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GNSS Developments and Applications in Pakistan

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GNSS APPLICATIONS IN PAKISTAN

- Introduction
- GNSS R&D Projects
- Applications of Differential GNSS
- GNSS Education and International Cooperation

Introduction

- **Owing to the benefits of GNSS based PNT, accuracy, stability and ease of use, like all other countries of world, a number of governmental organizations, universities and private enterprise have initiated R&D programs for design, development and application of GNSS technology in almost every sphere of life in PAKISTAN**
- **This talk covers a few of these activities to highlight the status of GNSS related research and applications development for the socio economic benefits and improved quality of life of Pakistani community**

GNSS R&D Projects

- **Two GNSS related Research Projects are selected as an example, as they will be applied across Pakistan**
  - **Geoid (Gravity) Model Development for Pakistan**

    (Courtesy: M. Sadiq, Z. Ahmad and G. Ahmad, Dep. Of Earth Sciences, QAU Islamabad)
  - **RTK based Differential GNSS Network**

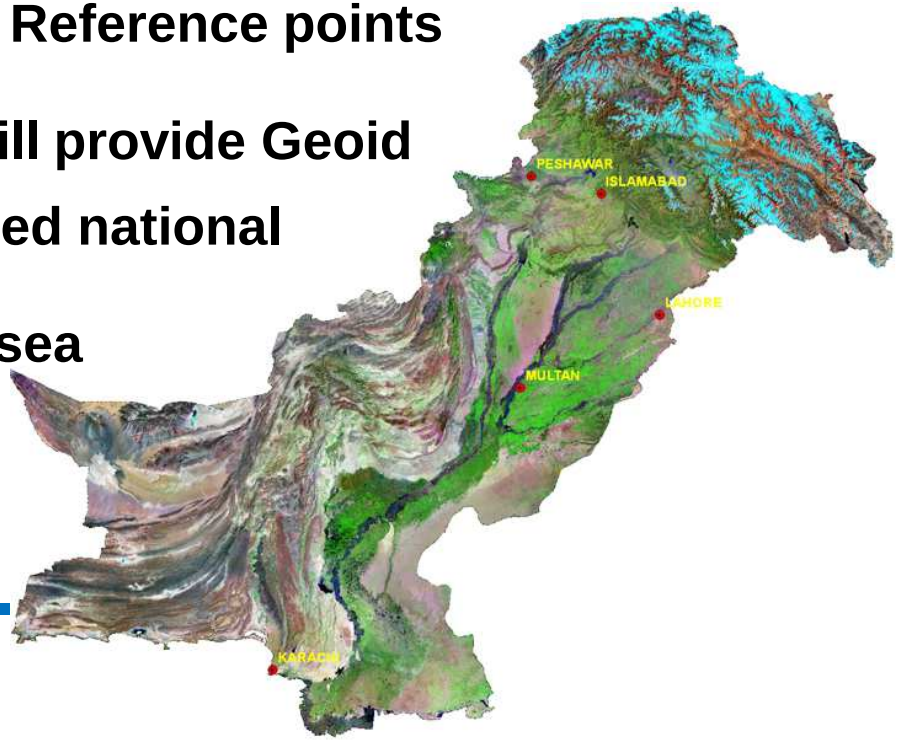
    (Courtesy: Z. Jamal, Manager (GNSS), SUPARCO)

DEVELOPMENT OF GEOID MODEL FOR PAKISTAN

- **Faculty of Earth Sciences, Qauid-e-Azam University, Islamabad has initiated this project with the help of Survey of Pakistan**
- **The project is titled as "Development of Geoid (Gravity) Model for Pakistan"**
- **In this project, a "Software Suite" with data base has been developed and being extended to compute the Geoid Level estimate for given location in Pakistan**

DEVELOPMENT OF GEOID MODEL FOR PAKISTAN

- Pakistan has ~7,86,000 Km^2 area with vast irrigation planes, highest mountains in the world, rivers, deserts and ~1000 km long Coastal line
- National Positioning System have been evolved over the years, but that is not as accurate and does not have evenly distributed Control Reference points
- This Project, once completed will provide Geoid Level/Gravity estimate and unified national height system across land and sea



