Airborne Wide Area Imager for Wildfire Mapping and Detection (WAI)

NASA PHASE III SBIR

PHASE II CONTRACT NUMBER

NNX09CA09C

Technical Monitor: Steve Dunagan

Xiomas Technologies, L.L.C.
Principle Investigator: John Green
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734-646-6535

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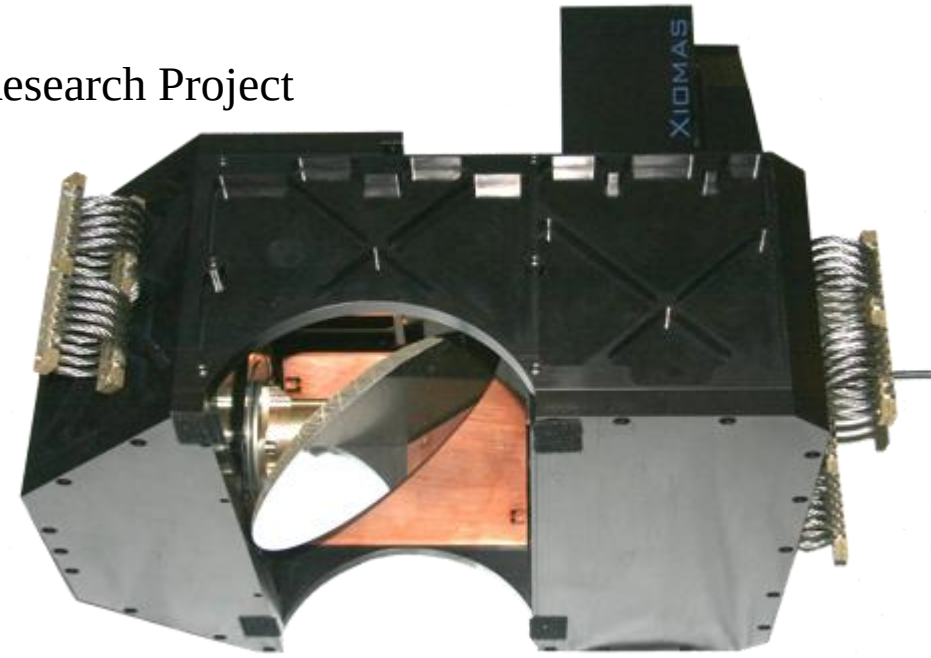
Wide Area Imager for Wildfire Mapping



- NASA Funded Small Business Innovative Research Project
- Multi-Band System – 2 to 5 Bands
  - 2 Band QWIP for Mid-Wave and Long Wave Infrared
  - 3 Band Color Infrared Sensor (Green Red NIR)
- "Step – Stare" Optical System Combines High Resolution -- 300 uRadian and Wide Field of View -- 90 Degrees
- Data System Generates Fire Layer and Terrain Layer
- Real Time Orthorectification Processing Unit (OPU) generates GIS compatible Files
- Image Classification and Compression
- Data Transmission via Ethernet -- Air to Ground or Satellite --

