Lesson 7: Using Remote Sensing Products

Lesson Overview

This lesson will focus on remote sensing capabilities and the use of remote sensing products in GIS.

This lesson should take approximately 10 minutes to complete.

Learning Objectives

By the end of this lesson, you will be able to:

- Identify remote sensing capabilities
- Recognize the steps of the remote sensing workflow process
- Use FEMA damage classification system to convey the severity of an incident

Tying It Back to the Job

This lesson aligns with the following PTB Behavior/Activity:

- Manage geospatial data

What is Remote Sensing?

Remote sensing (RS) refers to the acquisition of information (typically imagery) from ground, aerial, or satellite sensors.

RS is very useful during an event when areas are isolated or communication is limited. RS can provide critical information about an event, which can then be integrated into geographic information systems to produce maps or analytic databases.

This information can then be used by emergency managers and decision makers at all levels of the response structure.

How is Remote Sensing Used?

Remote sensing capabilities greatly improve a geospatial information unit's ability to provide situational awareness for a wide area in a very short timeframe.

Imagery and the data derived from it can be used to:

- Assess levels/patterns of damage within disaster areas.
- Assess impacts to populations and critical infrastructure.
- Monitor and assess the extent of flood inundation and storm surge extents.

- Assess scope and extent of debris fields within an area of impact (AOI).
- Support Situation Awareness in inaccessible areas.
- Quickly assess the order of magnitude of an incident.
- Enhance communication with survivors about the status of property and infrastructure.

Remote Sensing Capabilities

In your role as GIS Specialist, you will analyze data and images gathered by remote sensing sensor capabilities attached to platforms (e.g., satellites, planes and ground vehicles) that can observe areas of interest (AOI).

To gather the information needed (and account for differing environmental factors), a number of different capabilities may be used.

- Panchromatic Imagery
- Multispectral Imagery (MSI)
- Hyperspectral Imagery (HSI)
- Oblique Imagery
- Infrared Radiation (IR)
- RADAR
- LiDAR

Panchromatic Imagery

Panchromatic images are literal representations of objects or terrain derived from capturing reflected visible light by means of a panchromatic system. Unlike photography it does not use chemically processed film and therefore may be available on a Near Real-Time (NRT) basis. Panchromatic imagery can be obtained from satellites, aircraft, or unmanned aerial systems (UAS).

Projected uses for panchromatic imagery include:

- Assessing levels and patterns of damage within disaster areas
- Assessing scope and extent of debris fields within disaster areas
- Monitoring and assessing the extent of flooding

Multispectral Imagery

Multispectral remote sensing is the process of simultaneously measuring reflected or emitted energy across a variety of relatively narrow spectral bands, ranging from ultraviolet to the thermal-infrared portion of the electromagnetic spectrum.

Projected uses include:

- Analyzing changes to an area before and after an event (also known as 'change detection')
- Detecting pollution in or toxic contamination of water and soil
- Assessing the impact of drought on agriculture
- Providing a broad indication of flood inundation

Hyperspectral Imagery

Hyperspectral imaging is the process of scanning and displaying an image within a section of the electromagnetic spectrum. To create an image the eye can see, the energy levels of a target are color-coded and then mapped in layers. This set of images provides specific information about the way an object transmits, reflects, or absorbs energy in various wavelengths. Using this procedure, the unique signature can reveal valuable information otherwise undetectable by the human eye, such as fingerprints or contamination of groundwater or food.

Projected uses include:

- Detecting pollution in or toxic contamination of water and soil
- Assessing the impact of drought on agriculture

Oblique Imagery

Oblique imagery is aerial photography – taken by a low-flying aircraft equipped with a five camera system – that is captured at approximately a 45 degree with the ground. This allows viewers to see and measure the sides of objects, in addition to the tops. Oblique imagery more closely resembles how people typically view their landscape as opposed to orthogonal images, which are overhead photos from a long-range satellite. Oblique imagery has the ability to measure water marks of each point it photographs.

Projected uses include:

- For major events, oblique imagery provides additional details about damaged areas and may help to identify damage to buildings.
- Post-event oblique imagery can help identify collapsed and damaged buildings where traditional "top-down" imagery will only show rooftops.

Infrared Radiation

Infrared radiation is electromagnetic energy just below the visible light spectrum. Infrared remote sensing instruments function by sensing infrared radiation (IR) that is naturally emitted or reflected by the Earth's surface or from the atmosphere, or by sensing signals transmitted from, and reflected back to, a satellite or aircraft. Since thermal IR data are based on temperatures rather than visible radiation, the data may be obtained day or night.

Projected uses include:

- Determining forest fire or wildfire boundaries, or spot fire flare-ups
- Assessing damage to vegetation from various hazards
- Assisting in non-urban search and rescue activities

RADAR

Radar, which stands for RAdio Detection And Ranging, is a method of sending and receiving electromagnetic waves to determine the range of remote objects through measurement of the returned signals. Radar imaging provides the ability to detect objects at distances where sound or visible light emissions would be weak or non-existent.

Projected uses Include:

- Determination of flood extents
- Identifying changes to terrain and land surface
- Identification of oil spills on water.
- This data is especially useful in combination with comparable pre-event data of this type.