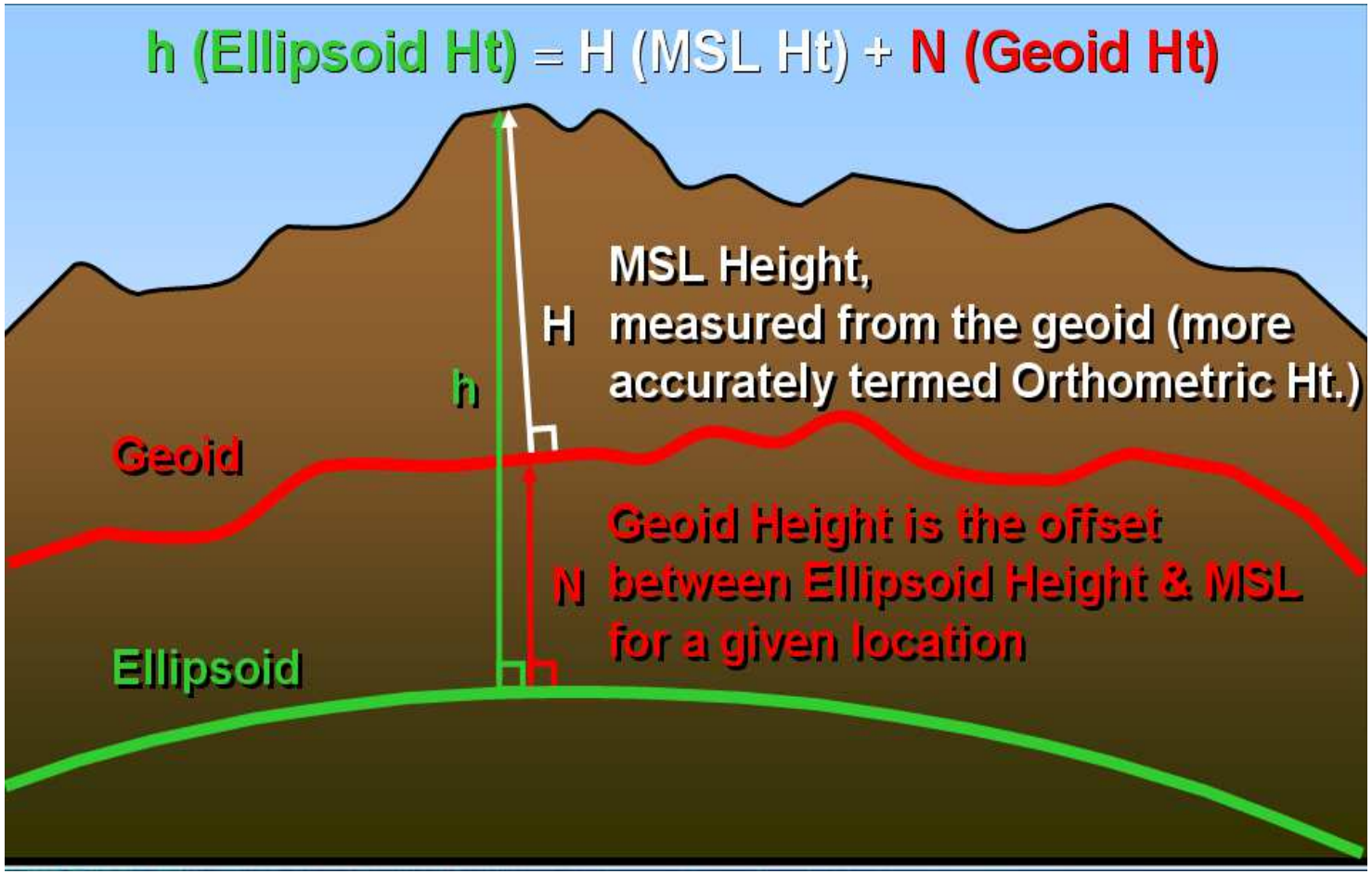
OBJECTIVES OF GEOID MODEL PROJECT

- To establish the reference of a particular ellipsoid with mean Sea level in Ocean and Land areas
- To help determine the accurate astronomical positioning, and deflections of vertical
- Besides the geometrical aspect of the Geoid it is also related to the gravity field of the Earth
- It is actually possible to calculate the gravity accelerations everywhere outside the Earth through analytical continuation if we know the gravity at the Geoid.
- Therefore, Geoid model could be used for high accuracy gravitational field model for that particular location

