TFRSAC Update April 2014

Thermal Mapping Airborne Simulator (TMAS)
Staring Wide Area Imager (StareWAI)
Wide Area Imager (WAI)

Xiomas Technologies, L.L.C.
Principle Investigator: John Green
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XIOMAS

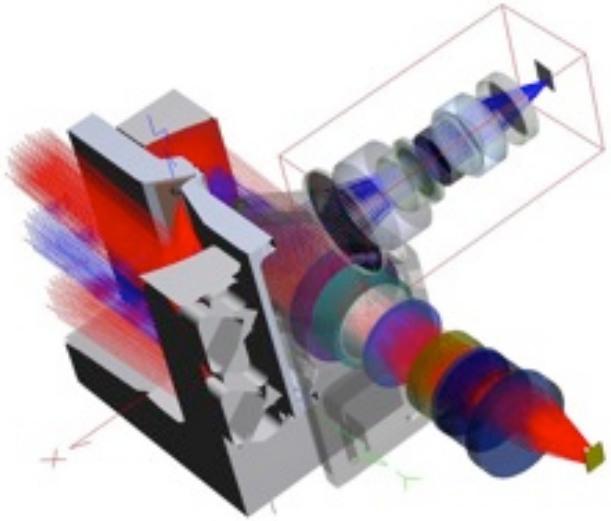
Come Visit Xiomas in Beautiful MICHIGAN!

Sleeping Bear National Lake Shore

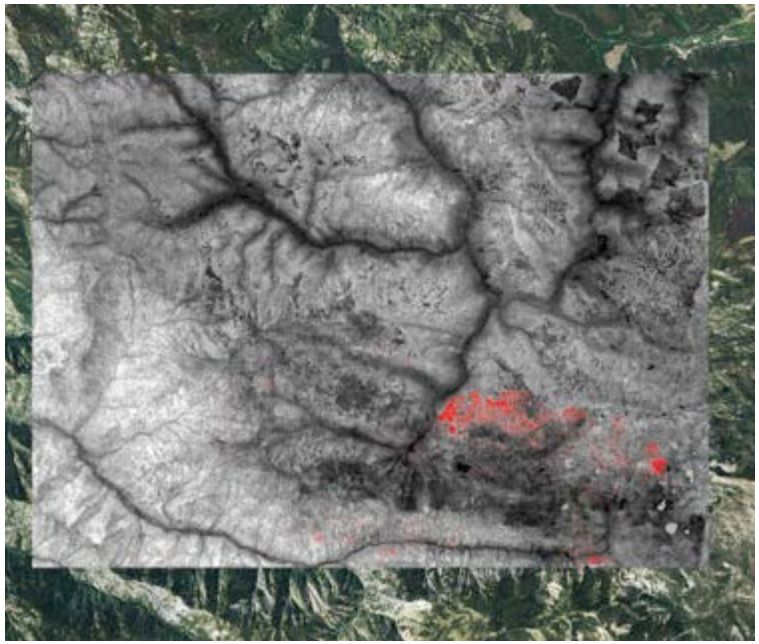

Lake Superior
Lake Huron
Lake Ontario
Lake Michigan
Lake Erie

About Xiomas --

- R&D for high performance airborne imaging systems
- Development of physics based models for remote sensing
- Software and computer engineering
  - Data acquisition, detection, identification, geo-location, and dissemination
- Optical Engineering
  - Hyperspectral imagers, thermal infrared imaging systems, multispectral imaging systems, and scanning imagers



Xiomas Hyperspectral Imager
developed under
U.S. Navy SBIR



Xiomas Thermal Image
with Fire Detection overlaid
on color photo

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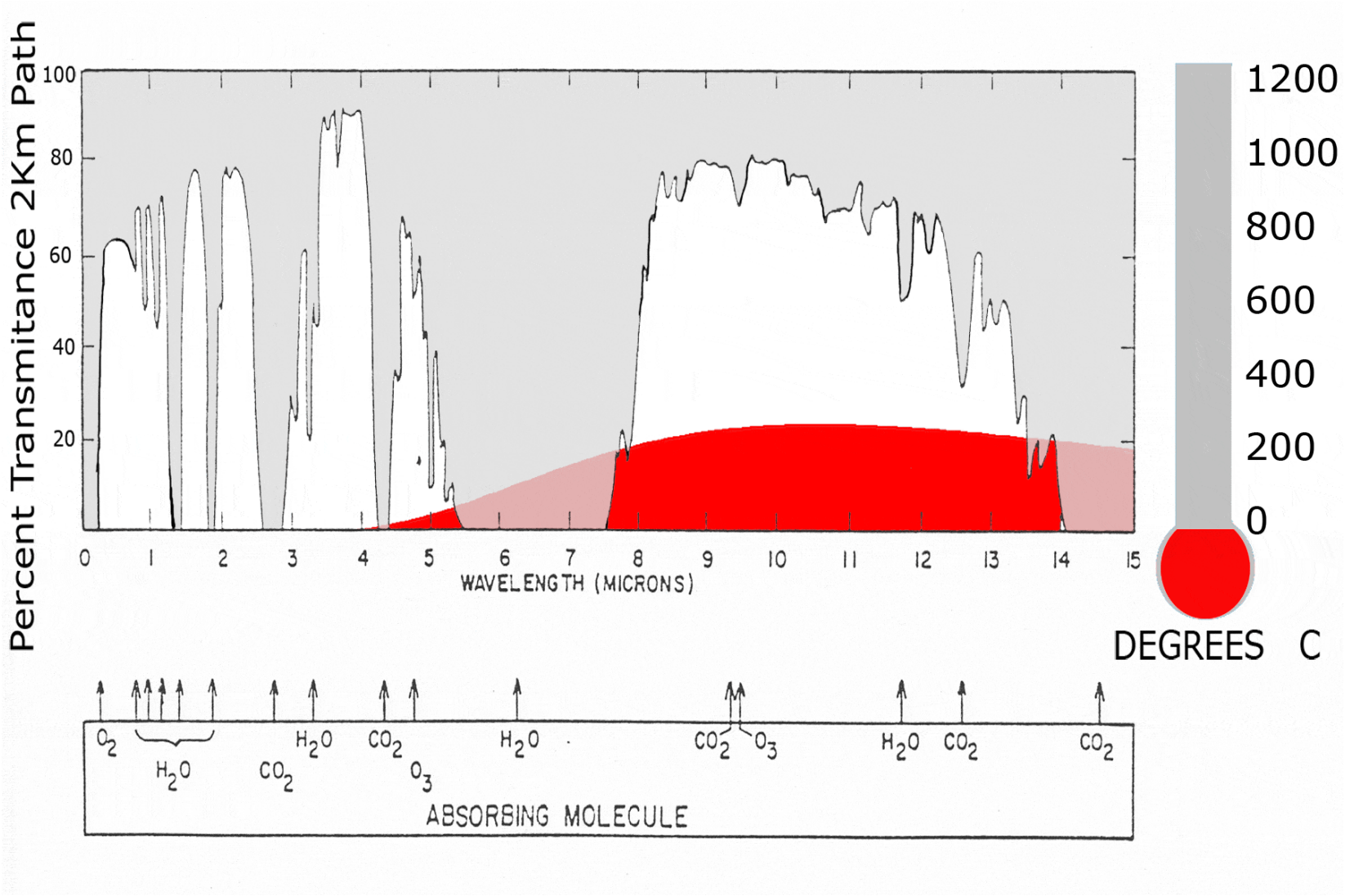
Planck's Law and the Atmosphere



