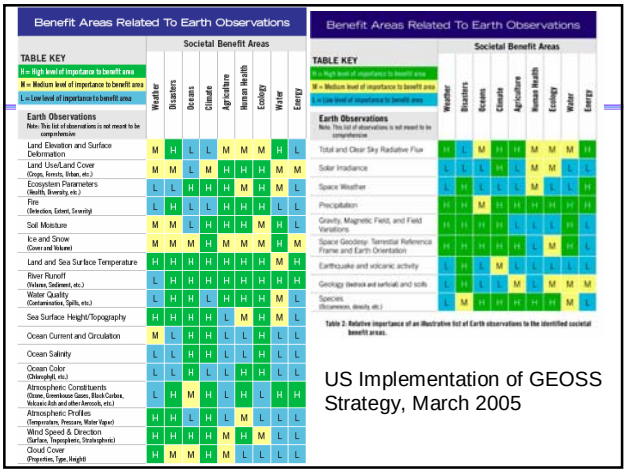
3.1 Purpose of GEOSS

- Reducing loss of life and property from natural and human-induced disasters;
- Understanding environmental factors affecting human health and well being;
- Improving management of energy resources;
- Understanding, assessing, predicting, mitigating, and adapting to climate variability and change;
- Improving water resource management through better understanding of the water cycle;
- Improving weather information, forecasting, and warning;
- Improving the management and protection of terrestrial, coastal, and marine ecosystems;
- Supporting sustainable agriculture and combating desertification;
- Understanding, monitoring, and conserving biodiversity.

4.1 Societal Benefit Areas

GEOSS will yield advances in the societal benefit areas defined by its purpose and scope. Each area has compelling reasons for the Earth observation advances envisioned in GEOSS.

For information needs common to many societal benefit areas, GEOSS will facilitate the provision of common products such as maps of topography, bathymetry, infrastructure, and land cover and land use, and a geodetic reference frame for Earth observation. Interpretation and use of Earth observations requires information on drivers and consequences of change, including geo-referenced socio-economic data and indicators.



US Implementation of GEOSS Strategy, March 2005

GNSS - Primary Framework

GNSS has significant positive benefit and promises considerable untapped potential for Surveying, Mapping and Earth Science applications.

- Geospatial data resources, in particular Geographical Information Systems (GIS), are used increasingly for decision making concerning economic, social, and development issues
- Geospatial resources are organized around the concept of spatial data infrastructure (SDI) which describes various assets or conditions based on their locations in space
- SDI must be based on a modern, globally consistent and accessible geodetic reference frame, *enabled by GNSS*, and applicable at local and regional levels
- GPS has successfully demonstrated the benefits of a common global reference infrastructure

Surveying & Mapping

- Surveying: satellite techniques provide a level of 3-D positioning accuracy and timing that is
  - highly efficient, instantaneous (depending on accuracies required, even near-real time at sub-decimeter level), and is very economical compared to conventional optical surveying techniques.
- Mapping: Maps, GIS, SDI, InSAR, photogrammetry - any imaging of the Earth requires
  - a geo-referencing system to be relevant
  - GNSS provides positioning information to relate mapping points or image objects to the local, regional (national) or global reference system, *including* spatial/temporal changes.
- Geoid and vertical datum must be included

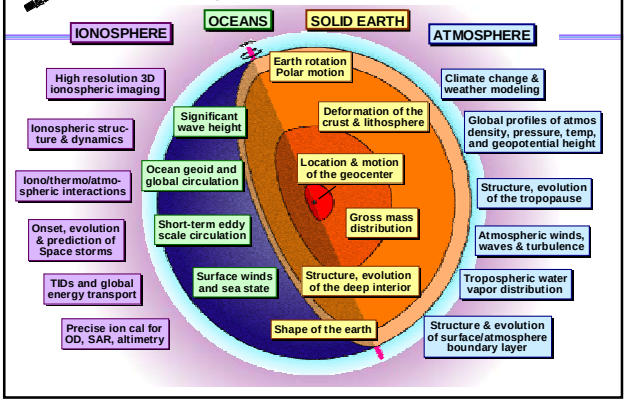
Surveying & Mapping

- Fundamental benefits of GNSS for Surveying &Mapping
  - Internationally accessible system provides positioning information that is related to the a common global reference frame, e.g., WGS'84 of the GPS, PZ90 of GLONASS all precisely related to the International Terrestrial Reference Frame 2000
    - WGS'84 is broadcast by the GPS satellites
    - WGS'84 and ITRF2000 have evolved together, and are virtually the same standard, being consistent at the ***few centimeter*** level - GPS has led to the extensive global densification of ITRF
    - The ITRF represents analytical rigorous combinations of multiple space geodetic techniques to realize the precise reference system of the Earth (combining VLBI, SLR, GPS, GLONASS, DORIS,...)
  - Maps and GIS tied to a global system (via GNSS) with common standards of SDI can be immediately related *even if independently produced*

