

USE OF COMMERCIAL REMOTE SENSING SATELLITE DATA IN SUPPORT OF EMERGENCY RESPONSE

S. W. Doescher^a, R. Ristyb, R.H. Sunne^b

^a U. S. Geological Survey, National Center for Earth Resources Observation and Science, 47914 252nd Street, Sioux Falls, SD 57198 – doescher@usgs.gov

^b Science Applications International Corporation, 47914 252nd Street, Sioux Falls, SD 57198 (risty, sunne)@usgs.gov

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ABSTRACT:

Natural disasters are constant reminders of the how powerful nature can be. The effects of these disasters can be devastating. The Emergency Response team from the U.S. Geological Survey's (USGS) National Center for Earth Resources Observation and Science (EROS) has provided remote sensing data to support disaster operations for hurricanes, earthquakes, and recently, the Southeast Asia tsunami. Landsat data are helpful for wide-area damage assessment and recovery. With the arrival of new-generation, high-spatial-resolution satellite imagery from commercial data providers, 1 meter spatial coverage is available to provide more detailed planning and recovery efforts. Unfortunately, the cost and licensing of commercial data makes the use cost prohibitive for large disasters. The U.S. Commercial Remote Sensing Space Policy has enabled the use of commercial remote sensing data for civilian government agencies. The broad licensing of the data through USGS contracts enables the sharing of commercial satellite data for a greatly reduced cost. The recent tsunami disaster enabled the sharing of data among relief organizations to determine the extent of the damage and to aid in recovery efforts. This disaster also highlighted the need for better coordination of Earth observation data provided by countries and organizations. The lack of coordination resulted in discussions at a Committee on Earth Observation Satellites (CEOS) meeting as to how best to respond to the next disaster.

1. INTRODUCTION

Vital national security, foreign policy, economic, and civil interests depend on the ability of the United States to remotely sense Earth from space. U. S. civil remote sensing systems enable such activities as research on local, regional, and global change. Support services and data products are provided for weather, climate, hazard response, agriculture, transportation, and infrastructure planning. This paper emphasizes the complementary role of commercial data and government in response to international emergencies.

A robust commercial remote sensing space industry can augment and potentially replace some government remote sensing capabilities and can contribute to U.S. military, intelligence, foreign policy, homeland security, and civil objectives, as well as economic competitiveness. Continued development and advancement of commercial remote sensing space capabilities is also essential to sustaining the nation's advantage in collecting information from space. Creating a robust commercial remote sensing industry requires enhancing the international competitiveness of the industry.

On April 25, 2005 the President of the United States authorized the U.S. Commercial Remote Sensing Policy, which established guidance and implementation actions for commercial remote sensing space capabilities. This policy supersedes Presidential Directive 23, U.S. Policy on Foreign Access to Remote Sensing Space Capabilities, dated March 9, 1994. The new policy provides guidance for:

- The licensing and operation of U.S. commercial remote sensing space systems.
- U.S. Government use of commercial remote sensing space capabilities.
- Foreign access to U.S. commercial remote sensing space capabilities.

- Government-to-government intelligence, defense, and foreign policy relationships involving U.S. commercial remote sensing space capabilities.

The fundamental goal of the Commercial Remote Sensing Space Policy is to advance and protect national security and foreign interests by maintaining the nation's leadership in remote sensing space activities and by sustaining and enhancing the remote sensing industry. Doing so will foster economic growth, contribute to environmental stewardship, and enable scientific and technological excellence. In support of this goal, the U.S. Government will:

- Rely to the maximum practical extent on commercial remote sensing space capabilities for filling imagery and geospatial needs for military, intelligence, foreign policy, homeland security, and civil users.
- Focus government remote sensing space systems on meeting needs that cannot be effectively, affordably, and reliably satisfied by commercial providers because of economic factors, civil mission needs, national security concerns, or foreign policy concerns.
- Develop a long-term, sustainable relationship between the government and the commercial remote sensing space industry.
- Provide a timely and responsive regulatory environment for licensing the operations and exports of commercial remote sensing space systems.
- Enable industry to compete successfully as a provider of remote sensing space capabilities for foreign government and foreign commercial users, while ensuring appropriate measures are implemented to protect national security and foreign policy.