Why MWIR and LWIR are ideal for Fire Detection

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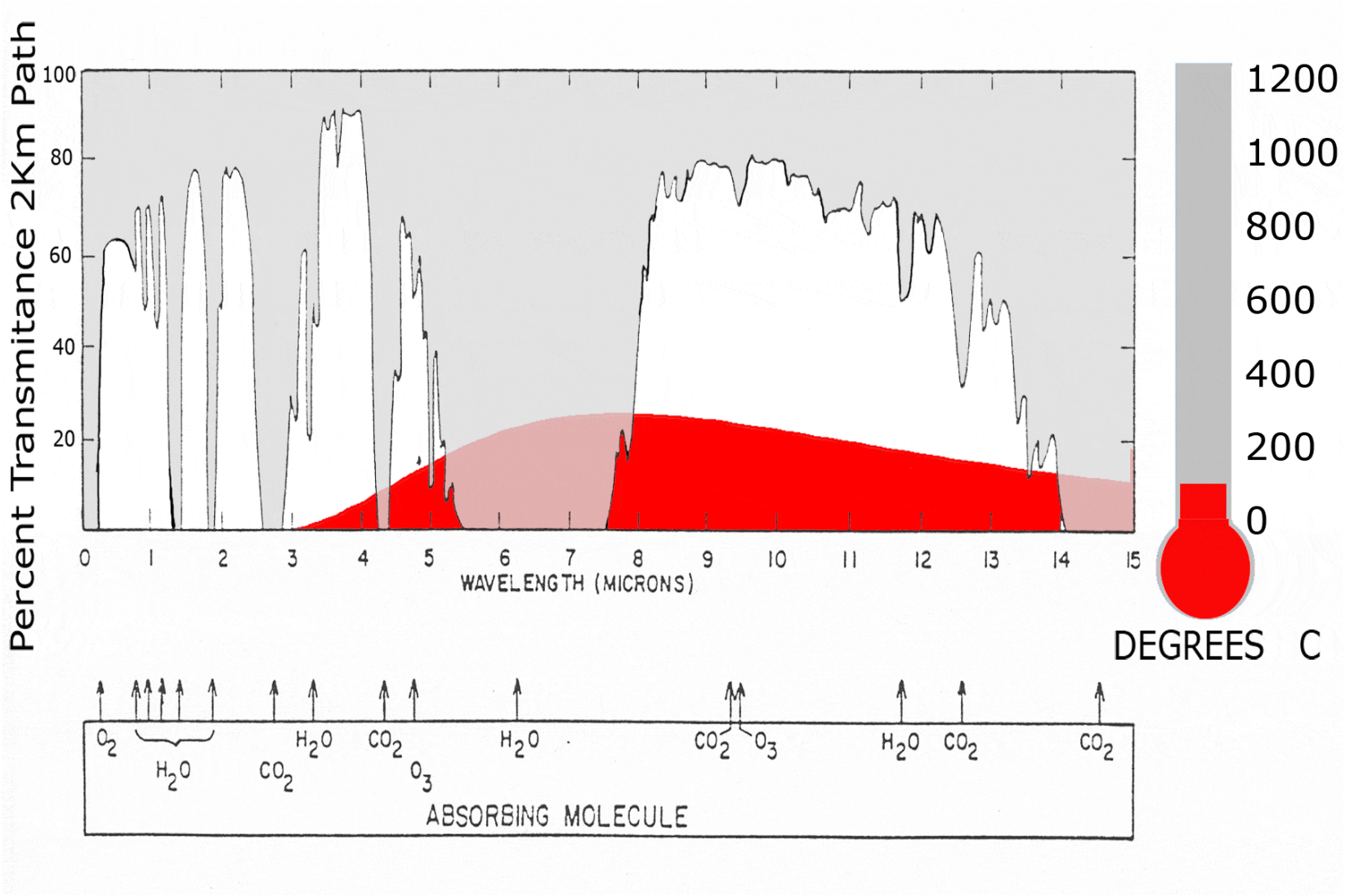
Planck's Law and the Atmosphere



