New Research Directions for the National Geospatial-Intelligence Agency
Workshop Report

Mapping Sciences Committee NGA Sponsor
Keith C. Clarke, MSC Chair

Context

- 2006 Mapping Science Committee report
- ***Priorities for GEOINT Research at the National Geospatial-Intelligence Agency***
- *"Hard" research problems*
- *Top ten priorities*
- *Prioritized Recommendations*

2006 Priorities Report

Priority 1:
- Spatiotemporal data mining and knowledge discovery from heterogeneous sensor systems
- Multilevel security

Priority 2:
- Spatiotemporal database management systems
- Process automation versus human cognition
- Visualization
- HPC and Grid computing for geospatial data
- Role of text and place name search in data integration
- Reuse and preservation of data
- Detection of moving objects from multiple heterogeneous intelligence sources

Committee Task

"Within this context, H. Gregory Smith, NGA Chief Scientist, asked the National Research Council to convene a workshop to explore the evolution of the five core areas and to identify emerging disciplines that may improve the quality of geospatial intelligence over the next fifteen years. This report summarizes the discussions at the workshop."

Historically, NGA has supported research in five core areas

- Photogrammetry and Geomatics
- Remote sensing and Imagery science
- Geodesy and Geophysics
- Cartographic science
- Geographic information systems and Geospatial analysis

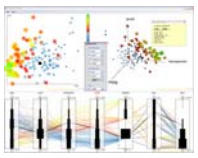
The Process

- Steering Committee: 7 people, met to plan workshop February 19th, 2010. Selected cross cutting themes
- Invited White Paper authors and keynote Speakers
- Workshop: May 17-19, 2010. Keck Center.
- Report-writing: Steering committee
- Report review: NRC
- Report release, briefing

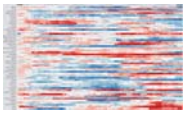
Cross-cutting themes

- **Visual Analytics**
- **Participatory Sensing**
- **Beyond fusion**
- **Forecasting**
- **Human terrain**

Visual analytics:
the science of analytic reasoning, facilitated by interactive visual interfaces.







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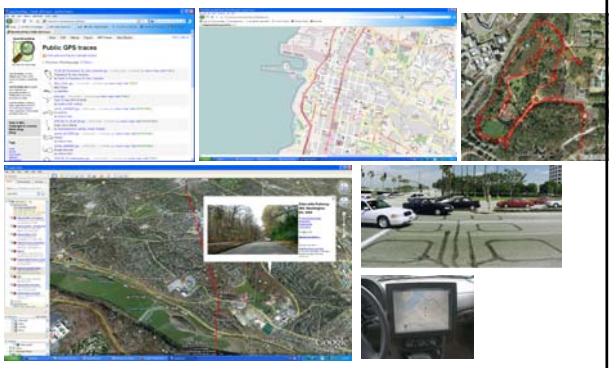
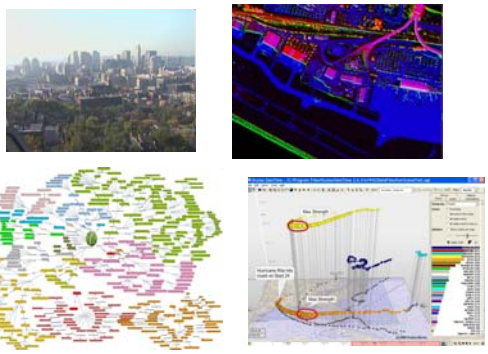
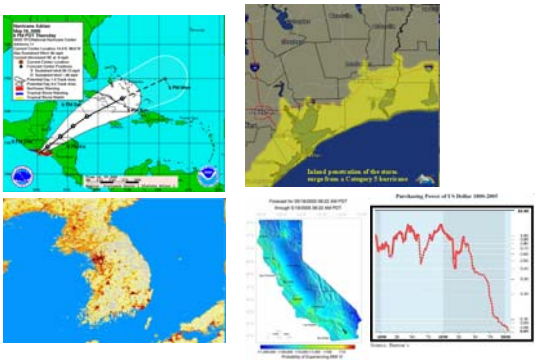
Participatory sensing: tasks everyday mobile devices, such as cellular phones, to form interactive, scalable sensor networks that enable the public and professionals to gather, analyze, share, and visualize local knowledge and observations



Beyond fusion: aggregation, integration and conflation of geospatial data across time and space with the goal of removing the effects of data measurement systems and facilitating spatial analysis and synthesis across information sources.



Forecasting: an operational research technique used to anticipate outcomes, trends, or expected future behavior of a system using statistics and modeling.



Human terrain: creation of operational technologies to model, represent, simulate, and anticipate behaviors and activities of individuals and social networks . (=Human Geography?)

The White Papers

- *Calibration of the Aerial Photogrammetric System*
  - Dean Merchant, Ohio State University
- *Remote Sensing: An Overview*
  - Russell G. Congalton, University of New Hampshire
- *Cartographic Research in the United States: Current Trends and Future Directions*
  - Robert McMaster, University of Minnesota
- *A Brief History of Satellite Geodesy - October 4, 1957 to Present*
  - Lewis Lapine, South Carolina Geodetic Survey
- *Geospatial Analysis*
  - Luc Anselin, Arizona State University

The Workshop

- Preparation: briefing book, white papers on core areas and cross-cutting themes
- Day 1: Five core areas, keynote, breakout
- Day 2: Five crosscutting themes, keynote, breakout
- Day 3: Brainstorm by theme, reduce list of research topics, present in plenary, summarize topics.