The U.S. Commercial Remote Sensing Space Policy assigns certain responsibilities to Federal civil agencies. The Department of Commerce, the Department of the Interior, and

NASA have established a Commercial Remote Sensing Space Policy (CRSSP) Implementation Plan Working Group (IPWG) to develop the plan to carry out these responsibilities. This Web site serves as the official IPWG mechanism to:

- Provide information about the Federal civil Agency plan being developed to implement the policy.
- Seek public comments on the plan and other Federal civil agency implementation activities.
- Post summaries of public comments.

2. DISASTER RESPONSE FOCUS

The USGS hazards activities gather data and prepare geospatial products that deal with describing, documenting, and understanding natural hazards and their risks. This information is delivered to public officials to help them make decisions about land use and hazard-resistant design requirements and to businesses and citizens to help them make long-term decisions about the use of and improvements on their land. USGS information is also used to help emergency officials, businesses, and citizens make crucial short-term decisions related to evacuations, movement of property, and rescue and recovery in response to current or impending natural disasters. USGS activities include long-term monitoring and forecasting, short-term prediction, and real-time crisis monitoring and communication with civil authorities and others. The USGS has the primary Federal responsibility for monitoring and notifying civil authorities about earthquakes, volcanoes, landslides, geomagnetic field changes, and wildlife disease outbreaks. The USGS streamgauge network provides most of the flow data used by the National Weather Service (NWS) in carrying out its mission of forecasting floods and droughts. USGS also prepares risk assessments for regions vulnerable to natural hazards and conducts studies following disasters to help develop strategies to mitigate future hazards.

The information provided by the USGS is essential to support saving lives and reducing the costs of natural disasters. The focus of the USGS for the beginning of the 21st century is on delivering information in real time so that lives can be saved and further damage avoided by the quick actions of emergency managers, businesses, and citizens. Future efforts will concentrate on more extensive monitoring, advanced technology, and better and faster synthesis of information to detect hazardous events and convey the information to decision-makers and the public. The USGS will also conduct risk assessments of natural hazards and intensive studies after an event to provide a solid scientific basis for land use planners and the public so that they can minimize losses from future hazardous events.

3. CRSSP IMAGERY-DERIVED REQUIREMENTS (CIDR) ENTRY TOOL

One of the goals of the USGS Commercial Data Program is to collect and provide query/report capabilities on the near-term land remote sensing data requirements of U.S. Federal civil agencies. This high-profile effort is part of the implementation of the Commercial Remote Sensing Space Policy to assist agencies in leveraging resources in areas of common interest.

The requirements information gathered/provided will be used to:

- Generate a civil agency requirements database to facilitate partnerships among agencies (or even within agencies).
- Serve as documented evidence for potential funding initiatives.
- Satisfy requirements with known existing data sources where possible (eventually including Geospatial One-Stop).
- Provide industries (e.g. commercial satellite industry) with a snapshot of civil agency needs in order for them to respond with better and more-tailored data and services.

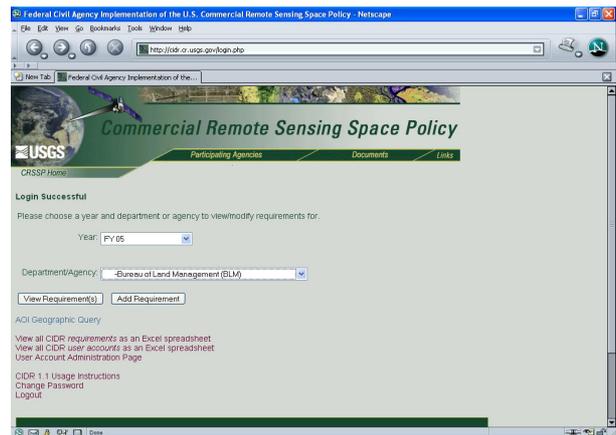


Figure 1. CIDR tool

Federal civil agencies are to use the CIDR tool to enter their remote sensing data requirements for upcoming years. This collection of data requirements will then be analyzed to find intersections in the data requirements, to put those users with intersecting requirements in contact and enable the opportunity for collaboration on potential purchases, as well as to provide commercial vendors with these intersections so that they may use this information to assist in their data acquisition scheduling for known geographic areas of interest.