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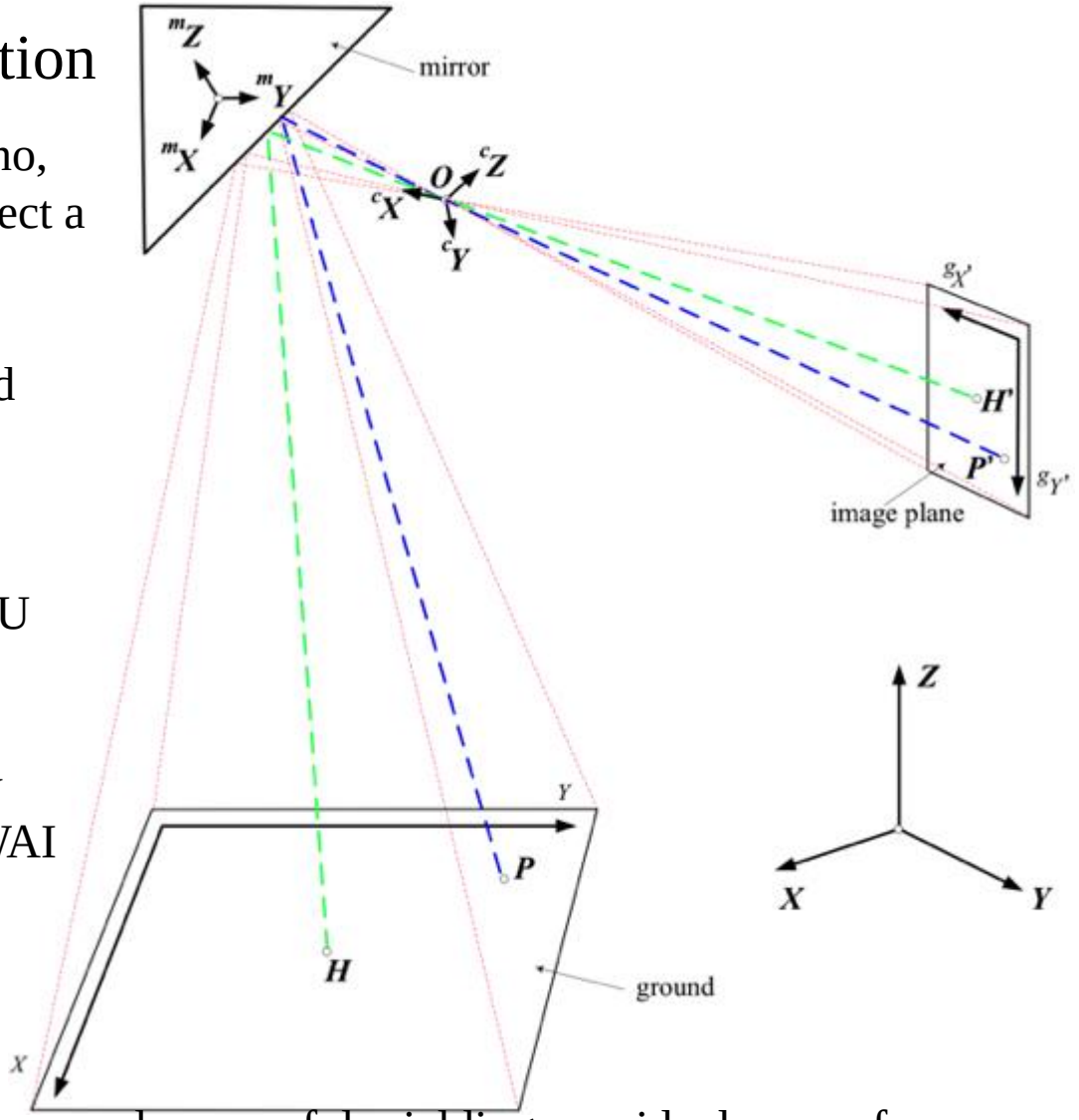
Summary of Bore Site Calibration

- The WAI sensor was flown over Reno, NV on July 11, 2011 in order to collect a dataset suitable for calibration and analysis of the system.
- The calibration process was modeled with two sets of 3-axis rotations (6 parameters)
  - one rotation modeling the transformation between the IMU and the camera optical path (standard boresight)
  - a second rotation modeling any residual rotation between the WAI scanning mirror axes and the optical path.



- Overall, this calibration approach proved successful, yielding a residual error of approximately 1 pixel RMS for image-to-image matching along a single flight line.
- Comparisons of multi-scan mosaics with existing visible-band image datasets indicates that the calibration is generally accurate to within 1-2 meters.

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WAI LWIR Mosaic and some zooms

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WAI MWIR Mosaic and some zooms

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#1 Resize (Band 1:Line4Mosaic16bitLW.tif):Line4NorthEndMosaic16bitLW.tif
File Overlay Enhance Tools Window
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#1 Resize (Band 1:Line4Mosaic16bitLW.tif):Line4NorthEndMosaic16bitLW.tif
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#1 Scroll (0.07979)


