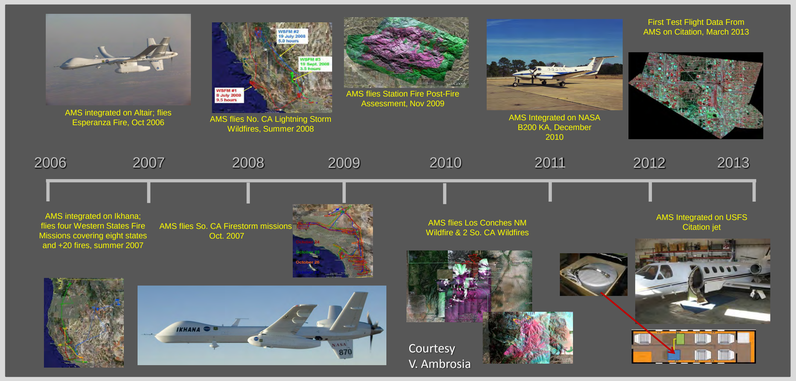
United States Department of Agriculture

Forest Service

Forest Service Autonomous Modular Scanner Testing, Integration and Operational Use

Background

The Autonomous Modular Scanner (AMS) - Wildfire Sensor is a multi-mission airborne sensor system developed at the NASA-Ames Research Center. The 16-channel Wildfire scanner was for operations on both manned and UAS platforms. The timeline below highlights some milestones in the operational development and deployment of the AMS.



The AMS was transferred to the Forest Service in 2013 through an interagency technology transfer agreement with NASA. As part of the agreement, NASA is providing continued training and technical support in AMS operation to the Forest Service .

The AMS-Wildfire instrument is currently operated by the Forest Service aboard a Cessna Citation Bravo jet, N144Z. Planned operational missions include: wildfire imaging, post-fire assessment and various resource inventory projects. Mission development is currently being guided by the Forest Service Remote Sensing Applications Center (RSAC) in Salt Lake City, Utah. N144Z is currently the only available AMS platform in the agency.

Flight safety limitations for the Cessna Citation Bravo restrict AMS imagery acquisition to 10,000 feet AGL or higher.

AMS Specifications

The AMS wildfire instrument is an airborne multi-spectral imaging line scanner that operates in the VIS-IR-TIR bands. The table shows the approximate spectral bands for each spectrometer.

The TIR channels have been calibrated for accurate (~0.5° C) temperatures discrimination of hot targets, up to ~800°C. The TIR channels simulate those found on the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument aboard the Suomi National Polar Orbiting Partnership (S-NPP) satellite.

AMS imagery is spectrally and thermally calibrated on the aircraft then ortho-rectified using location and aircraft attitude data from an Applanix INS/IMU and 30-meter National Elevation Data (NED). The imagery is downlinked to a Forest Service FTP site using an Aircell ATG 5000 telecommunications systems.

AMS Specifications

Spectral Band	Wavelength (µm)	Landsat 5/7 Equivalent
1	0.42- 0.45	
2	0.45- 0.52	TM1
3	0.52- 0.60	TM2
4	0.60- 0.62	
5	0.63- 0.69	TM3
6	0.69- 0.75	
7	0.76- 0.90	TM4
8	0.91- 1.05	
9	1.55- 1.75 (high gain)	TM5
10	2.08- 2.35 (high gain)	TM7
11	3.60- 3.79 (high gain)	VIIRS M12
12	10.26-11.26(high gain)	VIIRS M15
13	1.55- 1.75(low gain)	TM5
14	2.08- 2.35 (low gain)	TM7
15	3.60- 3.79(low gain)	VIIRS M12
16	10.26-11.26 (low gain)	VIIRS M15
Field of View: 42.5° or 85.9° (selectable)		
IFOV: 1.25 or 2.5 milliradians (selectable)		
Spatial Resolution: 3 - 50 meters (variable based on altitude and IFOV)		

Operational Use in 2014

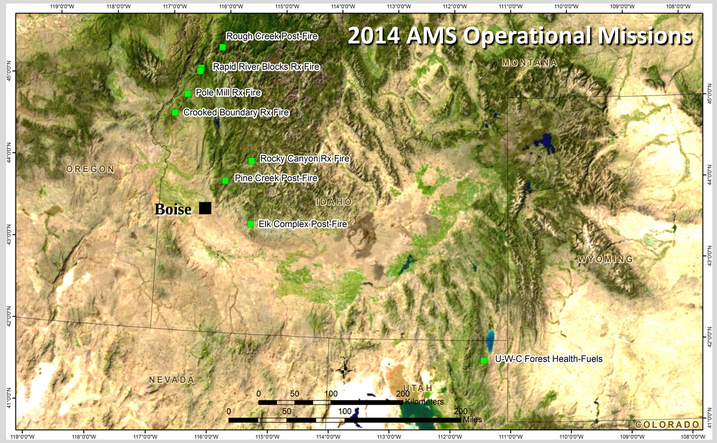
The AMS was installed on N144Z in late March 2014 and used in a series of operational and familiarization missions through late May 2014. Goals for the missions included:

- Infrared technician training and familiarization with the AMS system
- Testing of the On-Board Processing System (OBP) for near real time data production and delivery
- Remote control of the AMS from the ground using the Aircell telecommunication system

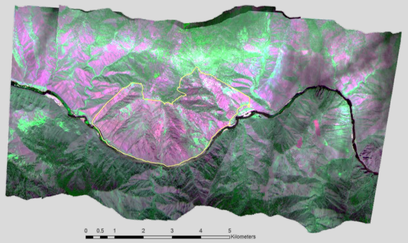
Constraints on aircraft and flight crew availability limited the missions that were flown to Idaho and Utah. The missions covered the following resource applications:

- 4 prescribed fires
- 3 post-fire assessment areas
- 1 forest fuels treatment area

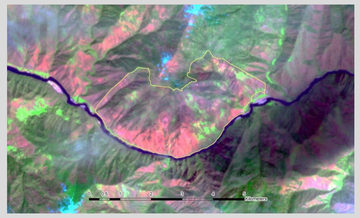
The AMS was also used in operational support of 2 wildfires in Arizona and New Mexico. This was the first use of the AMS by the Forest Service for wildfire support.



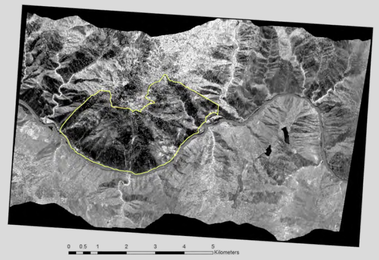
Rough Creek Post Fire Assessment
Nez Perce National Forest, Idaho 18 April 2014



BAER Imagery Product
AMS false color visual product mosaic (left), Bands 10, 9, and 7. The AMS bands correspond to the Landsat TM bands used in post fire BAER assessment.



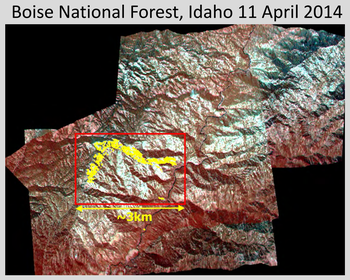
On the left is a Landsat 8 image acquired on 8 May 2014 of the Rough Creek burn scar for comparison to the AMS visual product.



Normalized Burn Ratio (NBR) Product
The image shown on the left is the NBR output product produced from the AMS imagery. The Normalized Burn Ratio (NBR) algorithm uses Bands 10 and 7 as inputs. Low/Unburned vegetation are the brighter areas in the image.

Initial Burn Severity
Low
High

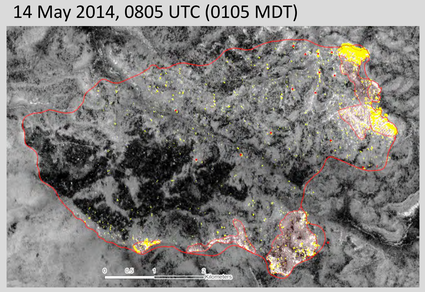
Rocky Canyon Prescribed Fire
Boise National Forest, Idaho 11 April 2014



CIR visual product mosaic (Bands 7, 5, 3) and the AMS fire detection product (yellow). AMS imagery was acquired at ≈1945 UTC (1245 MDT).

The AMS fire detection product is a modified CCRS fire detection algorithm. During daytime imagery acquisition, Bands 11, 12 (TIR) and 7 (SWIR) are used as inputs.

Signal Wildfire, Gila National Forest, New Mexico
14 May 2014, 0805 UTC (0105 MDT)



"Nightfire" visual product mosaic (Band 12) and the AMS fire detection product (yellow). At night, Bands 11 and 12 (TIR) are used as inputs to the modified CCRS algorithm.

The red polygons represent the standard National Infrared Operations (NIROPS) interpreted product that was delivered to the incident's management team. The polygons were interpreted from the AMS visual product mosaic.

Based on input from the Forest Service, an option for a three band (Bands 12, 11, 11) "Nightfire" visual product was added to the suite of AMS output products.

Next Steps For the AMS in the Forest Service

At this point in time, the Forest Service has a functional sensor and a suitable, though not optimal aircraft platform that is available on a part-time basis. The desired future condition for the AMS would have the sensor on a dedicated aircraft that would be available for a variety of resource and all hazard missions.

Near Term Goals:

- **Spring 2015**
  - Test command and control of the AMS from the ground using the Aircell telecommunication system.
  - Acquire contemporaneous AMS wildfire imagery for comparison with NIROPS Phoenix thermal imagery.
  - Continue testing and familiarization missions
  - Continue operational missions
- **2015/2016**
  - Continue working with WO-Fire and Aviation Management on the modifications to the Forest Service Southern Region King Air B200, N182Z, for use as a dedicated sensor platform.