Major uses of Geoid model

- Better estimates of sea level and its variability
- Improved understanding of ocean currents
- More powerful tools to determine the sea and land ice thickness
- Monitoring of glaciers
- Ground water estimates
- Improved weather forecasts
- Unified national height system across states and regions
- Unified height system across land and oceans
- Improved accuracy of remote sensing data
- Consistent reference frames

Definitions of Geoid Surface

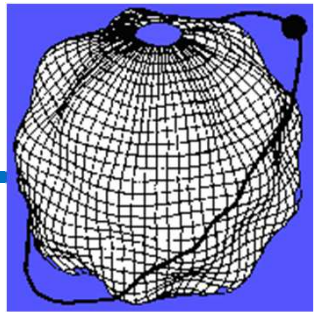


Geoid Model Research Work

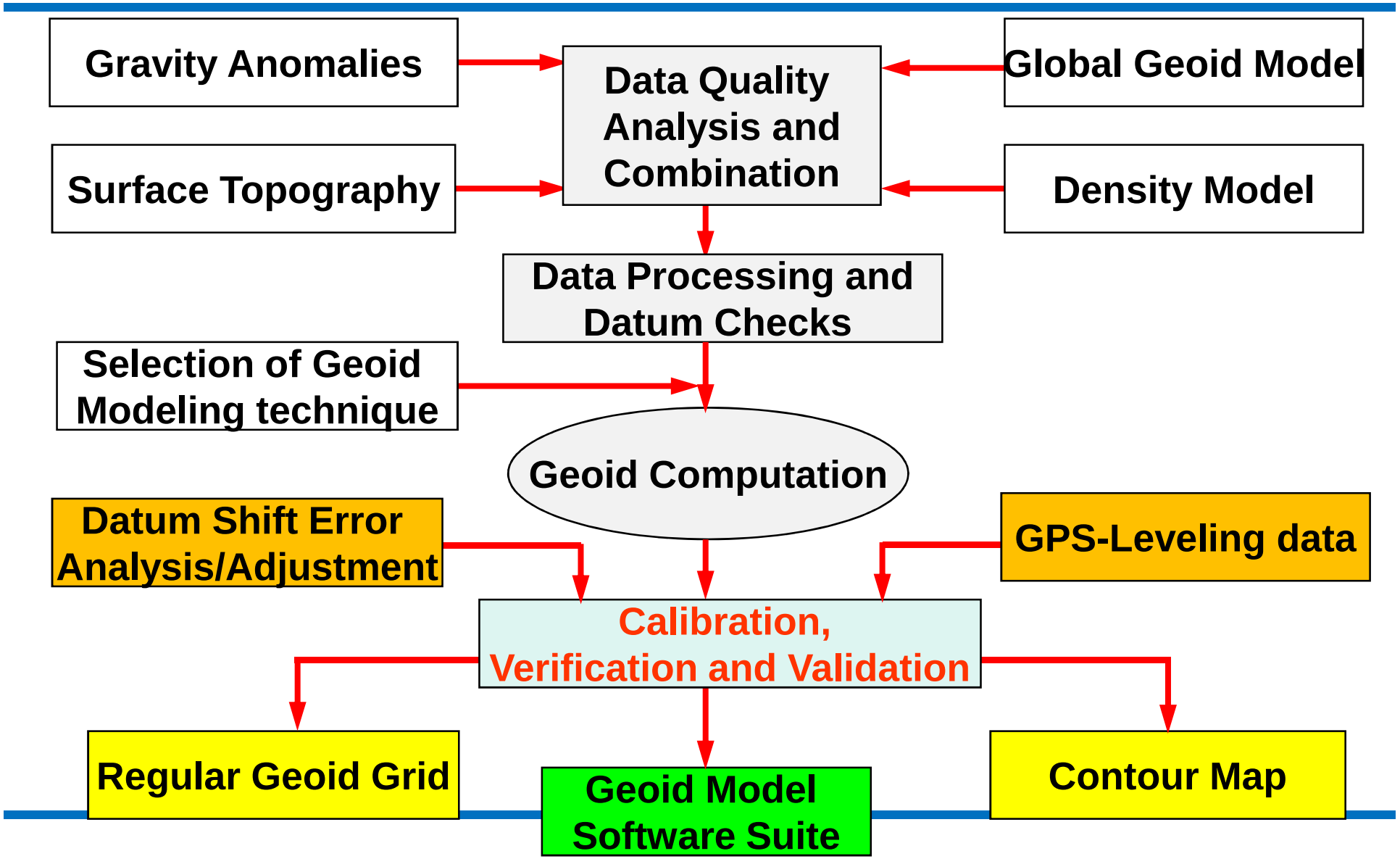
- The project involves the data acquisition, measurement, management and quality control of