#1 Band 1:Line4Mosaic16bitLW.tif
File
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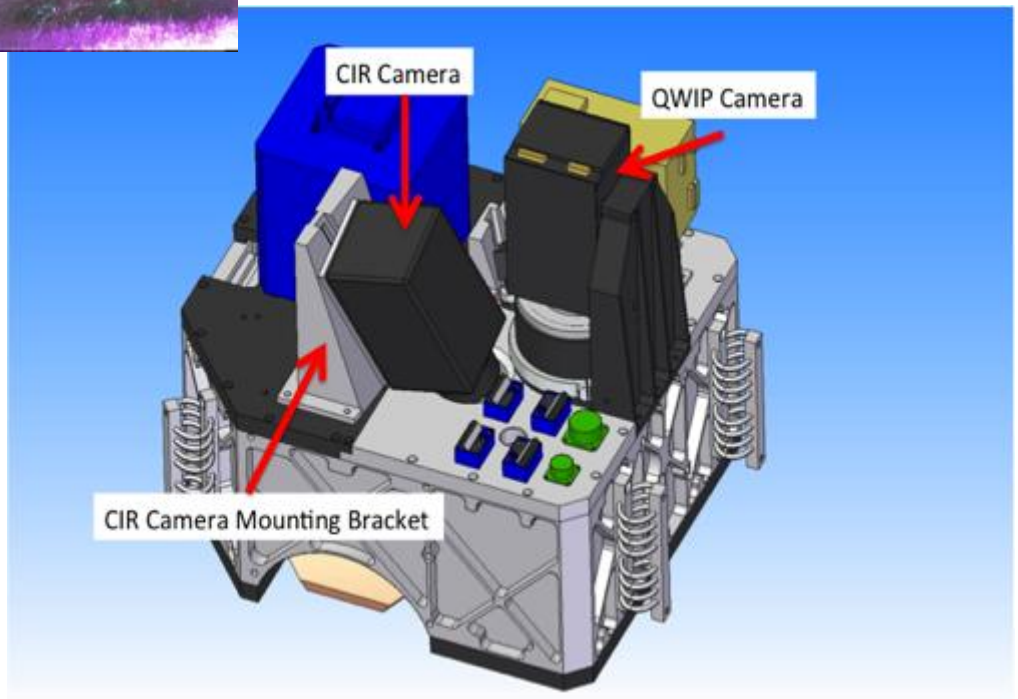
Test image from the CIR Camera

We are currently in the process of adding a 3 band Color IR Sensor to the WAI



Mechanical Design

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NASA SBIR/STTR Technologies

Airborne Wide Area Imager for Wildfire Mapping and Detection

Contract No. NNX09CA09C

PI: John M Green

Xiomas Technologies

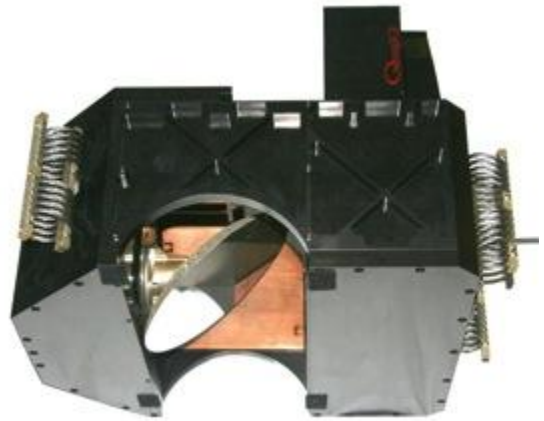
Identification and Significance of Innovation

An autonomous airborne imaging system for earth science research, disaster response, and fire detection is proposed.

The primary goal is to improve information to researchers and operations personnel at reduced cost. By operating autonomously and with higher spatial resolution, the system will deliver a 3X to 4X reduction in operating costs compared to current systems.

The system uses a two color Quantum Well Infrared Photo detector (QWIP) to improve the accuracy of energy release from wildfires, thereby improving our understanding of the carbon cycle.

Expected TRL Range at the end of Contract (1-9): 7



Xiomas Wide Area Imager Sensor Head

Technical Objectives and Work Plan

1) Detect 8-inch diameter, 600°C hot spots, while imaging the day and night ground terrain through smoke from an altitude of 30,000 to 40,000 feet.
2) Generate fuel loading and burn area classification maps.
3) Locate the image pixels to a map accuracy of 10 meters.
4) Image terrestrial features with dimensions of around 2 meters in order to observe natural and man-made fire barriers.
5) Transmit geometrically corrected and classified imagery in near real time to a centralized spatial data base.
6) The airborne system must be capable of autonomous or remote operation.
7) The airborne instrument must small enough for light aircraft or UAV installations

NASA and Non-NASA Applications

NASA:
- Unmanned Airborne System and Sensor Development
- Fire Detection and Mapping Research
- Research into the Development of Automated Sensors
- Carbon Cycle Research

US Forest Service:
- Reduced cost of National Infrared Operations
- Real Time Fire Detection and Mapping

DHS:
- Disaster Response
- Border Patrol

Firm Contacts

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NON-PROPRIETARY DATA

TMAS
Thermal Mapping Airborne Simulator
for
Small Satellite Sensor

Phase I

February 2012

NASA Proposal Number – S1.08-8082

Technical Monitor James Brass

Xiomas Technologies, L.L.C.

