GGOS Working Group on Ground Networks and Communication

GGOS Steering Committee Meeting

Perugia, Italy

July 8, 2007

Working Group Charter

- Develop a strategy to design, integrate and maintain the fundamental geodetic network of instruments and supporting infrastructure in a sustainable way to satisfy the long term (10 - 20 years) requirements identified by the GGOS Science Council. At the base of GGOS are the sensors and the observatories situated around the world providing the timely, precise, and fundamental data essential for creating the GGOS products. Primary emphasis must be on sustaining the infrastructure needed to maintain the evolving global reference frames while at the same time ensuring the support to the scientific applications' requirements. Opportunities to better integrate or collocate with the infrastructure and communications networks of the many other Earth Observations disciplines now organizing under GOESS should be taken into account.

GGOS Working Group
Ground Networks and Communications

- **Membership**: The Working Group has accumulated participants as topics have been addressed through its meetings and telecons. We have considered all of them to be members of the Working Group; some participate every week, some once in while. Some we don't hear from:

  Zuheir Altamimi, David Arnold, Yoaz Bar Sever, Norman Beck, Dirk Behrend, Wolfgang Bosch, Rene Ferland, Rene Forsberg, Richard Gross, Werner Gurtner, Steve Kenyon, Frank Lemoine, Linling Li, Dan MacMillan, Chopo Ma, Zinovy Malkin, Jan McGarry, Angelyn Moore, Ruth Neilan, Carey Noll, Mike Pearlman, Erricos Pavlis, John Ries, Markus Rothacher, David Rowlands, David Rubincam, David Stowers, Frank Webb, Pascal Willis

- **Publications:**

  "GGOS Working Group on Ground Networks and Communications", Pearlman et.al., Dynamic Planet (ed. P. Thegoning and C. Rizos), Springer, IAG Symposium. Vol. 130, ISBN 978-3-540-49349-5, p719.

  "Global Geodetic Observing System – Considerations for the Geodetic Network Infrastructure", Pearlman et. Al., Geomatica, Vol 60, No. 2, 2006, p193-204.

- WG Meeting on Monday, July 9, 12:00 – 14:00, Department of Education, Room 3.

GGOS Working Group
Ground Networks and Communications
Initial Tasks

- Develop a model to estimate the stability of the reference frame as a function of the number of co-located SLR and VLBI stations, their geographic distribution, and their data quantity and quality to scope the network necessary to provide a stability of 1 mm/decade;
- Seek an effective way of monitor inter-technique vectors at colocation sites to support the above task;
- Develop an “effective cross section” standard for GNSS satellites and examine options for implementation;
- Provide charts on stations and product information for GEO and INDIGO;
- Promote communication and integration among the Services;