    1. **Observed Gravity along with Elevation data**
    2. **Global gravity models**
    3. **Digital elevation models**
    4. **Precise GPS-Leveling data**

- The mathematical Geoid model development for Pakistan using above datasets.
- The calibration of the developed Geoid model using GPS-Leveling data



Generalized Flowchart for Geoid Model



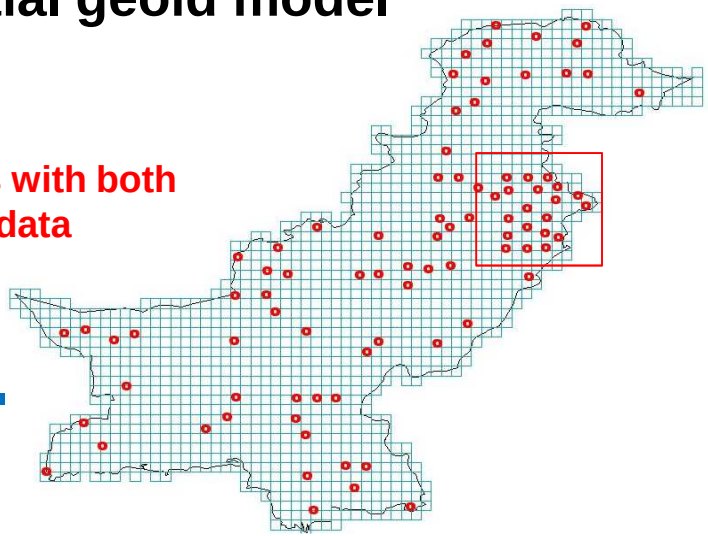
GPS-Leveling data Points

- **Benchmarks data points having both GPS and**

  Leveling data has been provided by Survey-of-Pakistan

- **The distribution of available data is not conforimg the requirement of calibration all over Pakistan**

- **A selected area with relatively better distribution of GPS-Leveling data has been used for an initial geoid model**



Data used for Geoid Modeling

- **Tens of thousands absolute gravity data points all over Pakistan with different distributions**
- **GETECH derived Bouguer anomalies covering Pakistan area with 5' x 5' grid interval**
- **Global geo potential model of earth e.g. EGM96, CHAMP and PGM2000, EIGEN-CGL04C etc**
- **Global Digital Elevation models with good resolution**
- **Most importantly, for calibration of Geoid with local vertical datum:**
- **GPS-Leveling data i.e. Latitude/longitude and Altitude above Ellipsoid and Mean Sea Level is used**

Comparison of Traditional Leveling and Leveling with Geoid Model using GPS

Conventional Leveling

- Traditional and well understood technique
- Time consuming and costly for maintaining as national vertical datum
- Datum is accessible only at benchmarks
- Not compatible with GPS
- MSL suffers from temporal variations and natural events e.g. earthquakes, uplift/ subsidence of land mass
- Large systematic errors
- Very costly

Geoid Model with GPS

- More complex to determine
- Quick and economical
- Datum does not require benchmarks
- Defined everywhere (land and water)
- Compatible with GPS
- More stable datum
- Some systematic errors
- Very cost effective

Multi-GNSS RTK based (CORS) Network

- **SUPARCO, space research agency of Pakistan is developing a pilot project for Multi-GNSS RTK Network to provide differential corrections to authorized users**
- **The Pilot Project based on Multi-GNSS RTK Network will provide differential corrections in-and-around Karachi city**
- **Reliable, Accurate, Robust and Economical Positioning Service**
- **This will be expanded with 80 to 100 base stations to provide country wide coverage**
- **The project will be backbone for providing common datum**

