***PROJECT PROGRESS REPORT***

**Inter-Service Data Integration for Geodetic Operations**

# *Project INDIGO*

*Prepared for:*

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Report for 9/2004 through 12/2005

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# *INDIGO*

## Inter-Service Data Integration for Geodetic Operations

Overview

The main objective of INDIGO is to enable improved performance, accuracy, and efficiency in support of NASA's Earth science and international user community by developing and providing uniform access to heterogeneous space geodetic data systems. This collective effort will be built upon data and information systems of space geodetic observations that come from the techniques of the Global Positioning System (GPS), Very Long Baseline Interferometry (VLBI) and Satellite Laser Ranging (SLR), which are fundamental for defining and maintaining the precise reference system. The system will be flexibly designed to be able to include or incorporate other geodetic techniques data and products, and have comprehensive links to other data system holdings.

The community-based international scientific services - the International GNSS Service (IGS - formerly the International GPS Service), International VLBI Service (IVS) and International Laser Ranging Service (ILRS) - are committed to support and evolve data information systems. INDIGO is a collaborative activity led by JPL and GSFC, the homes of these three service information systems. These geodetic services fundamentally support the International Earth Rotation and Reference System Service (IERS) and therein the generation and maintenance of the International Terrestrial Reference Frame (ITRF). Recognizing current scientific concepts and requirements of the Global Geodetic Observing System (GGOS), a program of the International Association of Geodesy (IAG) and acknowledged participant of the GEOSS, unification of these data systems is very timely and the first steps towards identify scientific users needs has been taken in order to implement an architecture best suited to serve the community.

Extensive user participation in the formulation of the new system has been undertaken resulting in an assessment report and concept notes to guide development. INDIGO website has been established. INDIGO principals are engaged in the GGOS activities and to a large extent are leading the developments towards realizing an inter-technique data information system. We foresee the user interface and access as streamlined and seamless with state-of-the-art web-based service. This is because INDIGO will extend the GPS Seamless Archive (GSAC) philosophy to all data types, creating a *Global Seamless Archive* for geodetic data, products, and information. Data and products can be made readily available to a user from globally distributed data systems without the user searching through multiple systems.

Accomplishments since inception

1. Finalize task details and budget (30 July 2004) secure HQ approval, funds on contract.

2. INDIGO www presence established, see: http://indigo.nasa.gov/

3. Assessment of current services, review existing structures, data and product holdings, information, meta-data, and services. Service data and product comparison tables on website : http://indigo.nasa.gov/indigo_serva.html

4. User Assessment conducted, report available (July 2005).

4. Static collocation table developed as first step to dynamic database on station catalog and observations; http://indigo.nasa.gov/sgp_colocations.html

5. Establish the Inter-Service WG and lead the Data and Information System Working Group of the Global Geodetic Observing System (GGOS). INDIGO principals lead the Ground Networks and Communications Working Group of GGOS to work toward integration of the networks. People from many different disciplines and organizations, including gravity field, are engaged and communicating regularly. The WGs collaborated in putting together papers for the IAG meeting in Cairns and its proceedings. INDIGO team is involved in unprecedented approach to network integration and is working towards developing quantitative measurement user requirements, which will certainly impact the data systems. Continuous since mid-2004.

6. Science Advisory Team set up, March 2005

*INDIGO Science Advisory Team*

| | |
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Findings, Actions and Plans Stemming from Assessment Report

The technical team noted that development of a metadata specification for geodetic sites is necessary for achievement of several goals presented in the assessment report:

- Provide authoritative tables of inter-technique tie vectors. Offer vectors between each pair of reference points, whether measured or calculated. Time dependence must be considered.
- Provide upgraded site information, including anomalous periods for each data type.
- Provide ability to discover suitable spatiotemporally coincident multi-technique data sets.

The metadata specification was therefore identified as an early goal which will in several ways enable the stated specific goal of INDIGO services: easy comparison of single and multi-technique results with one another in sensible ways. This will also meet INDIGO's extensibility goal of allowing related data providers (such as other geodetic techniques) to participate by providing information in a standardized way. The team noted related developments in this area:

- XML development at the IERS CB, related to ISO 19115/19139
- XML development at SOPAC, including a full specification of a geodetic monument

The team has developed a prototype based on the SOPAC geodetic monument definition, with extensions for identifying geodetic technique, vectors between nearby monuments, and operating status. The team has also identified sources of input data to populate the database once defined. This initial set of information will allow INDIGO to begin providing valuable information to the multi-technique community such as site tie information and technique co-location information. Further developments in the phased approach will include anomalous periods and specific operating periods.

Budget

INDIGO Budget Guideline is $500K Funds split between JPL and GSFC at NASA HQ, FY05/FY06 request:

JPL: $248K

GSFC: $252K inclusive of full cost accounting per NASA HQ direction (~$72K)

Plans CY 2006

1. Architect and begin implementing the phased design for INDIGO services and capabilities. Design including Global Seamless Archive System (GSAC) approach for INDIGO and continue to propagate approach and methods to benefit GGOS as appropriate.

