The National Map Hazards Data Distribution System

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Abstract

The U.S. Geological Survey (USGS) EROS Data Center (EDC) responds to emergencies on behalf of various Government agencies for human-induced and natural disasters. This response consists of satellite tasking, imagery acquisition, image registrations, disaster-extent maps, data processing and photographic laboratory services, Web-based mapping services for product delivery, and post-disaster data archiving and distribution.

EDC staff also work on disaster preparedness, including providing base data such as satellite images, vector data layers, and other pre-disaster data. These data augment eight base layers provided by *The National Map* and are incorporated into a Web-based browser and data delivery service, *The National Map* Hazards Data Distribution System (HDDS). These data are made available until the usage for a particular event declines substantially; then they are moved to a near-line archive. When usage has declined completely, the data are stored in an off-line archive. A goal of HDDS is to anticipate customer requirements and provide efficient delivery of disaster data and services.

1. Introduction

Natural disasters are constant reminders of how powerful nature can be. The impact of these disasters can be devastating. There have been many advances made in the areas of public awareness and planning for disaster preparedness, response, and mitigation, but “the most remarkable advances, however, have come as

computer speeds and capacities make possible new applications and extensions of geographic information systems." [i] Historically, the issue of information integration has been problematic. However, the improvement in computer capabilities allows for the integration of information from a variety of sources and organizations, helping to solve a fundamental issue facing crisis responders.[ii] Integration allowed by these improved services has helped reduce costs by facilitating the sharing of consistent datasets among agencies and by providing archiving capabilities that allow for easy data reuse.

This paper discusses *The National Map* Hazards Data Distribution System, a disaster response system that includes satellite tasking and data acquisition, product development, Web applications, and data archiving. A summary of each activity will be found in the following sections.

1.1 Satellite tasking and data acquisition

The USGS EDC has been engaged in emergency response activities for many years. The USGS EDC functions as the Federal Emergency Management Agency's (FEMA) executive agent for the acquisition and coordination of commercial and civil government aerial and satellite remote sensing during national disaster response operations. The USGS EDC also

has Memorandums of Understanding (MOU) with other State and Federal agencies for emergency response support. These MOUs are being supported through the implementation of *The National Map* HDDS.

An emergency request is one that involves a national emergency, national security, law enforcement matters, or that is a matter of life and death, personal injury, or severe property loss. Typical emergency requests might originate from the Department of Defense or Central Intelligence Agency, law enforcement agencies, or from the Department of Homeland Security/FEMA. Requests for data commonly occur at the onset of natural disasters such as fire, flood, hurricane, earthquake, or volcanic eruption.

The most critical and yet difficult category of information to capture immediately following a disaster is accurate and timely intelligence about the scope, extent, and impact of the event. The infrastructure and environmental trauma resulting from the disaster may also hinder or prevent the timely acquisition of such information. And yet, the disaster related remote sensing tasking and acquisition process begins with the identification of such information.

Remote sensing is the aerial or satellite acquisition of information. The capabilities available through remote sensing are integral to the assessment process and directly support the information and planning activities. Remotely sensed information can prove valuable to emergency managers throughout the life cycle of the event; from emerging threat through the post disaster recovery plans. Remote sensing capabilities can vary according to a wide variety of factors including availability, sophistication of collection systems, sophistication of measurement systems, type of data platforms, and data processing requirements.

Every disaster, emergency, or threat should be evaluated for supportability by remote sensing. Some basic questions that need to be answered are:

- Is the information necessary or just nice to have?
- Will the absence of the requested information have an adverse effect on the operation?
- Is the remote sensing required to support explicit planning and decision-making?
- Is the requested information discernable from the analysis of the imagery?
- What is the overall size of the area?
- Is it geographically remote?
- Does it support disaster response activities?
- How fast is the imagery or derived information needed?
- How often is the imagery or derived information needed?
- What level of resolution is required?
- Are other sources of information available?
- How quickly will the information usefulness diminish?
- When will it no longer be needed?

Each type of disaster or hazard has specific characteristics that are best characterized by specific remote sensing data. The USGS EDC is able to provide support in an advisory capacity to assess the remote sensing needs pertaining to a particular disaster. This support includes providing remote sensing products in a real-time capacity and also includes supplying personnel to assist with disaster

support. The USGS EDC can provide data sets from Landsat 1-5 and 7, digital orthophoto quadrangles, digital raster graphics, digital line graph, and digital elevation model in accordance with applicable data pricing and distribution policies and agreements. Other data sets that can be supplied include Advanced Spaceborne Thermal Emmission and Reflection radiometer (ASTER), Moderate Resolution Imaging Spectroradiometer (MODIS), Advanced Very High Resolution Radiometer (AVHRR), Hyperion, Advanced Land Imager (ALI), IKONOS, Quickbird, SPOT, Radarsat, aerial photography, and Disaster Monitoring Constellation (DMC). Data will be acquired for each event that meets the specified criteria. The data will be obtained from the most cost effective data providers whose imagery meets the criteria needed for responding to the event. The data will be made available around the clock and acquired in a timely fashion by USGS staff. The data will be processed to a standard processing level, preferably precision terrain corrected. If that level of processing is not possible, then the next highest level will be sought. The USGS EDC will also take on the responsibility of invoking the International Charter: Space and Major Disasters. The data provided by the Charter is free of charge but may have provider distribution restrictions that would need to be applied.