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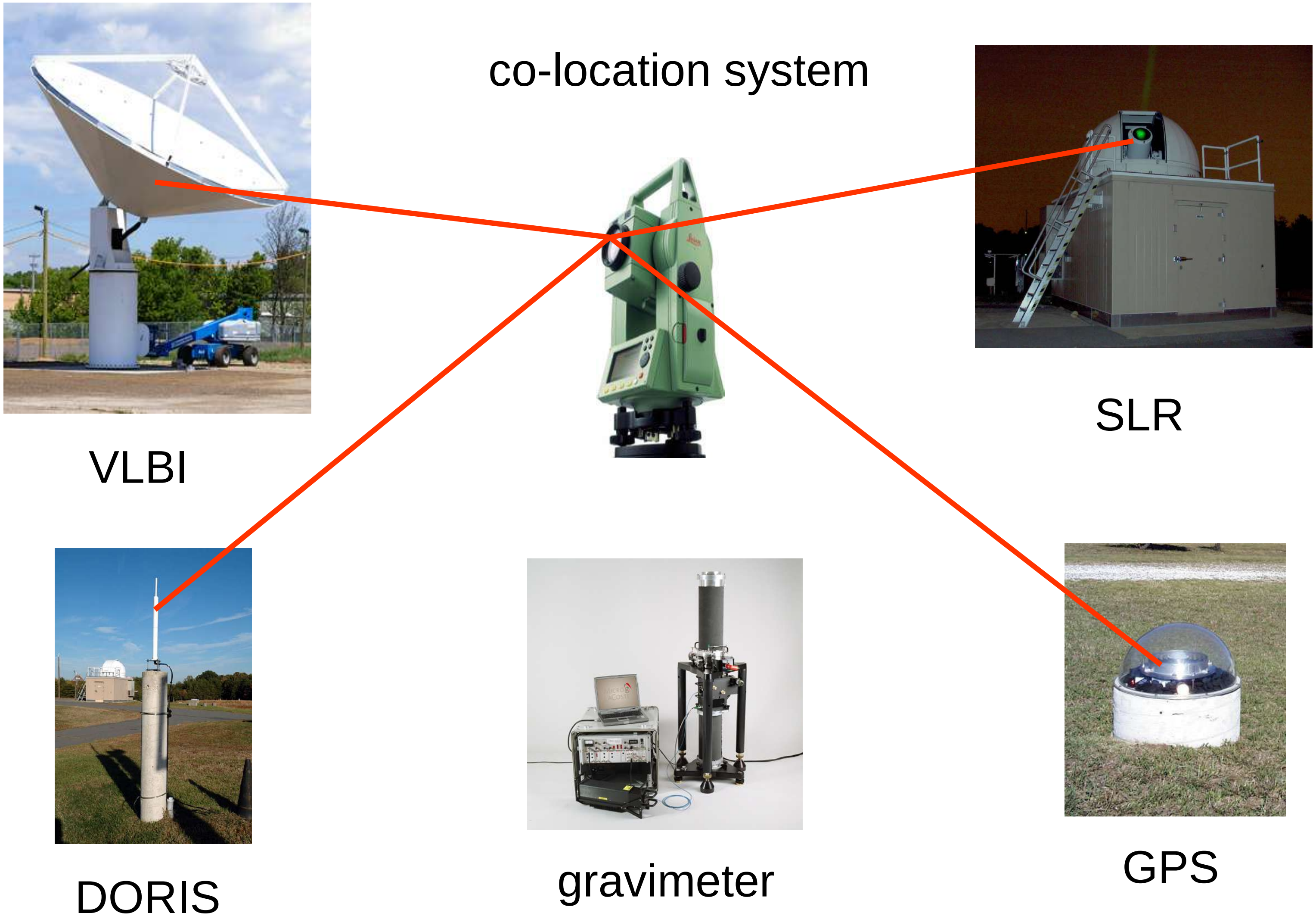
Initial Tasks

- **Develop a model to estimate the stability of the reference frame as a function of the number of colocated SLR and VLBI stations, their geographic distribution, and their data quantity and quality to scope the network necessary to provide a stability of 1 mm/decade;**
  - **Presentation on the SLR/VLBI simulation to date made by Erricos Pavlis at the IUGG session;**
  - **Need to add GPS and DORIS; assume they will remain pretty much global as they are now**
  - **Still need to include gravity;**
- **Seek an effective way of monitor inter-technique vectors at colocation sites to support the above task;**
  - **Option with Leica “Total Station” system examined; but still very expensive;**
- **Develop an “effective cross section” standard for GNSS satellites and examine options for implementation;**
  - **Standard has been developed;**
  - **New hardware options being examined**
- **Provide charts on stations and product information for GEO and INDIGO;**
  - **Done for SLR, VLBI, GPS, DORIS; now working on gravity**
- **Promote communication and integration among the Services;**
  - **WG meets at least twice per year (AGU, EGU)**
  - **Weekly telecons**