Phase I Contract Number: NNX12CD20P

Principle Investigator: John Green
734-646-6535

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	Small Sat	Ikhana	King Air B200	Comment
GSD (m)	94	0.93	1	
Fire detection limit	6 m by 6 m	6 cm by 6 cm	7 cm by 7 cm	Approximate based on radiometric model and flight tests with existing QWIP using kA-B fire detection algorithm
Swath Width (km)	2013	14	8.7	
Operating Altitude (feet)	2,291,250	22,750	24,375	
Operating Speed (kts)	14,600	180	280	
Step Stare Mirror Total Scan Angle aka Field of View (degrees)	110 degrees	90 degrees	60 degrees	Note that due to the very high spatial resolution, the speed of the King Air requires us to reduce the FOV. This could be adjusted by flying higher and or slower.
Frame Rate (Hz)	27	28	29	
Pixel Smear due to forward motion During Dwell Time (FMC mirror removes this)	120%	149%	216%	Pixel smear is included for information only. This drives the need for the forward motion compensation mirror (which removes the pixel smear)
Data Rates (kBytes/s)	8,100	8,400	8,700	
3 Band (QWIP plus NIR) Data Storage Required for 24 hour mission	1,001	1038	1075	

NASA SBIR/STTR Technologies

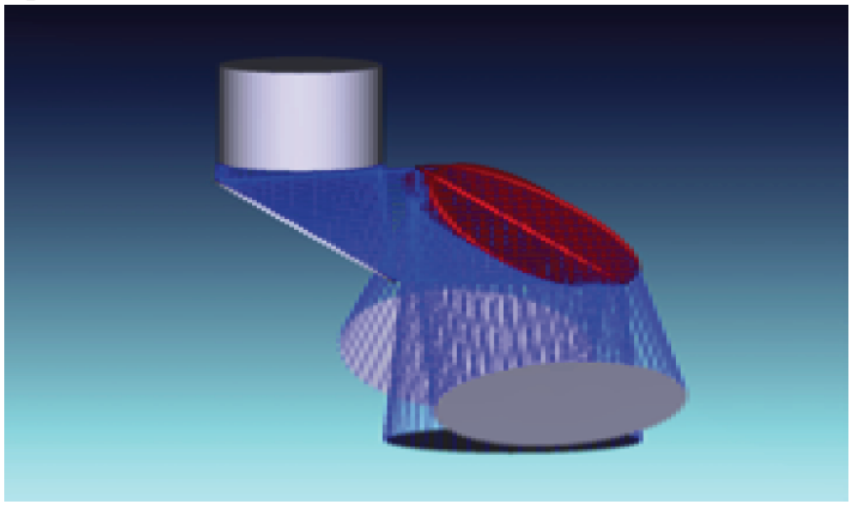
S1.08-8082 - Thermal Mapping Airborne Simulator for Small Satellite Sensor

PI: john green
Xiomas Technologies - Ypsilanti, MI

Identification and Significance of Innovation

Currently global mapping of thermal anomalies is performed by satellite based imagers operating in low earth sun-synchronous orbit, most notably the MODIS and ASTER imagers on board the satellites, Terra and Aqua.

We propose to develop the Thermal Mapping Airborne Simulator (TMAS) with the high revisit rate of MODIS but with the spatial resolution of ASTER, and have based our notional design on a 110 degree field of view (like MODIS) and a 94 meter spatial resolution (close to ASTER). Operating at the same altitude and velocity as MODIS the TMAS will have the same capability to map the globe every one to two days providing the high revisit rate of MODIS and the high spatial resolution of ASTER.



Estimated TRL at beginning and end of contract: (Begin: 2 End: 4)

Technical Objectives and Work Plan

The overall objective of the SBIR is to develop a high performance, inexpensive, airborne simulator that will serve as the prototype for a small satellite based imaging system capable of mapping thermal anomalies on the surface of the earth with a high revisit rate and high spatial resolution. The Thermal Mapping Airborne Simulator for Small Satellite Sensor will be developed to a TRL 8 in the Phase II and the space-qualified system will be developed and built in Phase III.