4. USGS COMMERCIAL DATA PURCHASES (UCDP) IMAGERY

The UCDP imagery collection is an archive of commercial remote sensing imagery from several different commercial vendors. The overall goal of the UCDP imagery collection is to provide data to qualified users, primarily Federal agencies, at no cost or at a nominal cost. Limitations on which users have access to use/purchase copies of the imagery are based on vendor licensing for individual images. Users are allowed to search all UCDP imagery in the archive, but are restricted to ordering only properly licensed images. Users have the option to purchase imagery license upgrades for imagery not currently licensed appropriately for their Federal agency. The Commercial Remote Sensing Data Contracts (CRSDC), available through the USGS, handle the imagery license upgrades. The imagery license upgrades enable Federal users to purchase and use a copy of the imagery at a nominal fee.

Copies of current imagery can be downloaded/purchased through the USGS Earth Explorer client. Users cannot specify processing parameters for the imagery. (For example, if an IKONOS image was originally purchased from Space Imaging as a "Standard Ortho" product, Universal Transverse Mercator

projection, WGS84 Datum, and GeoTiff format, those are the only parameters available for that image.) A large quantity of the data is in National Imagery Transmission Format (NITF). NITF is the digital imagery standard for the US intelligence community and is widely used by U.S. military commands, other U.S. Government departments and agencies, as well as international organizations such as North Atlantic Treaty Organization. The NITF standard provides a common basis for the storage and interchange of images and facilitates the use of multiple imagery sources and annotations. NITF files can contain multiple images as well as other information such as graphics and text. Current USGS Commercial Data Purchases (UCDP) imagery includes:

- IKONOS: Since its launch in September 1999, Space Imaging's IKONOS Earth imaging satellite has provided a reliable stream of image data that has become the standard for commercial high-resolution satellite data products. IKONOS produces 1 meter black-and-white (panchromatic) and 4 meter multispectral (red, blue, green, near infrared) imagery that can be combined to accommodate a wide range of high-resolution imagery applications.
- OrbView: ORBIMAGE's OrbView-3 satellite is among the world's first commercial satellites to provide high-resolution imagery from space. OrbView-3 produces one-meter resolution panchromatic imagery and 4 meter resolution multispectral imagery. One-meter panchromatic imagery enables the viewing of houses, automobiles, and aircraft, and creates highly precise digital maps and three-dimensional fly-through scenes. Four-meter multispectral imagery provides color and infrared information to further characterize cities, rural areas, and undeveloped land from space.
- QuickBird: The DigitalGlobe QuickBird satellite is the first in a constellation of spacecraft. The company is developing that offers highly accurate, commercial high-resolution imagery of Earth. QuickBird's global collection of panchromatic and multispectral imagery is designed to support applications ranging from map publishing to land and asset management and insurance risk assessment.

The U.S. Geological Survey's EarthExplorer provides secure access to data in the UCDP archive. Users must register with the EarthExplorer system to identify the user's civilian agency. Licensing of the data in the UCDP archive requires prior knowledge of the user. The user's agency and the licensing of the data determines if the data is accessible. If the user meets the licensing guidelines of the data, the user can either download the data directly or request the data be copied to media, for a minimal charge. If the civilian user wishes to uplift the license of the data to make the data more accessible, the user can forward the request to a customer service representative to determine the cost through the USGS Commercial Remote Sensing Data Contracts (CRSDC). (<http://geodatacontracts.er.usgs.gov/crsdc/index.html>).