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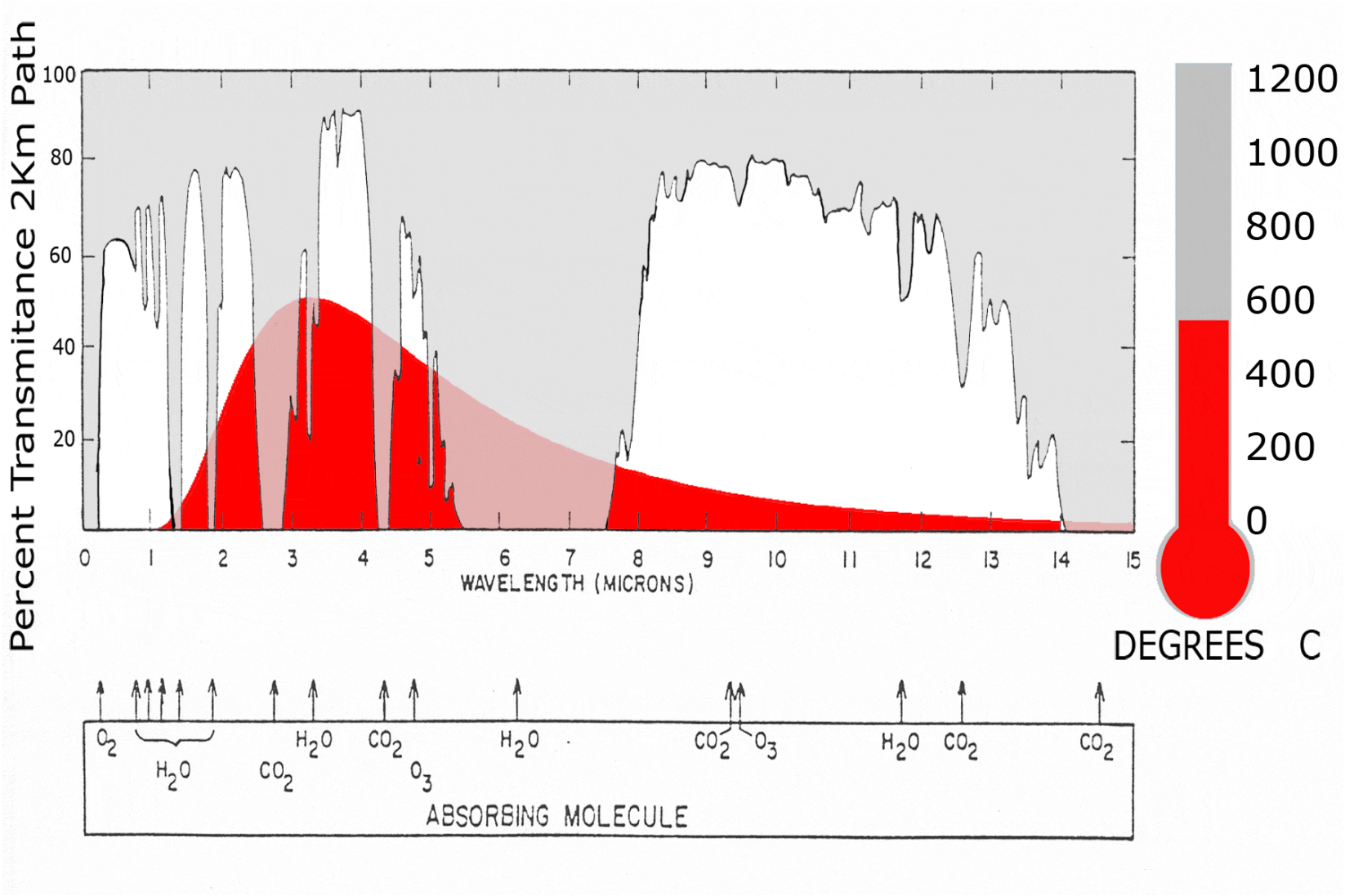

Why MWIR and LWIR are ideal for Fire Detection

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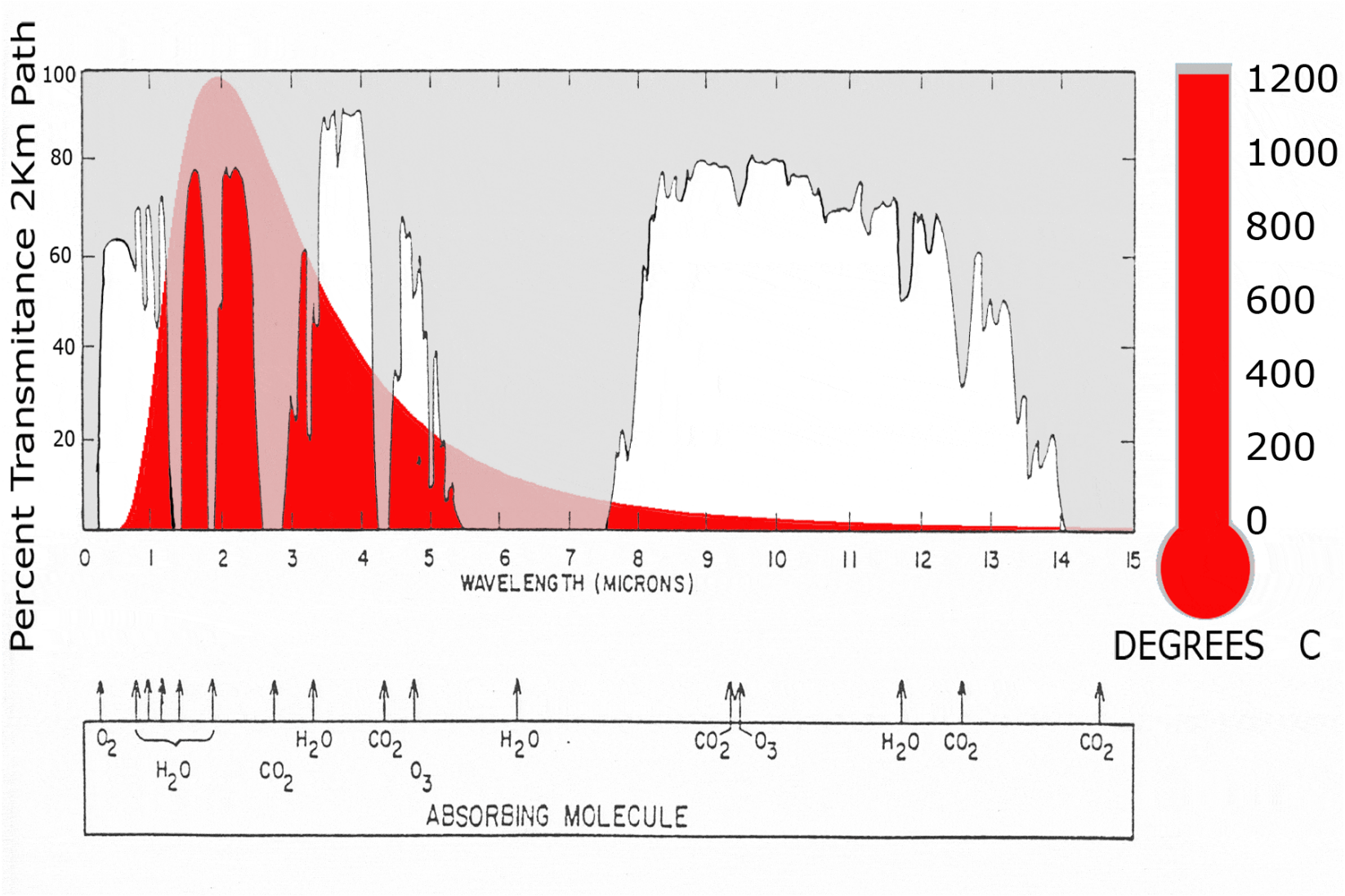
Planck's Law and the Atmosphere