Current Situation in Pakistan

- There is very good GNSS (GPS/DGPS) technology infrastructure available and is utilized since the availability of GPS in Pakistan (1995)
- A number of govt. and private sector copanies are utilizing RTK/DGPS techniques
- Particularly in Surveying, GIS, mining and construction
- Each institution/company has its own reference station and rovers for precise positioning, thus expensive and limited services
- Technology is limited to fewer companies and institutions

Multi-GNSS RTK Network Pilot Project

- **Karachi is the largest city and financial capital of Pakistan with a population of 12 million**
- **The pilot project will provide RTK based Multi-GNSS differential corrections in an area of 70 km^2 covering Karachi and adjacent areas**
- **The adjoining areas in Arabian sea for marine/port applications will also receive correction signals**
- **A total 05 base stations along with central processing and station will be established**
- **The RTK pilot network is expected to be operational by year 2014**

Multi-GNSS RTK Network

- **Any authorized compatible Multi-GNSS receiver can use the correction signals over GSM/internet link**
- **Multi-GNSS differential corrections will be transmitted to rover GNSS receivers over a standard protocol RTCM 3.0**
- **The proposed accuracy level to be achieved by the GNSS rover receivers after incorporating corrections are as under:**
  - **2D Positioning accuracy: 2- 4 cm (Real time)**
  - **Altitude accuracy: ~ 8 cm (Real time)**
  - **<cm level accuracies through post processing**

Objectives of RTK (CORS) Network

- To provide fast, economical and accurate position, velocity and time services for authorized users on a variety of platforms
- To maximize the benefit of satellite based precise positioning and timing information for Pakistan
- Unfold the potential GNSS applications e.g., Common datum, up-to-date mapping infrastructure, modern technology in fleet management, mining, GIS, town planning and construction
- Enhance national scientific and technical capabilities
- Continuously model the effects of different error sources in the GNSS
- GNSS Measurements and Assessment (GMAS)

Differential GNSS Applications

- There is a variety of DGPS application areas in Pakistan:
  - National Survey of Pakistan
  - Search and Rescue (1122) / Disaster management
  - Vehicle monitoring and Fleet management
  - Meteorology/Weather Monitoring
  - Land information system
  - Scientific Date Acquisition and measurement
  - Agro farming
  - Waste Management System
  - Mining, Oil Exploration and construction

GNSS Applications: Agro-farming

- There are well established Companies provide DGPS Boundary Surveys for Agriculture Farming
  - High Accuracy Differential GPS Receivers based Field Boundary Surveys & Mapping
  - Mapping Software's to survey the boundaries and features of fields to within 1 meter accuracy
  - Surveying conducted by car, 4-wheel drive jeeps, or farm tractor, or any other means
  - Generate the digital map of fields in very short time
  - The software's are then assists in selecting and positioning the exact equipment to meet specific requirements.

GNSS Applications: Waste Management System

- **LAHORE is 2nd largest Metropolitan city and beautiful of Pakistan with a population of ~ 8 Million**
- **Lahore Waste Management Company (LWMC) conducts operation using GPS technology**
- **Android based gadgets (GPS equipped Tablets) are used by field operators, to provide real time geo-referenced waste images to Central Control Station**
- **Central Control Station directs nearest Garbage collection vehicle to collect the subject garbage in few tens of minutes**
- **After a short time, the field observers transmits again the cleared area images to Central Control Station for confirmation**

GNSS Applications: Waste Management System

- The efficiency and response time is analyzed and optimized using the recorded data
- All the waste collection vehicles and field observer gadgets are equipped with GPS receivers supported by GPRS network
- GPS technology has lead to better management, efficient and cost effective cleanliness of Lahore Metropolitan City
- In future, Multi-GNSS and RTK based network may further improve the accuracy and performance of LWMC

GPS/DGPS Applications: Oil Fields

- **Oil Field Exploration Surveys with DGPS provide sub-centimeter accuracy and site maps, access roads, land information:**
  - **Well location Survey Sara-A for Tullow Oil**
  - **Mariwah-1 Sulman Baloch for British Gas**
  - **Meting-1 Hydrabad for Tullow Oil**
  - **Gamat Block for British Gas**
  - **Pariwali -2 for POL**
  - **Pindori-4 for POL**
  - **Sara-B for Tullow Oil**
  - **Bolan Well for Premier Oil**
  - **Kandra-3 for Petroleum Exploration**
  - **Hassan-2 for Petroleum Exploration**