The proposed system will deliver high spatial resolution, high signal to noise performance, two or three spectral bands, and onboard processing to extract the information of greatest value, orthorectify the imagery, and reduce the size of the data for transmission. This sensor system is designed to fit within the size, weight, and power (SWaP) envelopes of typical remote sensing aircraft and small satellites.

For this proposal we have developed a notional design that will be reviewed and further developed during the Phase I. The proposed design incorporates a step stare scanning mirror, a two band (LWIR 8 to 9 um and MWIR 4 – 5 um) Quantum Well Infrared Photodetector (QWIP), a short wave IR sensor (1.6 um), and an FPGA based image processing and orthorectification processing module.

NASA Applications

the TMAS prototype delivered in the Phase II will be the most advanced airborne system of it's type in both the civilian and defense worlds. In addition to the primary role as a prototype for the small satellite sensor, significant interest exists in wildfire science, wildfire detection and mapping, volcanology, oil spill detection and mapping, and mapping of large for thermal anomalies in general

Non-NASA Applications

In addition to the primary role as a prototype for the small satellite sensor, the TMAS is of interest to other U.S. government agencies including: Departments of Energy (especially NA22 Nuclear Non-Proliferation), Agriculture (Forest Service), Border Patrol, and Defense.

Firm Contacts

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NON-PROPRIETARY DATA

Staring Wide Area Imager
(STAREWAI)

USDA Phase I SBIR
Contract Awarded
Start Date May 2012

Xiomas Technologies, L.L.C.