Why MWIR and LWIR are ideal for Fire Detection

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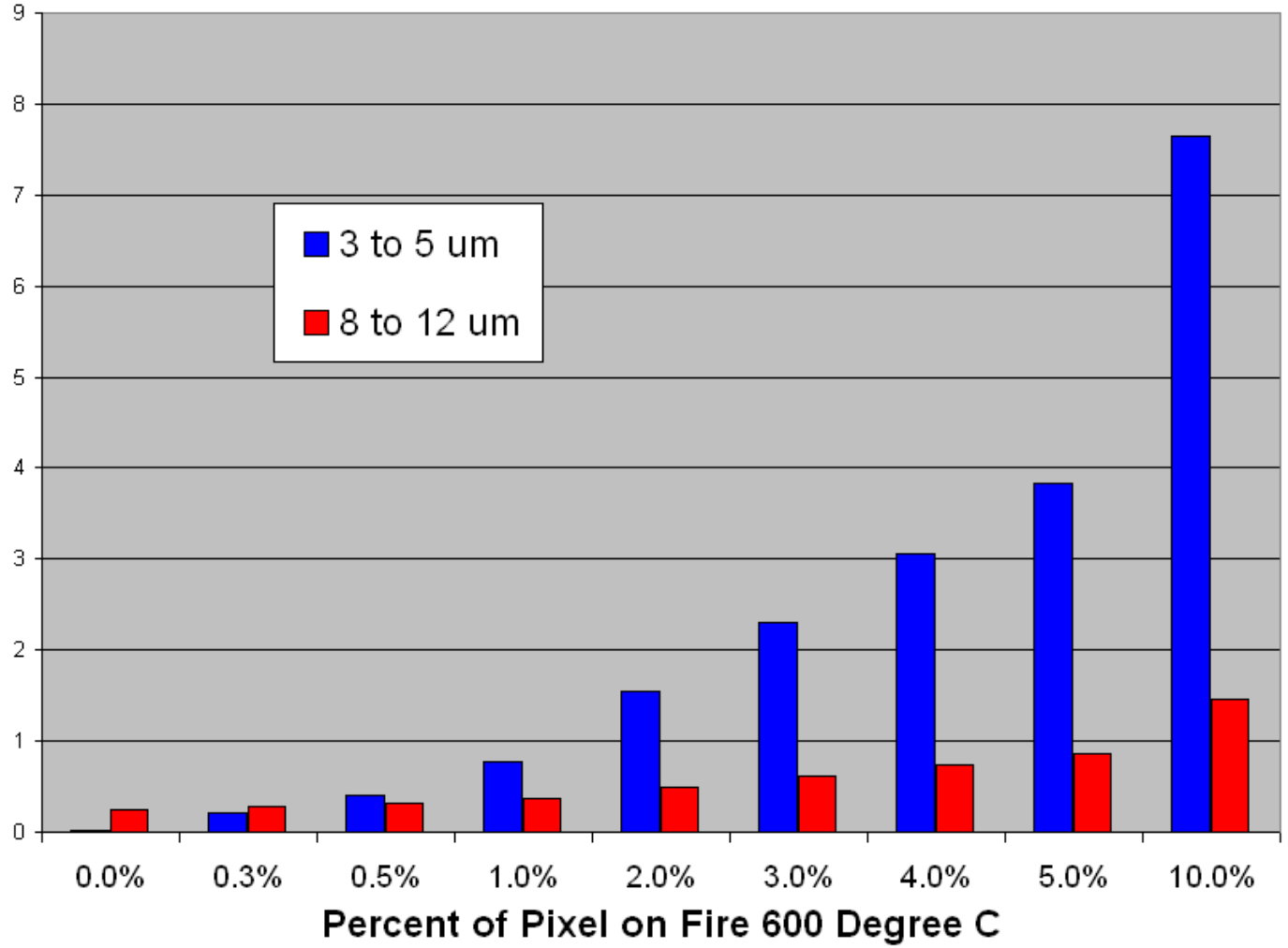
Planck's Law and Hotspots



Relative Amount of Mid and Long Wave IR energy produced by small 600 degree subpixel fires against a 0 degree background

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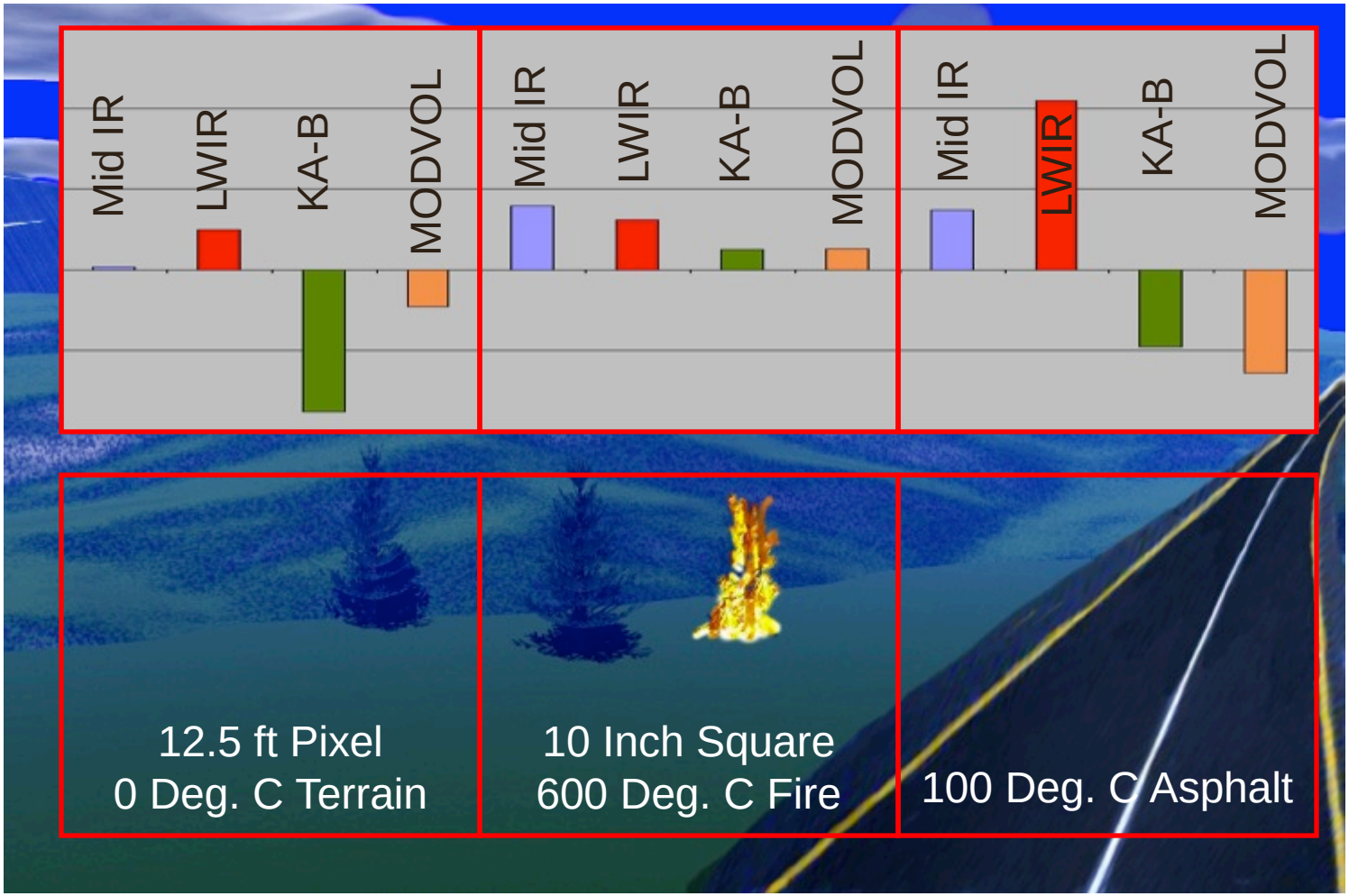
Hot Spot Detection and False Target Rejection Using KA-B or MODVOL Algorithms