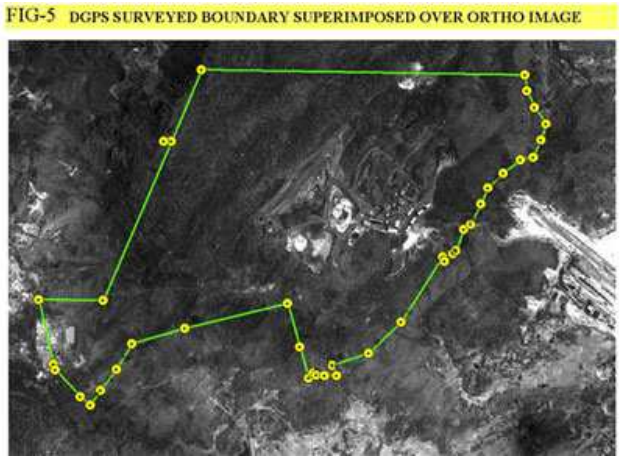


FIG-5 DGPS SURVEYED BOUNDARY SUPERIMPOSED OVER ORTHO IMAGE

DGPS Applications: Mining, Seismic Survey and Construction

- Establishment of GPS Control points for Seismic Survey at Sinjhoro Block, Distric Sanghar in Sindh Province
- Establishment of more than 300 GPS Control points along the alignment of M-1 Motorway, Islamabad-Peshawar section
- Establishment of GPS Control Network at Lowari Tunnel Site KPK Province
- Establishment of GPS Control Point network for Seismic Survey
- GPS Control Point Network in Neelum Valley Azad Kashmir
- GPS Control point network at GAMBAT Block, Ghauspur in Sindh Province
- More than 30 GPS control points for Eight water Dams in KPK Province

Education and International Cooperation

- **Education:**
  - **At Beihang University, a Pioneer Regional Centre in GNSS Technology Education and Training**
  - **A Number of Pakistani students are perusing their MS in GNSS Technology under MASTA Programs**
  - **Pakistani Professional GNSS Participated in 18 Day Training Workshop sponsored by APSCO at Peking University, Beijing in 2010**
  - **A number of Pakistani GNSS Professionals participated in GNSS Workshop at Beihang University in 2012**
  - **Master Program on Space Technology Applications for APSCO Members**
  - **Promoting research in GNSS Technology in Pakistani Universities**

Bilateral Collaboration and Exchange

- **Pakistan has signed an MoU with China Satellite Navigation Office (CSNO):**
  - **Satellite navigation cooperation meetings between China and Pakistan to jointly promote BeiDou/GNSS international popularization.**
  - **Promotion and Demonstration of BeiDou / GNSS Technology in Pakistan as part of BADEC program**
  - **Provide Support to Establish BeiDou/GNSS Measurement and Assessment (iGMAS) setup in Pakistan**

Bilateral Collaboration and Exchange

- The International Symposium on Food Security and Monitoring of Agriculture through Satellite technology, held during Sept. 21-24, 2010, Islamabad Pakistan
- Pakistan and China jointly arranged 1st BeiDou / GNSS Workshop at Karachi Pakistan in Sept. 2012
- UN/Pakistan Workshop on the Integrated use of Space Technology for Water and Food Security, Islamabad, Pakistan Feb. 2013
- Participation in International GNSS Conferences/ Symposiums/Workshops

Looking forward for Future Cooperation

- **NCP, Pakistan is interested in becoming a local partner for International GNSS exchange and training center :**
  - **Beihang University**
  - **Polytechnic Institute, Torino, Italy**
- **Promote Education and Training in GNSS technology by establishing GNSS research facilities**
- **Implement GNSS Curriculum at Pakistani Universities with help of UNOOSA**
- **NCP, Pakistan Organizes regularly an "International Conference on Applied Science and Technology (IBCAST)**
- **IBCAST Management has agreed to hold an Independent session on "GNSS, Applications and Integrated Navigation" in IBCAST'14 to be held in 2nd Wk of January 2014**

THANKS for Kind Attention!

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