Earth Science Applications

- GPS as the first fully operational GNSS has enabled development and demonstration of novel applications that benefit society
  - Solid Earth, Oceans, Atmosphere and Ionosphere are all explored with GPS technology
- UN workshops of UNISPACE with GNSS focus mostly on aspects of
  - Disaster management, hazard monitoring and mitigation
    - Earthquakes, landslides, bridge and dam deformation, sea level change, subsidence
  - Climate change, atmospheric applications, weather forecasting, severe storm predictions

Probing the Earth with GPS/GNSS



Considerations

- Generalized issues:
  - Great need for education and training on GNSS technology and applications for surveying, mapping and Earth science
    - Workshops and in-depth technical exchanges necessary
  - Developing nations request assistance to:
    - Procure, implement and operate GNSS equipment, processing *and* communication systems, with emphasis on sustainable systems
    - Establish GPS-based control points, precisely locatable
    - Develop coordinate systems consistent with modern ITRF
      - transformations from national horizontal and vertical datum to modern 3-D national continental datum based on the global reference system - challenging - National Mapping Organizations critical lead here
    - Fully integrate GNSS as the precise geodetic base of SDI for GIS
  - All GNSS must operate in identical reference *and* timing systems
    - Interoperability between GPS, GLONASS and future Galileo, the European GNSS System slated for first launch 2008

Recommendations

- Many national mapping organizations base their fundamental operations now on GPS - this will evolve as GNSS develops.
- Governments should therefore be encouraged to:
  - Establish national plans for GNSS with user support groups and access to 'experts', coordinate regionally and internationally
  - Provide for long-term protection of the GNSS signal spectrum through collective action and voice, e.g. interference detection, mitigation and reporting; and World Radio Conferences (WRC) participation
  - Maintain close contact with countries and international organizations which are developing GNSS technology for geodetic and cadastral surveying, mapping, geological surveys, marine navigation, and so forth
  - Provide financial incentives that stimulate private investment in GNSS (e.g., reduce or eliminate import taxes)

Africa - AFREF

- Establish a continental reference system for Africa (including vertical), fully consistent within the ITRF framework through an international project concept *'AFREF'* that will
  - Use GPS/GNSS as primary tool
  - Standardize and modernize 50+ national datums to utilize GNSS across Africa - common developed & accepted continental grid
  - Adopt the internationally accepted conventions, standards and procedures of the International Association of Geodesy, through the ITRF and the International GNSS Service (IGS)
  - Similar projects or initiatives needed on national level: India, Bangladesh, Viet Nam, others
  - SIRGAS (South America) and EUREF (Europe) are very successful models for these projects
- International assistance and partnerships for developing nations

Summary

- AFREF shows tremendous potential to utilize state of the art technology, 'leap-frogging' development stages
- IAG committed to support especially through the relevant geodetic Services
- Decade long project to last for much longer
  - ***Sustainable for future generations***
- Looking forward to return to amazing Africa!

AFREF Extended Steering Committee Meeting Cairo April 18, 2005

Backup Slides

Earth Science Applications

- GPS impact on Earth Science is remarkable -
  - "GPS was the most productive space system, providing 1.0% of world scientific return." (Science News Metrics 2000)
- Discover Magazine (next slide, March 2002) highlights the growing interest and use of GPS technology for science and engineering
- Interoperable GNSS of the future will strengthen our ability to monitor the Earth and global change


Discover
SCIENCE'S FAVORITE NEW TECHNOLOGY
GPS
BY KATHY A. SVITIL PHOTOGRAPHY BY TOSHIO SHIBATA
HOW DID WE TRACK OCEAN WHIRLPOOLS, MONITOR VOLCANOES, PREDICT EARTHQUAKES, AND WATCH SUSPENSION BRIDGES BEND BEFORE GPS?