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TMAS
Thermal Mapping Airborne Simulator
for
Small Satellite Sensor
Phase II
July 2013 to July 2015
Technical Monitor James Brass

Xiomas Technologies, L.L.C.

Phase II Contract Number: NNX13CA58C

Principle Investigator: John Green
734-646-6535

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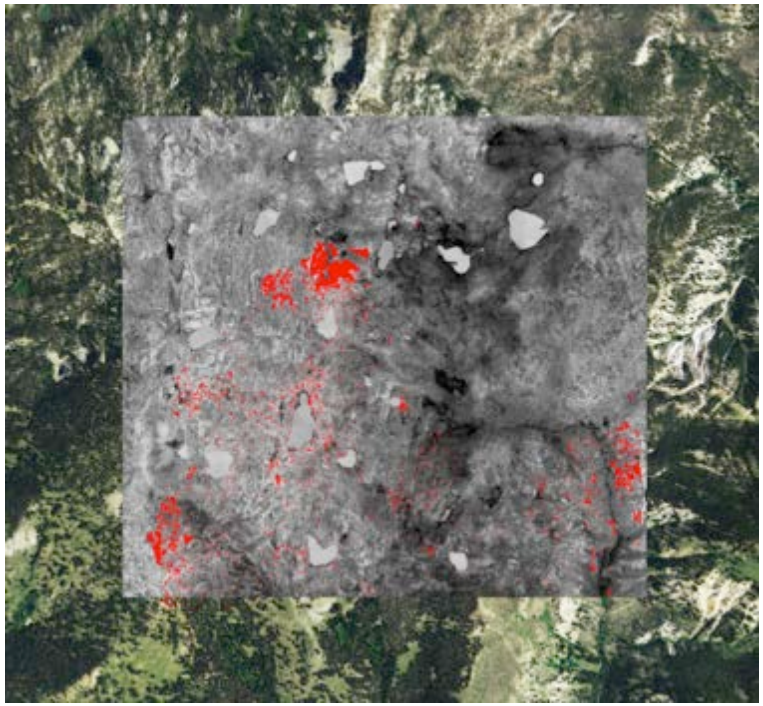
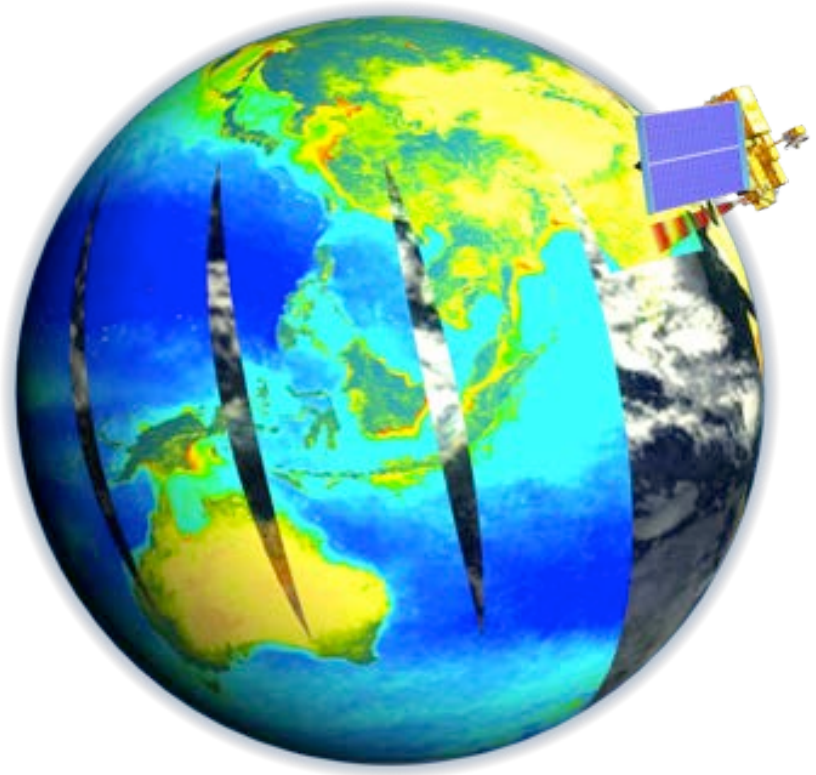
TMAS

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

110 degree field of view (same as MODIS)
94 meter spatial resolution (similar to ASTER)
3 Spectral Bands (more can be added in Phase III)