5. USGS EMERGENCY SUPPORT

The USGS and the National Center for Earth Resources Observation and Science (EROS), in support of *The National Map* provides geospatial data access via downloads and Web services. Using the base layers of *The National Map*, web services and downloads provide instant data access in support of homeland security and emergency response issues. The base layers consist of the following framework categories:

- Transportation
- Boundaries
- Hydrography
- Orthoimagery
- Land Cover
- Elevation

To support relief efforts for natural disasters, such as floods, earthquakes, hurricanes, etc., the capability to look at potential problem areas affected is a feature of several Web services. The incorporation of national data sets, not only *The National Map* layers, but layers such as Advanced Very High Resolution Radiometer (AVHRR), Landsat, and higher resolution commercial imagery for hurricanes is a great asset to these Web services. *The National Map Hazards Data Distribution System* (HDDS) provides a dynamic online map interface that can be used to view USGS data sets that are part of *The National Map* (http://gisdata.usgs.net/website/Disaster_Response/).

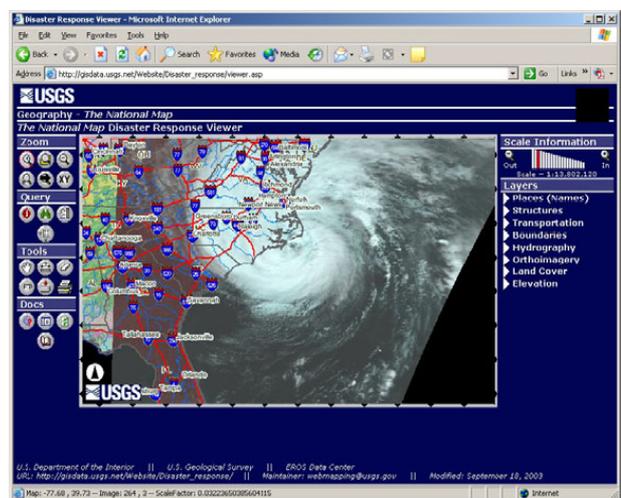


Figure 2. The National Map Hazards Data Distribution System

5.1 Hurricanes

EROS has helped support emergency response efforts for hurricanes over a number of years. The USGS, through *The National Map* HDDS, continues to provide information regarding hurricanes Charley, Frances, Ivan, Jeanne, and Franklin. Support is also provided for other disasters such as fire, earthquakes, flooding, and other hazards that impact the lives and infrastructure of the United States.

This information can be accessed by going to the site and clicking on "Eastern Hurricanes". FTP access to data is obtained by clicking on the FTP tool located to the left of the interactive map. Navigational help is available on the main page of the Disaster Response Web site. That page also contains a link to EROS Customer Services for additional assistance. The Web site may also be accessed through ESRI's ArcMap tool.

5.2 Fires

Fire is an integral part of ecosystem functions and processes. The need to develop spatial information and technology lies in a fire's natural cycle: fire danger and live fire monitoring, post-fire mapping of burn scars and analysis of fire effects, fire fuels characteristics and mapping. These activities form the core of a strategy for USGS EROS fire research and development.

To plan for early and successful fire containment, land and fire managers rely on accurate and timely information on the potential for fires to ignite and spread. USGS EROS scientists, in collaboration with scientists at the U.S. Forest Service (USFS) and the Bureau of Land Management (BLM), developed the Fire Potential Index (FPI) in 1997 to help provide that information. The FPI assesses the probability of occurrence of fire for forests, rangelands, and grasslands at a 1-Kilometer resolution for the conterminous United States and Alaska.