2. Develop catalog of stations and observations; provide a central template to collect station meta-data and encourage all Service network coordinators, managers and stations operators to provide information and adhere to the convention

3. Prepare space geodetic colleague directory.

3. Meeting with Science Team for review of the design and implementation for the above (3rd quarter 2006)

## INDIGO GOALS & OBJECTIVES

**Service System Unification and Integration**

- Develop a common catalog of existing services and products
- Analyze interdependencies and identify synergies between current services
- Develop and implement the structure to unify the services' data information systems via website INDIGO
- Re-architect the independent services' data information systems
- Develop and implement common interfaces for user access at each service where synergistic
- Foster an international working group for the development and promotion of data and metadata standards
- Present similar products side-by-side and uniformly formatted
- Explore and implement 're-use' of GPS Seamless Archive philosophies/tools, extend to all techniques creating a Global Seamless Archive Center
- Support and implement data processes for 'deep' inter-technique data integration
- Provide reference frame data and products in support of IERS
- Design flexible data system for future inclusion of emerging technologies: altimetry, InSAR, space gravity, and magnetometry.

**INDIGO Support to the Earth Science User Community**

- Provide precise geospatial/temporal data search as well as word search of information
- Implement a station coordinate/velocity plots for all sites in cooperation with the IERS
- Create a new Site Ties catalog that is inter-technique and flexible to incorporate other techniques in the future
- Prepare and publish the INDIGO Catalog of Observing Instruments and Stations (including GNSS constellation info)
- Investigate and prototype approach to quality assurance of INDIGO
- Combine and upgrade the web based directory of colleagues for the few thousand current users, enable expansion for many new users

**INDIGO Responsiveness to Science Drivers**

- Establish a Science Advisory Team for direction on developments closely associated with developing scientific requirements of GGOS/NGO; INDIGO directly supports these activities (of expert users) while continuing to serve broad Earth science users

✓ Completed or action in process

| | INDIGO High Level Tasks and Milestone Chart revised 12.2005 | CY 04 | | CY 05 | | CY 06 | | CY 07 | |
|---|---|---|---|---|---|---|---|---|---|
| | **Phase→** | 1 | | 2 | | 3 | | 4 | |
| | | Jun | Dec | Jun | Dec | Jun | Dec | Jun | Sept |
| ✓**1** | Funds on contract | | | | | | | | |
| ✓**2** | Task plans finalized | | | | | | | | |
| ✓**3** | Secure formal approvals of Service Governing Boards | | | | | | | | |
| ✓**4** | Establish Inter-service WG on Data and Information Systems within IAG | | | | | | | | |
| ✓**5** | Establish a Science Advisory Team, annual reviews/reports | | | | | | | | |
| ✓**6** | Assess current services, prepare report on data and products, Assess inter-technique network architecture & mix of data | | | | | | | | |
| ✓**7** | Develop and implement website INDIGO, on-going | | | | | | | | |
| **8** | Re-architect service information systems, maximize multi-technique standardization | | | | | | | | |
| **9** | Compile and distribute INDIGO publications: Catalog of Observations and Stations | | | | | | | | |
| **10** | Develop & implement Global Seamless Archive Center services | | | | | | | | |
| **12** | Prototype quality assurance approach INDIGO (descope – June 2004) | | | | | | | | |
| **13** | Provide Annual Reports/e-newsletters | | | | | | | | |
| | Progressive task action - light grey | | | | | | | | |
| | Deliverables, or task completion period - dark grey | | | | | | | | |

Related publications and presentations

Noll, C.E. and M. Dube "Archiving Space Geodesy Data for 20+ Years at the CDDIS", EOS Trans. AGU, 85(47), Fall Meet. Suppl., Abstract G53A-0124.

R.E. Neilan, A. Moore, J. Dow, G. Gendt, and R. Weber (2004), "International GPS Service - 10 Years History, New Directions for GNSS and Space Geodesy", EOS Trans. AGU, 85(47), Fall Meet. Suppl., Abstract G53A-0124.

Thomas P Yunck, T.P, and R. E. Neilan "Integration of Space Geodesy: A US National Geodetic Observatory", Journal of Geodynamics, in press, 2005

Noll, C.E. "The Crustal Dynamics Data Information System: NASA'S Archive of Space Geodesy Data", NP-2005-111-734.

Pearlman, M., et al., "GGOS Working Group on Ground Networks and Communications", Proceedings IAG/IAPSO Assembly, Cairns, Australia, August 22-26, 2005, in preparation, 2006.

Neilan, et al., "Integrated Data and Information System for the Global Geodetic Observing System", Presentation, IAG/IAPSO Assembly, Cairns, Australia, August 22-26, 2005

Moore, A.W. et al., "INDIGO: Inter-service Data Integration for Geodetic Operations", Potsdam, Germany, March 01-02, 2005.

Moore, A.W. et al., "INDIGO: Inter-service Data Integration for Geodetic Operations" at IERS Combination Pilot Project (CPP) Workshop, Napa, CA, December 11, 2004.