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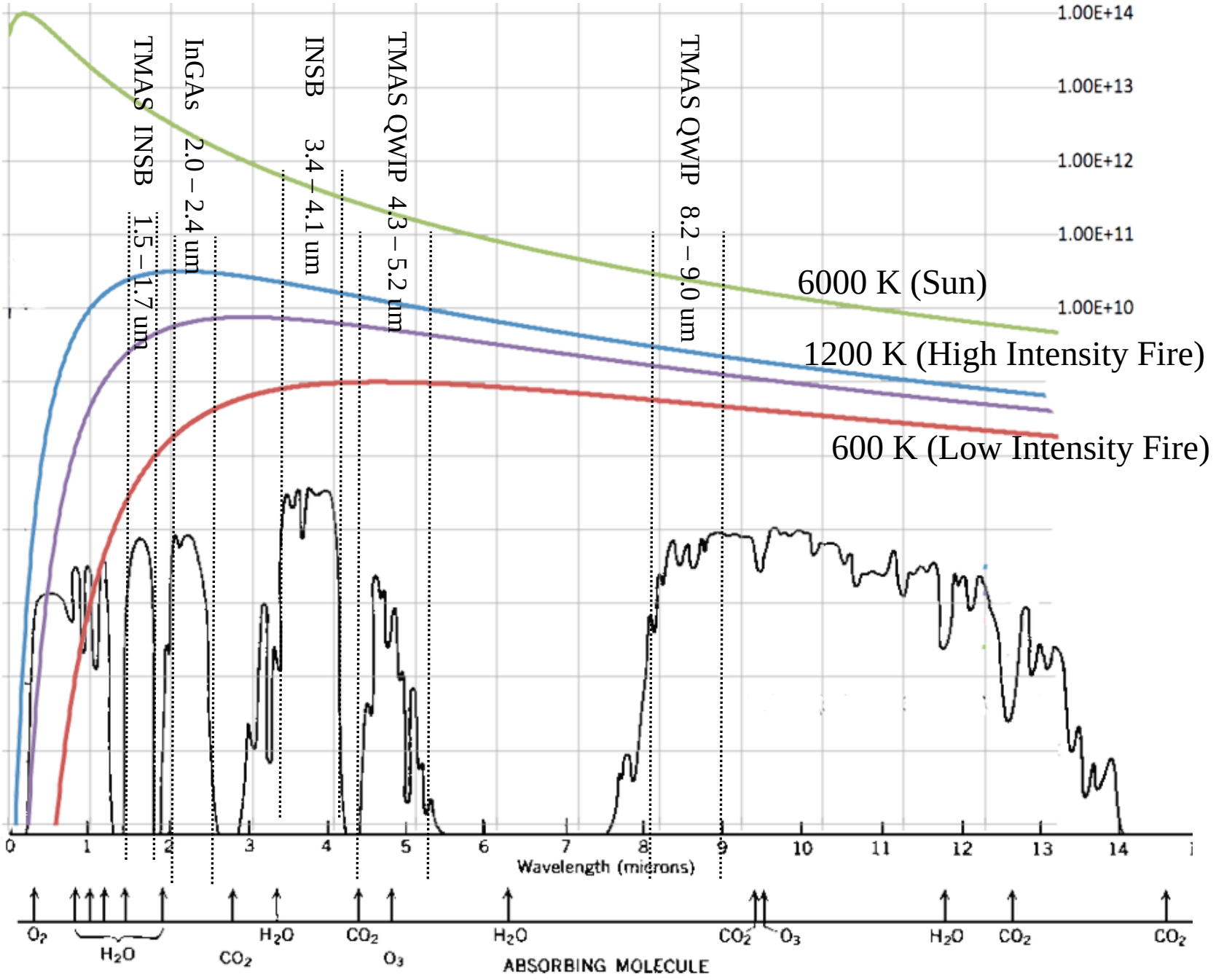

TMAS INSB 1.5 – 1.7 um
InGAs 2.0 – 2.4 um
INSB 3.4 – 4.1 um
TMAS QWIP 4.3 – 5.2 um
TMAS QWIP 8.2 – 9.0 um
6000 K (Sun)
1200 K (High Intensity Fire)
600 K (Low Intensity Fire)
1.00E+14
1.00E+13
1.00E+12
1.00E+11
1.00E+10
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Wavelength (microns)
O2
H2O
H2O
CO2
H2O
CO2
O3
H2O
CO2
CO2
CO2
O3
ABSORBING MOLECULE

Phase I engineering prototype:

- XVME-6300 processor board with dual core i7 @ 2GHz, 8GB RAM
- Intel 64GB SSD with 3Gb/s SATA interface. Formatted as EXT4 file system
- WD 256GB SSD with 3Gb/s SATA interface. Formatted as EXT4 or JFS file systems.
- EDT PMC DV C-Link frame grabber
- Teli 640 x 480 camera

1. Simulate the data rates of the two cameras
2. Simulates a GigE QWIP, with the simulation running on another PC and connected over a 1000BaseT wire
3. Simulate SWIR sensor using CameraLink frame grabber and a 640 x 480 Vis Camera