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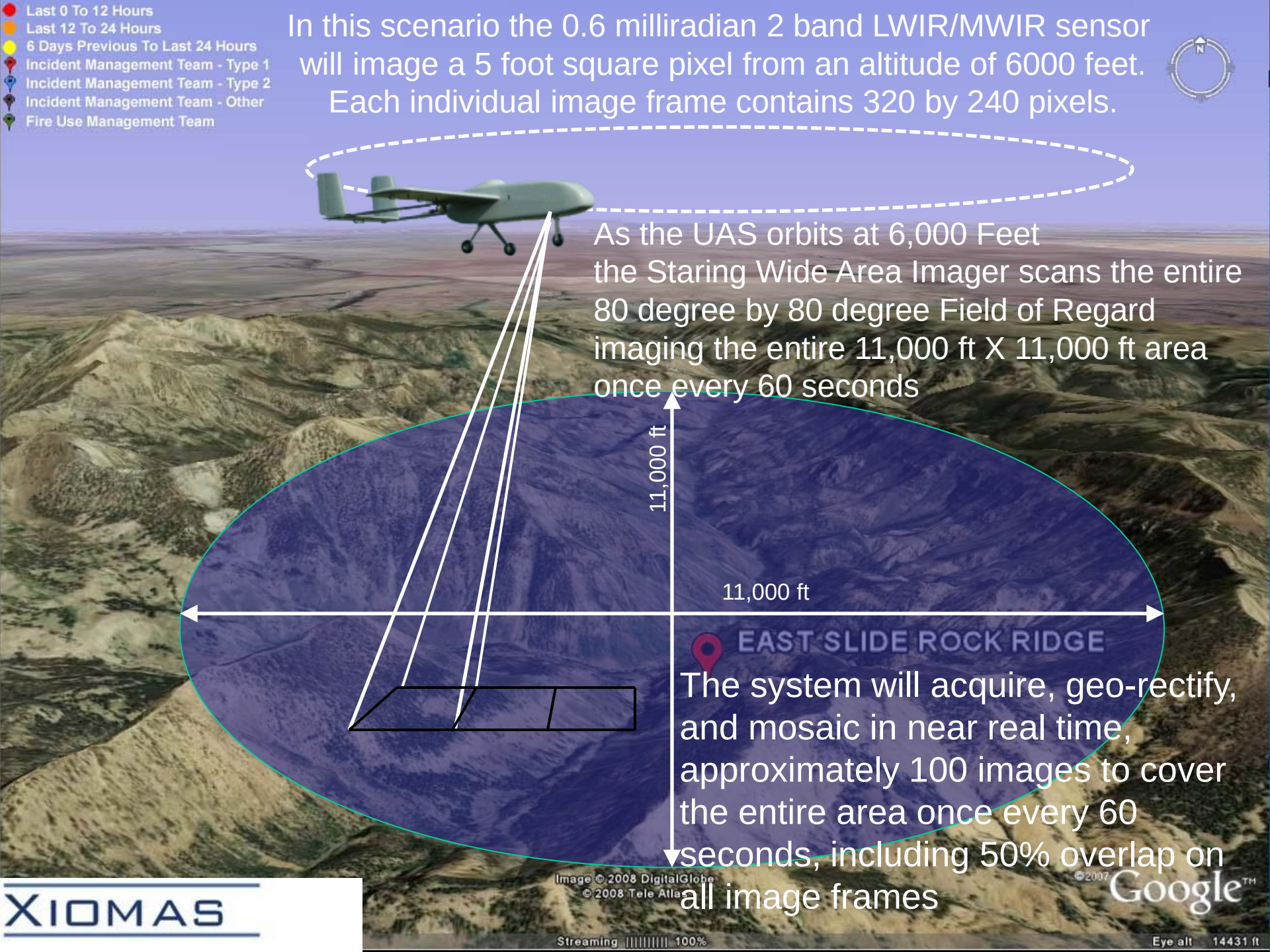
Last 0 To 12 Hours
Last 12 To 24 Hours
6 Days Previous To Last 24 Hours
Incident Management Team - Type 1
Incident Management Team - Type 2
Incident Management Team - Other
Fire Use Management Team
In this scenario the 0.6 milliradian 2 band LWIR/MWIR sensor will image a 5 foot square pixel from an altitude of 6000 feet. Each individual image frame contains 320 by 240 pixels.
As the UAS orbits at 6,000 Feet the Staring Wide Area Imager scans the entire 80 degree by 80 degree Field of Regard imaging the entire 11,000 ft X 11,000 ft area once every 60 seconds
11,000 ft
11,000 ft
EAST SLIDE ROCK RIDGE
The system will acquire, geo-rectify, and mosaic in near real time, approximately 100 images to cover the entire area once every 60 seconds, including 50% overlap on all image frames
Image © 2008 DigitalGlobe
© 2008 Tele Atlas
©2007 Google™
Streaming 100%
Eye alt 14431 ft
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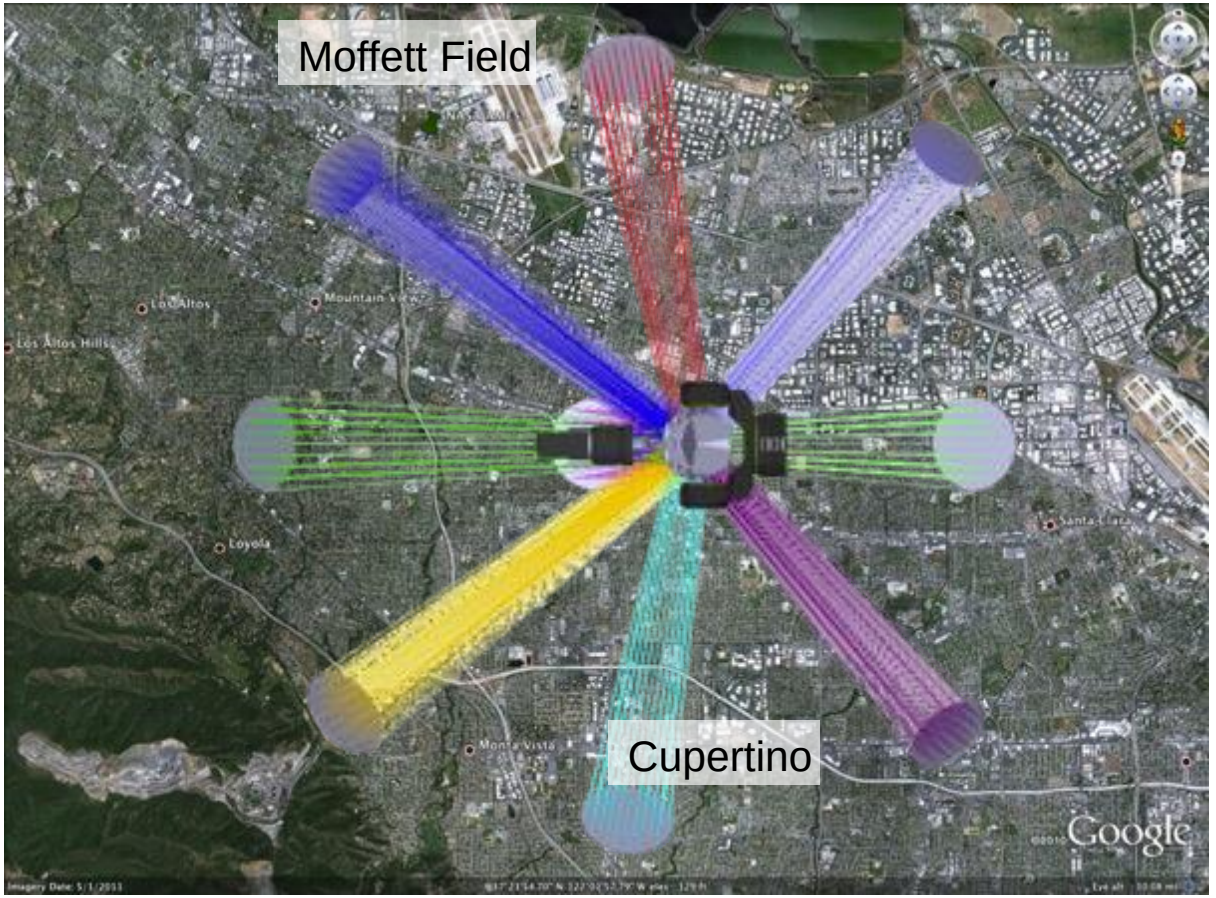
In this scenario the 0.6 milliradian 2 band LWIR/MWIR sensor will image a 14 foot square pixel from an altitude of 23,000 feet. As the aircraft orbits at 23,000 Feet the Staring Wide Area Imager scans the entire 80 degree by 80 degree Field of Regard, imaging the entire 8 mile diameter area once every 60 seconds -- acquiring, geo-rectifying, and mosaicking in near real time, approximately 100 images to cover the entire area once every 60 seconds. This calculation includes 50% overlap on all image frames