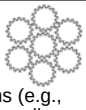
The A List

- **Visual Analytics**
- **Integrating Sensors**
- **Human Terrain/Behavior**
- **Participatory Sensing**
- **Improved Models of Space-Time**
- **Development of New Paradigms for Conveying Certainty**
- **Improved geodetic/photogrammetric/remote sensing positioning**
- **Geospatial Information Retrieval and Extraction from Text**
- **Database Technology and Spatial Data Infrastructures**
- **Geospatial Narrative**

Visual Analytics

- Short to medium term:
  - research on the computational modeling of large data sets and their organization for visual processing
  - models for integrating human intelligence and decision-making into GEOINT systems
  - building the scientific basis, e.g. theoretical frameworks, for visual analytics
  - integration into visual analytics of concepts from time-space analysis, multi-level data, uncertainty analysis, and human-computer interaction

Integrating Sensors



- New sensors (e.g., hyperspectral and LiDAR), platforms (e.g., UAV drones, sensor networks and sensor webs, and "small satellites"), and modalities will require new paradigms and significant research in:
  - sensor modeling
  - sensor calibration
  - sensor data fusion
  - new methods for mission planning and dynamic tasking
- Vast quantities of data collected will require the development of "smarter" real-time processing and georeferencing methods, perhaps coupled and on-board with sensor platforms
- Research will be required on automated feature extraction across sensors

Human Terrain/Behavior

- Key research areas include:
  - Geospatial data collection techniques for observing human behavior
  - Geospatial integration of social, behavioral and cultural data
  - Use of participatory data
    - policy for acquiring, influencing participation
    - dealing with security and privacy issues
    - mixing participatory data with traditional data
    - assessing reliability or credibility
    - understanding cultural and social constraints on participatory data

Participatory Sensing

- Key elements of a research agenda to enable participatory Sensing in GEOINT:
  - developing methods for planning and optimizing sensing
  - incentivization of participants
  - addressing quality, uncertainty, and trustworthiness of participant-contributed data
  - responsibly involving human participants, including addressing privacy and security concerns
  - integrating unplanned, unstructured participatory sensing data into GEOINT
  - incorporating prior information

Improved Models of Space-Time

- Key to furthering the representation and understanding of complex dynamic physical and socio-behavioral processes
- Requires the development of new and improved models that integrate the time structure of events, as well as their aggregates and narratives, with spatial structure.
- A theory of scale dependence in order to handle multiple resolution data bases
- Integration of social, cultural and behavioral factors

Development of New Paradigms for Conveying Certainty

- All working group discussions touched on uncertainty as a long term issue that cut across all NGA core areas and that will require more robust treatment.
- Emphasis on:
  - Development of tools for establishing data and information quality at all stages of the information chain, from collection to decision making
  - Creation of methods to establish reliability of participatory sensing data
  - Development of methods to detect manipulation in participatory data
  - Means to convey reliability in visual data

Improved geodetic/photogrammetric/remote sensing positioning

- Remote sensing, geodetic, and photogrammetry data will require improved positioning to be used effectively in GEOINT.
- INS (inertial navigation system) will need to be developed to high accuracy levels to supplement GNSS
- Improved gravity models are necessary to determine precise orbits and to reduce orbit errors associated with satellites

Geospatial Information Retrieval and Extraction from Text العربية

- Important to develop methods to use geospatial information to interpret unstructured and semi-structured textual information
- Integration of information from a wide range of sources by anchoring them geospatially
- Understanding and characterizing the geographic variation of language

Database Technology and Spatial Data Infrastructures

- Research needed to develop new database technology and spatial data infrastructures that are capable of handling data that are:
  - Multi-dimensional
  - Spatially and temporally multi-scale
  - Multi-source (authoritative to participatory and public)
  - Extremely high spectral and spatial resolution
  - Multimedia imagery
  - Free form text

Geospatial Narrative

- Many geospatial phenomena can be represented as narratives
- Difference from a known narrative becomes a mechanism by which the normal can be discriminated from the abnormal
- A research track in geospatial narrative would focus on:
  - How to develop computational narratives within a spatio-temporal database
  - allowing narrative objects of any type to be automatically recognized and created
  - Allowing objects to be manipulated for visualization and analysis

Data in the report

- No recommendations (Workshop only)
- Themes are summarized and explained by topic
- Extensive discussion and brainstorming
- Notes from discussions are included as appendices to the chapters

IMPLICATIONS FOR THE SCIENTIFIC INFRASTRUCTURE

- Some felt that academic programs will need to respond strategically to these research challenges
- May require new centers, resources, faculty and students.
- Participants felt a need to protect existing research programs in core areas
- The greatest challenge, however, will be dealing with the increasing need for interdisciplinary research and education