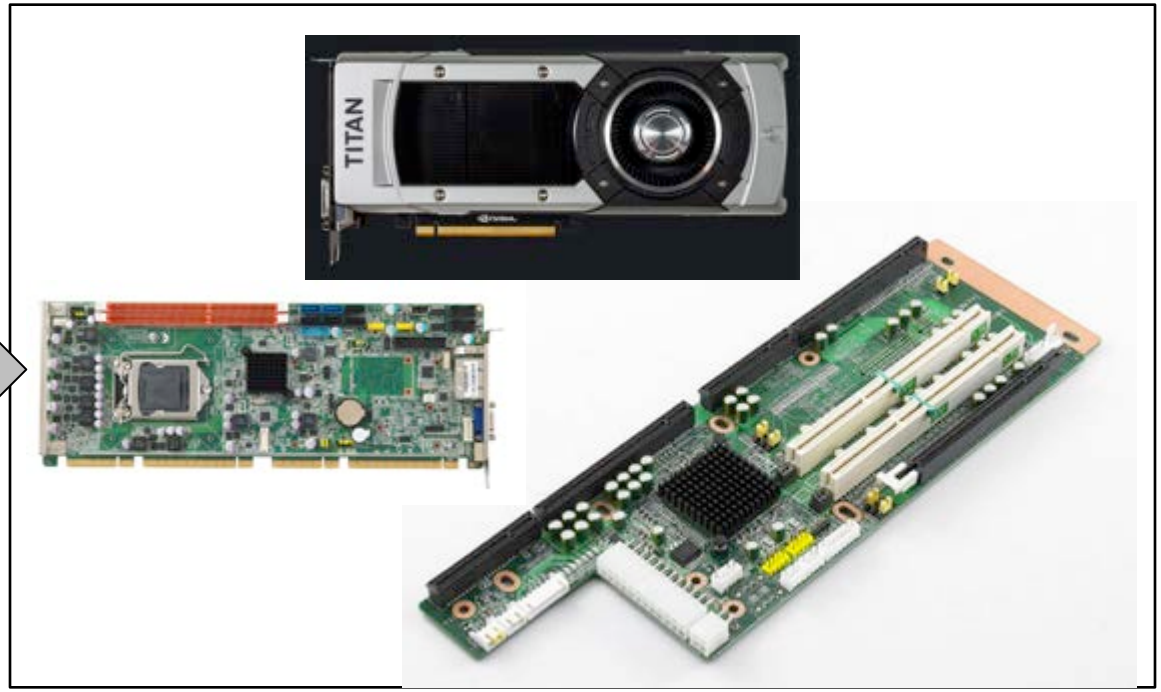
ACU Design Update

As the Phase II design has progressed we've settled on a VME based ACU with a separate PC Chassis with GPU or FPGA Based OPU

ACU: VME Dual Core i7

GigE

OPU: Separate Chassis with passive motherboard + plugin PC i7 card + PCIe Nvidia card or FPGA



Orthorectification Processing Unit –

The proposed OPU uses a rigorous sensor model and an explicit mathematical formulation that describes the relationship between individual pixels as imaged by the sensor's detector arrays and their location on the Earth.

The OPU uses the integrated GPS and IMU to establish the sensors position and orientation. This information is combined with the sensor model to compute a vector to a digital elevation model resulting in highly accurate registration of the imagery.

For a previous project (the WAI), Xiomas worked with ITTVis (the ENVI people) to develop an OPU running in CUDA on a GPU.

During the Phase I we researched the feasibility of adapting the ENVI CUDA technique for the TMAS

And we explored and alternate approach – Working with Fireball Information Technologies to develop an OPU running in the FPGA on the Atlas-II-V5x™.

This option would be based on Fireball's existing Seamless Image Processing utility, a highly accurate software tool for orthorectifying and mosaicing large numbers of individual image frames.

	FPGA	GPU	CPU
Performance Estimated Mega-pixels per second	200 Mpixels/s	17 Mpixels/s	8.3 Mpixels/s
SW Development Cost	Moderate -- 350 hours	Low – 250 hours	Low – 250 hours
Hardware Cost	High -- $10K	Moderate -- $5K	Moderate -- $5K

Results of Analysis (FPGA) and Testing the 3 candidate GPU architectures

Note that TMAS requires 13 Mpixels per Second to Process the 3 bands

System Test Plan outline

In the Phase II tests will be performed in accordance with the system test plan and will include:

Data System tests

Establish throughput and benchmark process performance.

System Acceptance Test

Full functional testing of the operational prototype will be performed in a laboratory setting according to the System Acceptance Test Procedure (ATP).

Environmental tests:

Determine conformance to relevant DO-160 shock, vibration, temperature, susceptibility to conducted and emitted noise, and other environmental specifications.

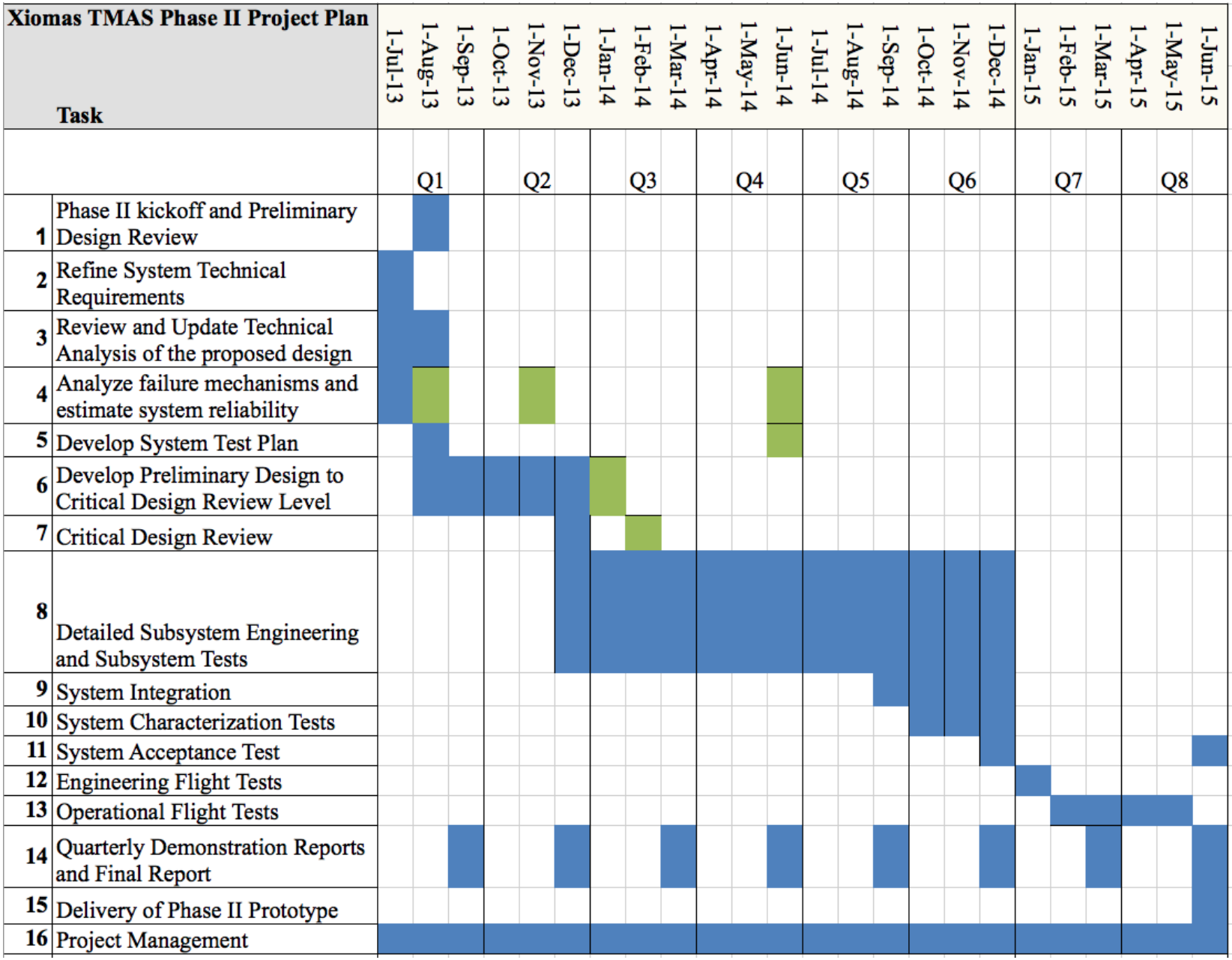
Engineering Flight Tests

Engineering test flights will be performed to determine level of functionality of the prototype in a relevant operational environment.