- LWIR (8 to 9 um)
- MWIR (4 – 5 um)
- SWIR 1.6 um
- 600 urad instantaneous field of view
- ground sample distance of approximately 14 feet from our notional operating altitude of 23,000 feet.
- At this altitude the system will be capable of detecting a 6 inch by 6 inch 600 degree C fire.
- 8 Mile Diameter Field of Regard



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Questions?


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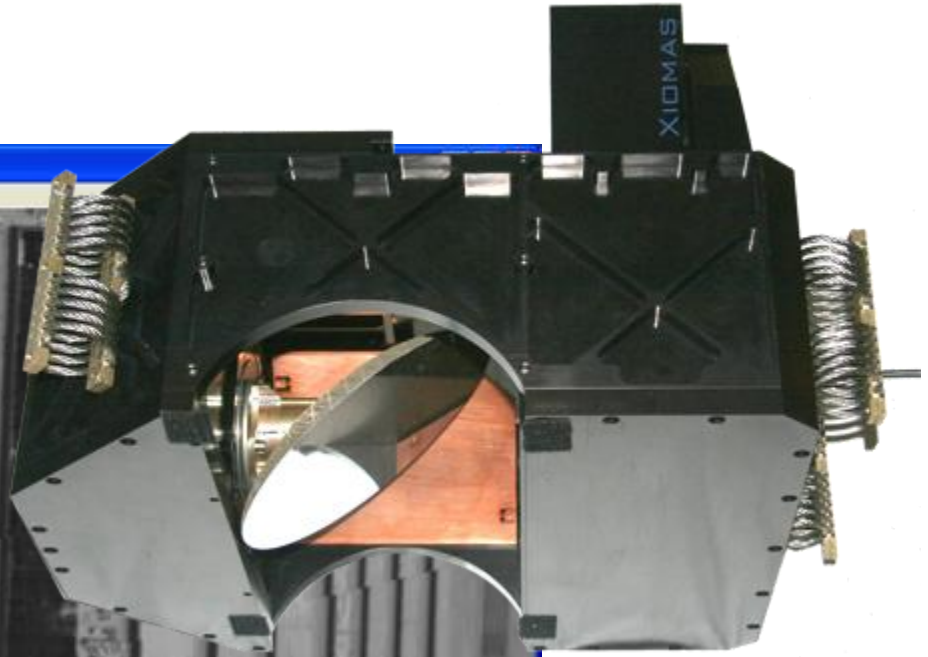
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