Approaches to Network Design

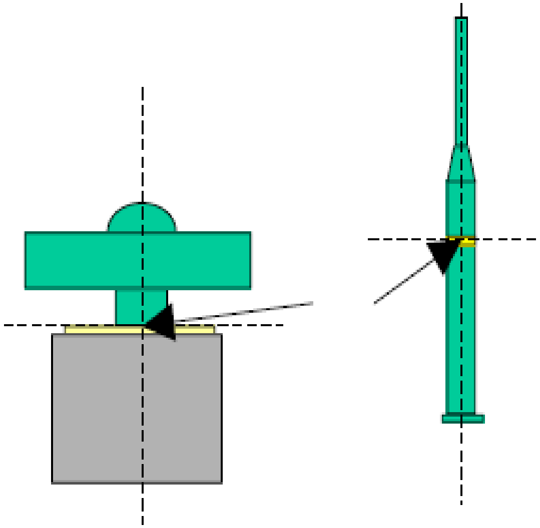
- The final design of the GGOS network must take into consideration all of the applications including the geometric and gravimetric reference frames. EOP. POD, geophysics, oceanography, etc. We will first consider the TRF, since its accuracy influences all other GGOS products. Early steps in the process are:
- Define the critical contributions that each technique provides to the TRF, POD, EOP, etc;
- Characterize the improvements that could be anticipated over the next ten years with each technique;
- Examine the effect in the TRF and EOP resulting from the loss of a significant part of the current network or observational program;
- Using simulation techniques, quantify the improvement in the TRF, EOP and other key products as stations are added and station capabilities (co-location, data quantity and quality) is improved; and
- Explore the benefit of adding new targets.

Fundamental Station



Antenna Reference Points (1)