LiDAR

Light Detection and Ranging (LiDAR) works something like Radar, but instead of transmitting radio waves, LiDAR transmits laser light pulses. The light bounces off objects and scatters. A telescope receives the backscattered light and a detector measures the intensity. Using the data, a computer produces a precise 3D image.

LiDAR instruments can operate as profilers and as scanners, day and night. LiDAR can also serve as a ranging device to determine altitudes (topography mapping) and depths (in water).

Airborne LIDAR is very useful during an event because it can be used to measure heights of objects and features on the ground more accurately than with radar technology.

Projected uses include:

- Detecting small changes in land surface
- Detailed 3D modeling of land and structures
- Detecting near shore changes in bathymetry

This data is especially useful in combination with comparable pre-event data of this type.

Geo-Tagged Photos

While satellites and planes are a valuable resource for gathering data remotely, today they are no longer the only tools available. Smartphones can also be used to access geospatial data. With the increased availability of “smartphones” and GPS enabled digital cameras, emergency management personal can now provide critical information on developing situations in near-real time.

In addition, the aggregation of these photos (for example in social media outlets) can provide additional perspective on the “where and when” of developing situations.

Geospatial data

Geo-Tagged photos contain reference information, usually geographic coordinates (latitude and longitude) that indicate the location of the image. These photos can be collected easily and displayed immediately in situational awareness viewers to provide information about specific events.

360° Interactive Video

360° interactive video is also used to provide needed GIS information. This technology stitches photographs together to provide the end user with a unique virtual experience. Many users are now familiar with this process, in part thanks to Google’s Street View© or Microsoft’s Street Side©.

This imagery can be quickly collected with specialized equipment mounted on automobile roofs and processed immediately following collection. Processed imagery can be posted and available for use in most mapping applications shortly following acquisition.

Full-Motion Video (FMV)

Another technology used to provide GIS information is full-motion video (FMV). FMV provides the ability to view motion imagery dynamically in real-time (RT) or near-real time (NRT).

The continuous and persistent NRT capability of the feed enables users to view changes over time to the same target area. In addition, FMV can be simultaneously broadcast to multiple consumers, allowing all echelons (HQ, Regional, Field, State, etc.) to view the same picture at the same time.

Accessing RS Data

With proper coordination, RS data can be available to any user to assist with mission support requirements. For Stafford Act events, RS efforts are coordinated by FEMA through the JFO, RRCC, and NRCC RS Coordinators.

As the ESF 5 Coordinator, FEMA works with the US Geological Survey (USGS), National Geospatial Intelligence Agency (NGA), Department of Homeland Security (DHS), and other Federal departments and agencies. Imagery is acquired, analyzed, and disseminated using a systematic process referred to as TCPED that includes five phases: tasking, collection, processing, exploitation, and dissemination.

Collection Management

When working with remote sensing data, you will follow the TCPED framework shown here.

Tasking

The tasking phase of the project production process begins with the receipt of a GIS request. This request is received directly by the GIUL for large incidents or the GIMG for smaller incidents. The request may be submitted in either hardcopy or electronic format.

The responsibility for tasking can be left to the GIUL at the Incident-level when assets are locally available and the expenditures have been approved and justified through the chain of command; however, most large and medium scale disasters will require extensive coordination with the Region and the HQ Remote Sensing Coordinator.

The determination of the area of interest (AOI) for collections is based on support requirements identified through the Joint Incident Objectives and Priorities set by the Unified Coordination Group. While it is safe to assume that adjacent areas will be included, requests for imagery should be very specific in coverage area and identify specific targets.

Collection

Once preliminary tasking is completed, the collection phase begins. This phase focuses on the acquisition of “raw” imagery. Because the post-event environment is dynamic, tasking and collection are closely linked; the combined tasks are reliant on continuous feedback.

Processing

During this phase, acquired imagery is processed. The processing requirements can include image registration, rectification, color balancing, and others. Once complete, the imagery is available for exploitation and dissemination.

Processing is often the most time-consuming, technically challenging, and resource-intensive process within the remote sensing lifecycle. Therefore, users in the Field are urged to rely on organizations with higher end workstations, broader bandwidth network infrastructure, and dedicated staff with reach back capabilities.

Several platforms exist, especially within the Department of Defense (DoD), which can assist FEMA personnel with the rapid receipt and processing of geospatial data, imagery, and other media.

Exploitation

This phase provides the interpretation required to generate usable end products. Analysis may be automated or interpreted visually by imagery analysts to derive vector data from the imagery source data. This derived data can then be attributed with key pieces of information to add value.

Dissemination

The final phase of the process ensures that the imagery and derived products are effectively delivered and available to the end users and products. This may be accomplished through a person-to-person exchange of physical media, embedded into a map viewer, or passed through email or web-based tools.

FEMA Damage Classification System

During an incident, RS data and imagery are analyzed and annotated based on the damage classification system guidelines developed by FEMA.

These guidelines are used by geospatial analysts to determine the type and magnitude of damage. Trained image analysts, including staff from NGA, delineate the damaged areas according to FEMA's criteria and provide this information to responders in both map and data product formats.

Lesson Summary

This lesson presented the following topics:

- Remote sensing capabilities
- The remote sensing workflow process
- FEMA Damage classification system

The next lesson explains how to check out of an incident.