



All Source Solution Decision Support Products Created for Stennis Space Center in Response to Hurricane Katrina

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Abstract

In the aftermath of Hurricane Katrina and in response to the needs of SSC (Stennis Space Center), NASA required the generation of decision support products with a broad range of geospatial inputs. Applying a systems engineering approach, the NASA ARTPO (Applied Research & Technology Project Office) at SSC evaluated the Center's requirements and source data quality. ARTPO identified data and information products that had the potential to meet decision-making requirements; included were remotely sensed data ranging from high-spatial-resolution aerial images through high-temporal-resolution MODIS (Moderate Resolution Imaging Spectroradiometer) products. Geospatial products, such as FEMA's (Federal Emergency Management Agency's) Advisory Base Flood Elevations, were also relevant. Where possible, ARTPO applied SSC calibration/validation expertise to both clarify the quality of various data source options and to validate that the inputs that were finally chosen met SSC requirements. ARTPO integrated various information sources into multiple decision support products, including two maps: *Hurricane Katrina Inundation Effects at Stennis Space Center* (highlighting surge risk posture) and *Vegetation Change In and Around Stennis Space Center: Katrina & Beyond* (highlighting fire risk posture).

Higher Resolution Image Evaluation

Remote sensing data, with GSDs (ground sample distances) from 0.30 m aerial images up to 1 km MODIS products, were identified by ARTPO as relevant. Evaluation of the higher resolution sources is highlighted here.

Access:

Conveniently, a large quantity of data was distributed through the USGS (U.S. Geological Survey) Center for EROS (Earth Resources Observation and Science) Hurricane Katrina Disaster Response Web site. Of the data available at the USGS, much of the high-resolution satellite data was purchased through the National Geospatial-Intelligence Agency ClearView contract.

Source	Sensor	Access
3001 (for U.S. Army Corps Engrs.)	ADS 40	FTP pull from http://edcftp.cr.usgs.gov/pub/data/disaster/katrina/usace_aerial/ (and other sources)
DigitalGlobe	QuickBird	FTP pull from http://edcftp.cr.usgs.gov/disaster_restricted/katrina/quickbird/ (password protected for U.S. government users)
OrbImage (now GeoEye)	OrbView-3	FTP pull from http://edcftp.cr.usgs.gov/disaster_restricted/katrina/orbview/ (password protected for U.S. government users)
Space Imaging (now GeoEye)	IKONOS	FTP pull from http://edcftp.cr.usgs.gov/disaster_restricted/katrina/ikonos/ (password protected for U.S. government users)

Formats:

However, file formats and coordinates systems varied considerably.

Source	Sensor	Product	Format	Projection	Horizontal Datum
3001 (for U.S. Army Corps Engrs.)	ADS 40	mosaic with 3 multispectral bands (red, green & blue), nominal 1 foot GSD	GeoTIFF 1.0	Geographic	NAD 83
DigitalGlobe	QuickBird	single acquisition panchromatic band, nominal 60 cm GSD	NITF 2.0	RPCs ref. to Geographic	RPCs ref. to WGS 84
OrbImage (now GeoEye)	OrbView-3	single acquisition panchromatic band, nominal 1 m GSD	GeoTIFF 1.0 (NITF available)	Geographic	WGS 84
Space Imaging (now GeoEye)	IKONOS	single acquisition panchromatic band, nominal 1 m GSD	GeoTIFF 1.0 (NITF available)	UTM	WGS 84

Geopositional Accuracy:

Geopositional accuracies ranged from 7 m to 25 m (CE₉₀). High-resolution commercial remote sensing products were consistent with product specifications for standard georeferenced products. Corps of Engineers aerial imagery, although acquired at a higher spatial resolution (0.30 m GSD), fell into the same range as the satellite remote sensing products. However, the Corps of Engineers imagery displayed significant and complex systematic errors that resulted from rapid image processing and mosaicking.