- GPS and DORIS Reference Points

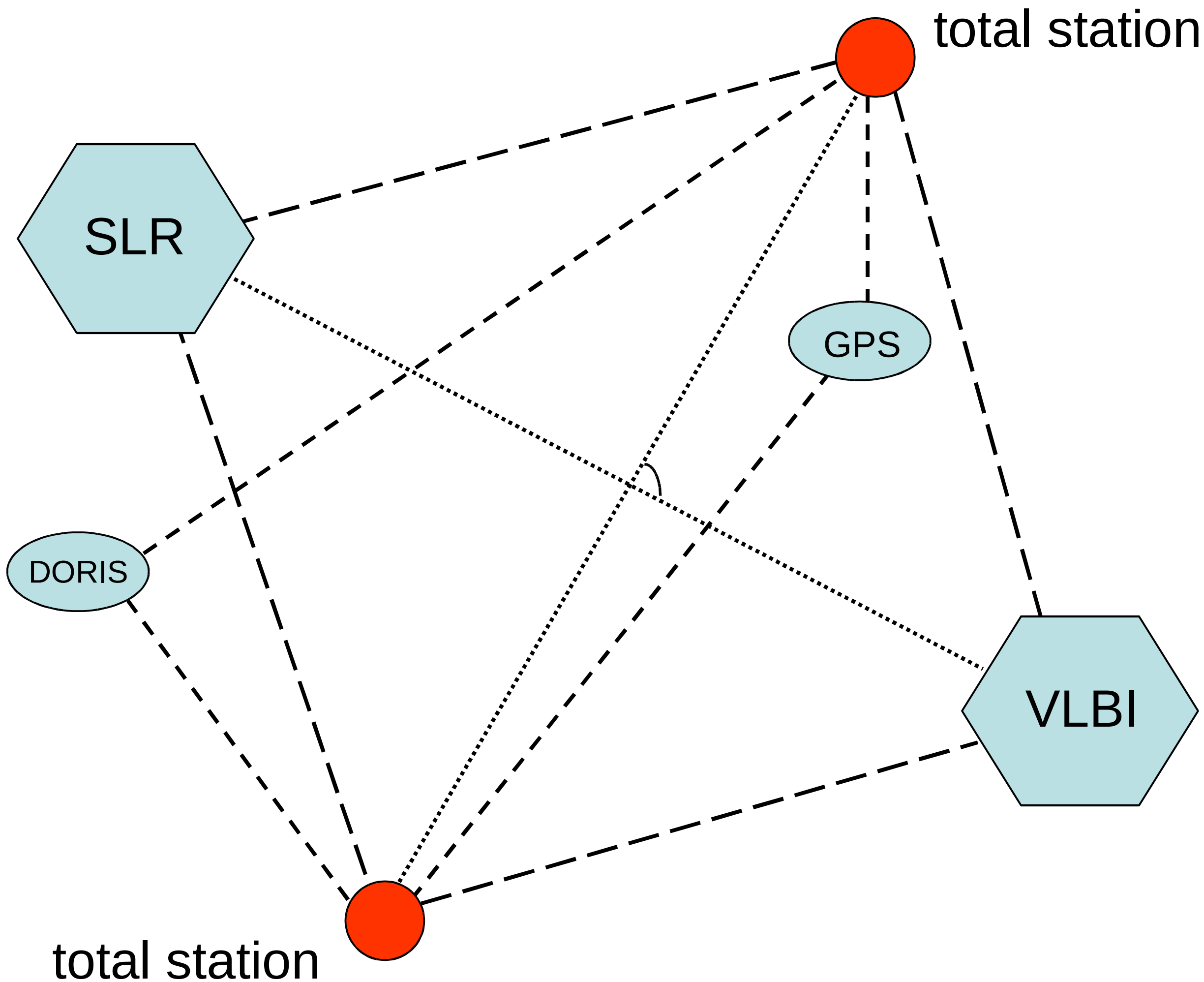


- VLBI and SLR Reference Points
  - RP through indirect approach
  - targets mounted on system structure
  - rotational sequence about axes of space geodetic instrument
  - model to determine axes location