5.3 Tsunami Relief Efforts

In response to the tsunami destruction in Southeast Asia, the USGS contributed to the disaster relief efforts by supplying before and after satellite images of the region through EROS. Within hours after the disaster occurred on December 26, 2004, EROS began providing relief organizations worldwide with Landsat 5 and Landsat 7 pre- and post-tsunami satellite images, as well as image-derived products that incorporate information on population density, elevation, and other relevant topics. These images and image-derived products are being used by relief organizations to make practical, well-informed decisions as to where relief efforts are most urgently needed and how best to carry out those efforts. As of June 30, 2005, approximately 915,000 files, more than 14 terabytes of satellite data had been made available, covering approximately one million square miles of coastal and inland areas. These products can be accessed via *The National Map Hazards Data Distribution System* at <http://gisdata.usgs.gov/website/tsunami/>.

In addition, the USGS procured approximately 5,700 square miles of high-resolution commercial satellite imagery over key tsunami affected areas in the Indian Ocean. The commercial satellite imagery was purchased from Space Imaging, Digital Globe, and SPOT Image. The commercial products consisted of multispectral imagery at 4-meter resolution and a single-band panchromatic at 1-meter resolution and provided detailed depictions of tsunami-impacted coastal areas.

The EROS emergency response team won the Information Resources Management Conference (IRMCO) 2005 Team Award for its support of tsunami relief/response/recovery efforts. The IRMCO Award is a prestigious award presented each year to those who have demonstrated exceptional ability to operate across organizational boundaries to improve the Government's services to its citizens. The selection was based on the following award criteria:

- Demonstrated leadership in operating across organizational boundaries;
- Willingness and ability to treat obstacles as challenges, and not barriers; and
- Measurable improvements in performance linked to mission objectives/results.

The team was recognized for providing emergency support to many Federal and international organizations that helped the victims of the December 2004 tsunami.

The tsunami event tested EROS disaster response capabilities as never before. The work required an enormous amount of coordination and support, 24 hours a day, 7 days a week. In the eight weeks that followed the tragedy, more than 915,000 files, 14.4 terabytes of data, were electronically downloaded from the EROS FTP site. Another 1 terabyte of data was delivered on media. The global disaster relief community required more than 70 percent of the EROS network bandwidth during the month of January.

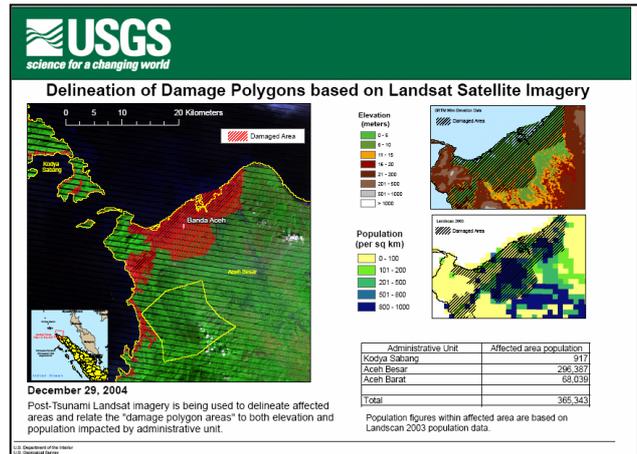


Figure 3. Delineation of damage polygons from Landsat imagery with Shuttle Radar Topography Mission 90-m Digital Elevation Model and affected population

6. CONCLUSIONS

The tsunami disaster validated the following basic premises—that there is a great need for remotely sensed data during disaster response operations. The tsunami's devastation was so vast that the Landsat 5 and Landsat 7 satellites, which provide multispectral 30-meter ground resolution imagery, once again became a prime source of remotely sensed imagery. Detailed commercial imagery was also acquired to support emergency response operations.

The maturity of the U.S. Commercial Remote Sensing Space Policy and Clearview licensing will continue to evolve and provide greater data availability of commercial data for U.S. civilian agencies. Nextview licensing, under negotiation at this time, will provide even greater opportunities for data sharing among agencies.

While the data in its own right was valuable, what was also discovered via discussion at the recent CEOS meetings was the need to effectively process and produce appropriate products to support the emergencies in a timely manner.

Future discussions on methodologies to improve response to emergencies will unfold through the CEOS Working Group on Information Systems & Services Data Utilization Task Team.

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