Source	Sensor	Acquisition Date	GSD	Geopositional Results			
				CE ₉₀ (m)	CE ₉₅ (m)	RMSE (m)	RMSE (m)
3001 (for Corps of Engrs.)	ADS 40	9/3/2005 - 9/30/2005	0.30	10.94	11.14	7.52	
DigitalGlobe	QuickBird	9/6/2005	0.60	24.73	24.85	23.86	
OrbImage (now GeoEye)	OrbView-3	9/2/2005	1.00	9.79	10.11	8.11	
Space Imaging (now GeoEye)	IKONOS	9/2/2005	1.00	8.59	8.61	8.22	
Space Imaging (now GeoEye)	IKONOS	9/13/2005	1.00	7.62	7.74	7.30	

Geopositional Accuracy Requirements

Drivers underlying decision support requirements for SSC included

- Ability to co-register with other information sources
- Ability to co-register multiple dates to detect change

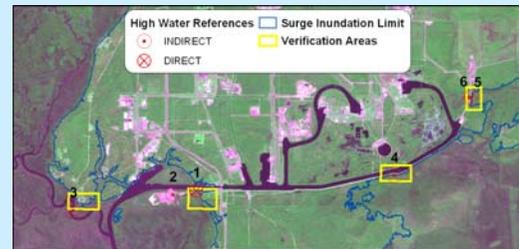
These drivers suggested absolute accuracies of 3 m (CE₉₀) or better to avoid artifacts and co-registration discrepancies that would reduce user confidence. As a result, none of USGS-distributed data sources were sufficient for immediate use; they all had to be rectified or orthorectified using ground control.

Surge Inundation Limit/High Water Mark Verification

Since the maximum inland extent of the Katrina storm surge had significant implications for many decisions regarding recovery, it was important to verify accuracy of surge-related data products with spatial coverage of Stennis Space Center and its surrounding buffer zone. Both HWM (high water mark) surveys and the surge inundation limit maps were generated under task orders from FEMA. FEMA teams surveyed high-water marks across the region; then GIS (geographic information system) analysts screened HWMs for data quality and used the best HWMs to interpolate an estimated high-water surface. The analysts intersected high-water pre-storm topographic elevations to estimate the surge inundation limit for maps and GIS products.

In February 2006, ARTPO verified high-water information, consisting of high-water marks and surge inundation limit map products, in three ways:

- 1) ARTPO technicians surveyed identified FEMA high-water marks directly
- 2) Using GIS analysis, ARTPO compared surge inundation limits with surveyed high-water evidence in the vicinity
- 3) ARTPO compared surge inundation limits qualitatively with early post-Katrina imagery



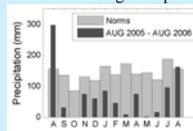
Summary of geographic distribution of high-water information verification effort (Includes material © Space Imaging, LLC)

Decision Support for Surge Risk Posture

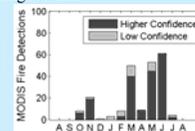
Once requirements and data quality were established, a decision support product was generated. This product complemented standardized FEMA "Katrina Recovery Map" information and extended that information to all pertinent areas of Stennis Space Center. This decision support product took the form of a map with the title *Hurricane Katrina Inundation Effects at Stennis Space Center* (first map on the right). This map employed IKONOS imagery as a base map, FEMA surge inundation limit estimates, NOAA Coastal Services Center lidar data acquired by EarthData, and Disaster Monitoring Constellation imagery for a regional overview.

Decision Support for Fire Risk Posture

Fire risk spiked on multiple occasions in the months following Hurricane Katrina due to the magnitude of fallen and damaged timber that was an immediate consequence of the storm and the year-long drought that ensued after the storm. Evaluation of vegetation change showed its potential to shed light on SSC fire risk posture. As a result, *Vegetation Change In and Around Stennis Space Center: Katrina & Beyond* (second map on the right) was created. This map employed QuickBird imagery as a base map and as a high-resolution change source, AWiFS (Advanced Wide Field Sensor) as a medium-resolution change source, and MODIS as a low-spatial-resolution/high-temporal-resolution change source.



SSC rainfall following Katrina



Fires near SSC (Hancock Co., MS) following Katrina