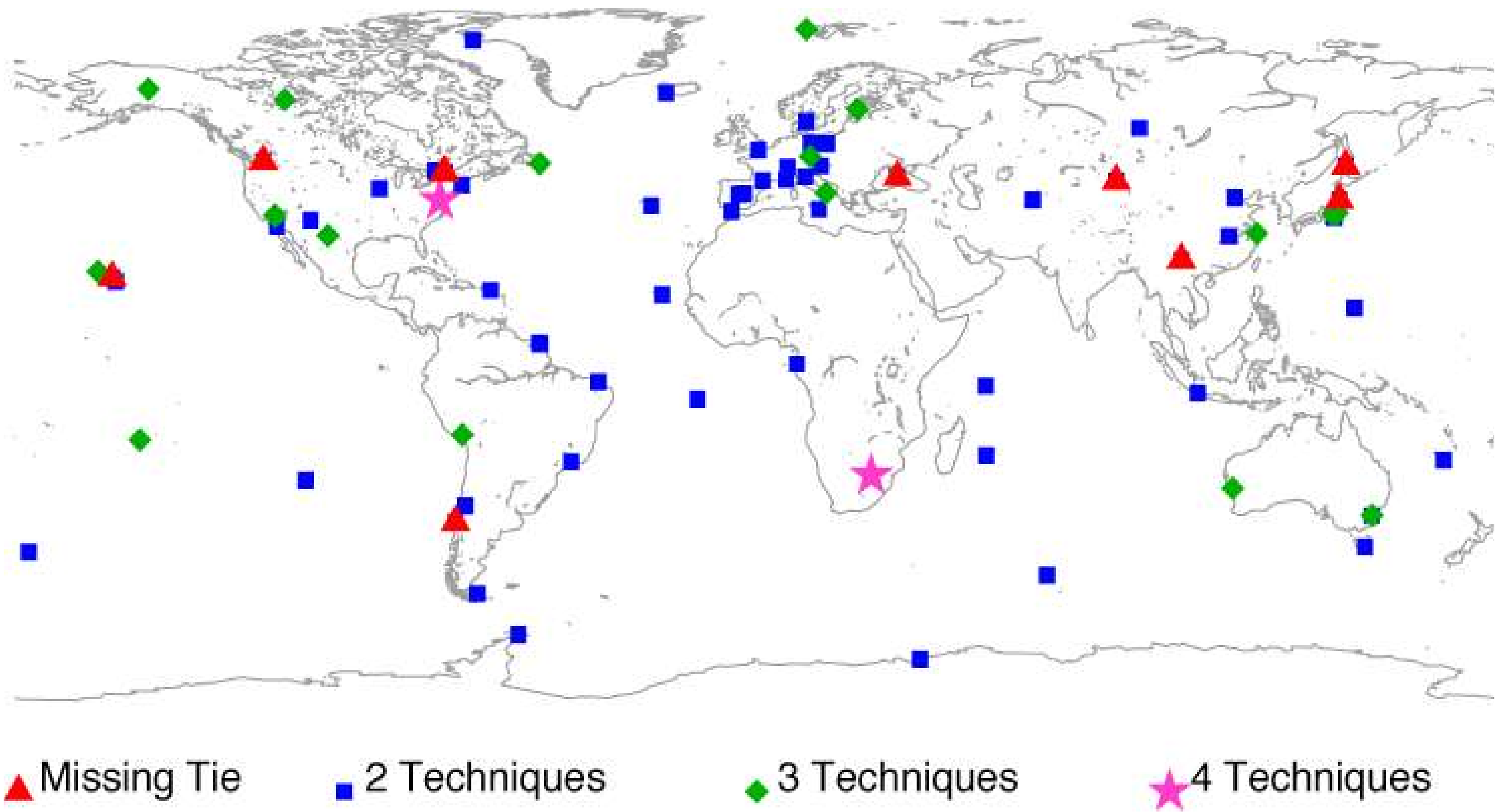
Possible Avenues

- Fully total-station-based approach
  - survey and monitoring with total stations
  - at least 2 total stations for idealized site
  - third total station as active spare desirable
  - existing sites likely to require more total stations
- Total stations plus ranging devices
  - total stations for full surveys at certain intervals, but not permanently installed
  - permanent ranging devices for monitoring
  - indication of motion triggers survey