1.2 Product Development

New product development and image analysis are vital to ensure continuing usefulness of remote sensing imagery for disaster response. The imagery is intended for use by those with little remote sensing background, so the analysis needs to be completed and literal products need to be delivered to the field. This value-added processing needs to occur in an expedited fashion, delivering the

products to the field in as short a time as possible. Value-added processing can be done for other Federal agencies or for those agencies with a current MOU in place. These products can also be made available via a web-based delivery system. Research into new applications is a critical part of the product development cycle. This research needs to take into account new sensors, new image processing techniques, and new customer requirements. Some of the current research and product development areas include:

1. Lidar research for feature extraction, integration with other remote sensing data types, vegetation mapping and monitoring, hydrologic applications, and verification of land cover products.
2. Radar research for urban area subsidence, volcano and earthquake deformation, flood inundation, and flood mapping classification.
3. Fire science research for burn severity assessment, fire danger monitoring, and fire fuels assessment and mapping.

1.3 Web Applications

The HDDS will provide *The National Map* base data layers as a default data set. Whenever a disaster occurs, an icon representing the disaster type (i.e. flood, tornado, hurricane, fire, earthquake, volcano, etc.) will be placed over that particular location on the map. When the user clicks on that icon, they will be provided with details on the disaster, along with all relevant satellite imagery and value added products for that location. The HDDS will link to state and local data servers as appropriate and will provide access to new acquisitions, GIS data layers, and other

value-added products as they become available. Some of the essential elements of information that may be required are:

- Boundaries of the disaster area.
- Social, economic, or political impacts.
- Status of the transportation systems and their critical facilities.
- Status of the communication network.
- Access points to the disaster area.
- Status of any operating facilities.
- Hazard specific information.
- Weather data affecting operations.
- Status of critical facilities and distribution centers.
- Status of remote sensing activities.
- Key personnel.
- Historical or demographic information that may be useful.
- Status of energy systems.
- List of participants (Federal, State, Local).

The data will be delivered in standard formats and map projections. The map projection will be determined based on the size and location of the event. The pixel sizes will be determined by the original resolution of the imagery. The datum will default to NAD83 in the conterminous U.S. and WGS84 for the rest of the world, unless specifically requested otherwise. The standard delivery formats will be either the native format of the provider or GeoTIFF.

The data delivery will be provided via the web, ftp, and media deliveries. The media deliveries will occur only if the web and ftp are not functioning or viable alternatives to a speedy response. All participating agencies will have a usercode/password to access the protected web/ftp site.

All new data acquisitions will be licensed appropriately to promote the sharing or information by all participating agencies. USGS EDC recognizes the importance of agencies working together to respond effectively to a major terrorist incident or natural disaster. Therefore, a mechanism will be in place for participating agencies to submit their value-added products or other data layers for distribution.

1.4 Data Archiving

An archive is defined as the non-current records of an organization preserved because of their continuing or enduring value. The USGS EDC houses the National Land Remote Sensing Data Archive (NLSRSDA). The NLSRSDA consists of Landsat MSS, Landsat TM, Declassification I and II, AVHRR, and SPOT data. The USGS archive contains aerial imagery, satellite imagery, cartographic data, and topographic data in analog and digital forms. These data sets are all available for use as historical and pre-event imagery.

The data on the HDDS will be located on readily accessible on-line disk until the demand has diminished and the agencies agree that the data can be moved to near-line storage. The near-line archive consists of a Storage Tek tape silo. The data will be moved in its entirety to the silo and will be stored there until such time that no data requests have been received for a period of three months. The data on

the silo are easily accessible through a special request and can either be restaged to the web/ftp servers or be made available through media requests. The access time for this data would be hours.

If the data have not been accessed on the tape silo for a period of three months, it will be migrated to tape media and moved to the long-term tape archive. The media locations will be logged in the tape library and an offline database of all contents will be created and stored. These data will be accessible through special requests and can be restored in 1-2 days. When access has been requested, the products can be served either via the web/ftp or through media delivery. When recurring events happen in the same location, the archive data sets will be restored to the web/ftp site of the new event. This data will provide a historical look at previous events and damage extent, which can be used as a basis for evaluating the current disaster.

2.0 Conclusions

The concepts presented in this paper will allow the USGS to provide disaster response in a timely and proactive fashion. The data will be easily accessible, in standard formats, and the response community will have the opportunity to share their value added-products with one another. There are many benefits to be gained by the implementation of this system. Benefits include:

1. Data sharing among agencies ensures that the same images are being used. This will allow for cooperation and sharing of value-added products, because standards are in place.

2. Near-line and off-line archiving and retrieval ensure that the data is preserved for historical evaluation and reuse. This also saves dollars for future studies and for events that occur in the same location.
3. Provides the capability to do pre-disaster work in areas of high risk. Flood models and other GIS capabilities would be built and integrated into the web delivery system.

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[i] G. Amdahl, *Disaster Response GIS for Public Safety*, p. 2, ESRI Press, Redlands, CA.
[ii] National Research Council, *Information Technology Research for Crisis Management*, p. 26, National Academy Press, Washington, DC

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