Idealized Site



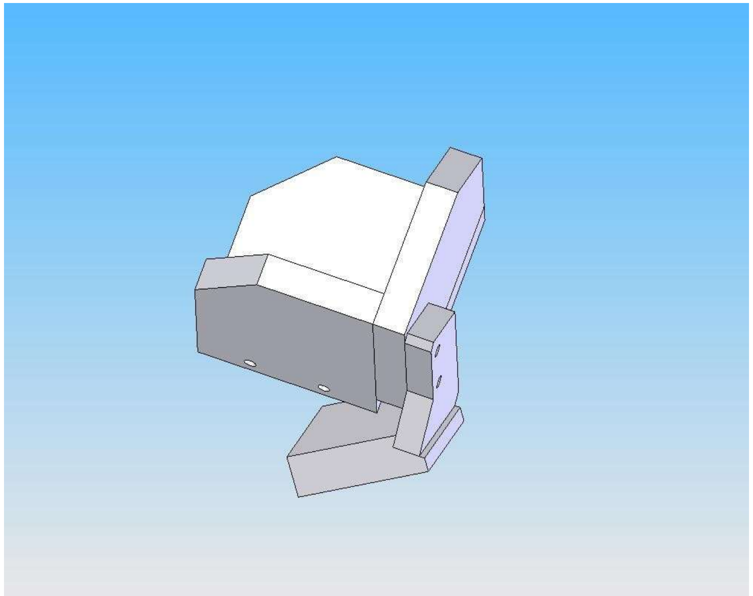
Recent Space Geodesy Co-location Sites



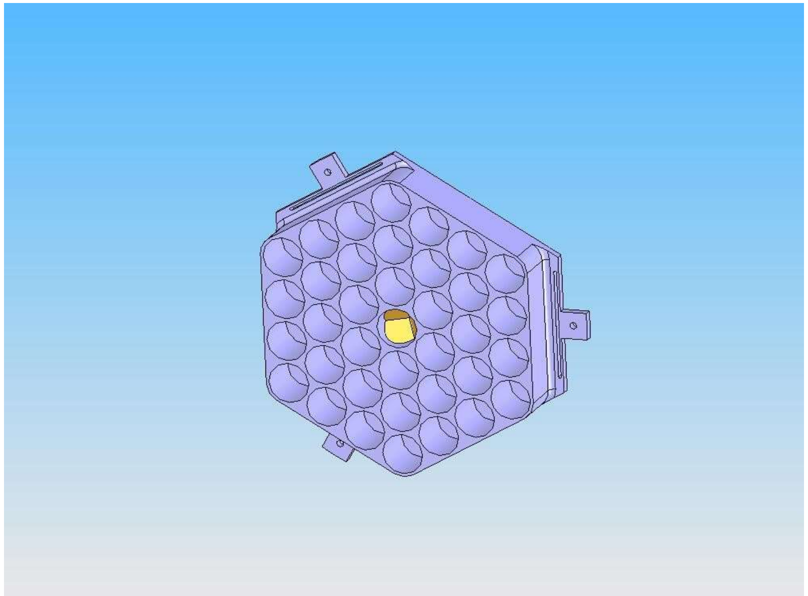
GNSS Retroreflector Activity

- **ILRS Array Standard for GNSS Satellites**
  - ILRS has approved a “standard” an “effective cross-section” of 100 million sq. meters (5 times that of GPS-35 and -36) for GNSS satellites;
  - Uncoated cubes can meet this standard with arrays about twice as large and twice as heavy as the current GPS array;
  - Hollow cube technology offer great promise of meeting this standard with smaller arrays weighing about the same as the current GPS array;
- **The ILRS urges all GNSS satellites projects to meet or exceed the ILRS standard in its retroreflector array designs to insure that the network will provide adequate tracking.**

Hollow Cube Array



Single hollow cube



Hollow cube array configuration

Some Issues

- **Integrate the gravity sites into the network;**
  - Several network sites have gravimeters (Wettzell, Concepcion, Herstmonceux, -----)
- **Define of co-location;**
  - Question of accuracy of the inter-technique vector monitoring rather than the distance apart;
- **Complete inter-technique survey ties at co-located sites;**
  - International effort; a few stations get done each year;
- **Define the phase 1 analysis tasks (Some reasonable quantification of how products depend upon the network)**
  - Report on simulation activity using reference frame;
- **Characterize the anticipated (10 years) performance of each technique;**
  - Reasonable characterization for SLR, VLBI, GNSS, DORIS;
- **Setup a communications activity;**
  - Needs attention;
- **GPS (GNSS) at all network sites;**
  - Still a few stations that need to add GNSS;
- **Include tide gauges? (how?)**
- **New target options (SLR, GPS, Galileo, etc.)**
- **Coordination with other Working Groups;**

Evolution of the Techniques

- GNSS
  - Modernizing of the GPS signal structure, Galileo signals and GLONASS signals;
  - Improved handing of calibration issues such as local signal effects, and antenna phase patterns, and consolidation supplementary instrumentation such as strain meters and meteorological sensors;
- SLR
  - Autonomous operations at kilohertz frequencies, improved pass interleaving, higher resolution counters, two wavelength operation for improved refraction delay recovery;
  - Improved, more compact satellite retroreflector arrays for better accuracy and optical transponders for extended range;
- VLBI
  - Fast slewing, high efficiency 10 - 12 meter diameter antennas, ultra-wide band front ends with continuous FR coverage, digitized back end with selectable frequency segments and improved recording and data transfer techiques;
  - Near real-time correlation among networks of processoors, automated generation of products;
- DORIS
  - Third generation antennae and improvements to beacon monumentation;
  - Added Doris beacons to support altimeter calibrations, co-location, and other experiments;
- Gravity
  - Introduction of transportable absolute gravimeters for calibration of superconducting gravimeters;
  - Airborne and ship campaigns over large areas that are devoid of gravimetric observations;
  - Development of a method to continuously “map” changes in the field with resolution many orders of magnitude higher than currently achievable from geopotential mapping missions;