Aircraft Integration and Operational Flight Tests

During the Phase II Xiomas intends to lease an aircraft, procure or develop all required interface components and fly 4 test flights in a an operational environment.

Phase II Project Plan and Schedule



TMAS Phase II Enhancement
The contract includes an optional $250K of additional SBIR funds.
The short story on the Phase II-E from the contract follows:

" Phase II-Enhancement (Phase II-E)
The purpose of the Phase II-E Option is to further encourage the advancement of innovations developed under Phase II contracts via an extension of R/R&D efforts to the current Phase II contract. Eligible firms must secure a third-party investor to partner and invest in enhancing their technology for further research, infusion, and commercialization. Under this option, the NASA SBIR Program will match, on a dollar-to-dollar basis, up to $250,000 of non-NASA-SBIR investments to extend an active contract up to a minimum of 4 months to perform additional R/R&D. These non-NASA-SBIR third party investments can come from a NASA project, NASA contractor, or any commercial investor. The total cumulative award for the Select Phase II contract plus the Phase II-E match is not expected to exceed $950,000.00 of SBIR funding. The non-SBIR contribution is not limited since it is regulated under the guidelines for Phase III awards."

Possible Phase II E candidates.
1)Commercial TMAS Sale to PhotoScience or other remote sensing company
2)TMAS Sale to the USFS
3)USFS funds conversion of the WAI to TMAS configuration
4)NASA funded transition (or partial/preliminary design effort) of TMAS to small satellite

Staring Wide Area Imager (STAREWAI)

USDA Forest Service Phase II SBIR
Award Number: 2013-33610-21054
Period of Performance September 2013 to September 2015

Xiomas Technologies, L.L.C.

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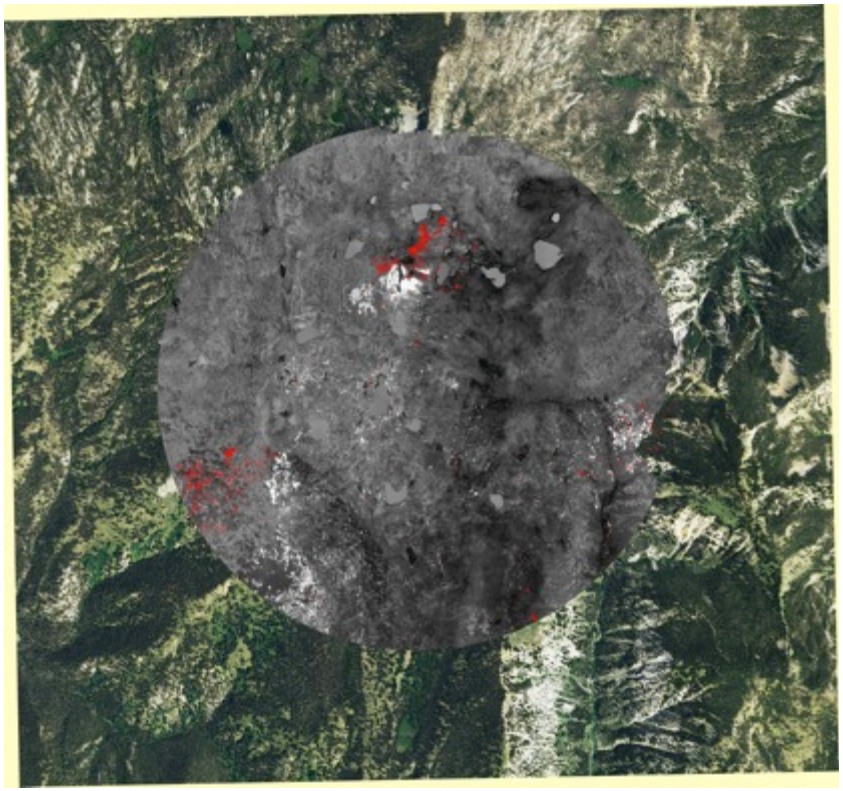
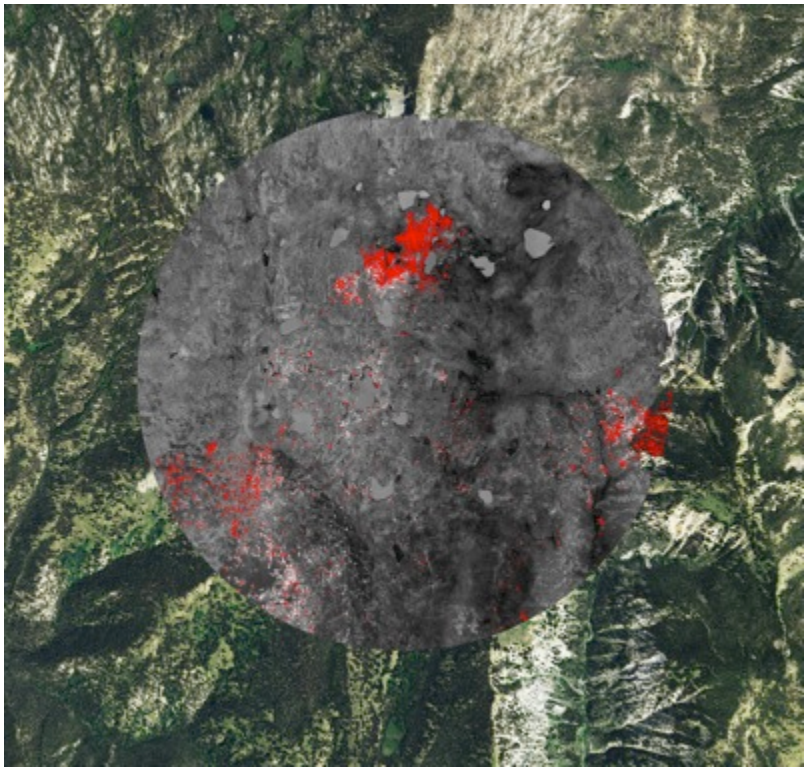
Staring Wide Area Imager (StareWAI)

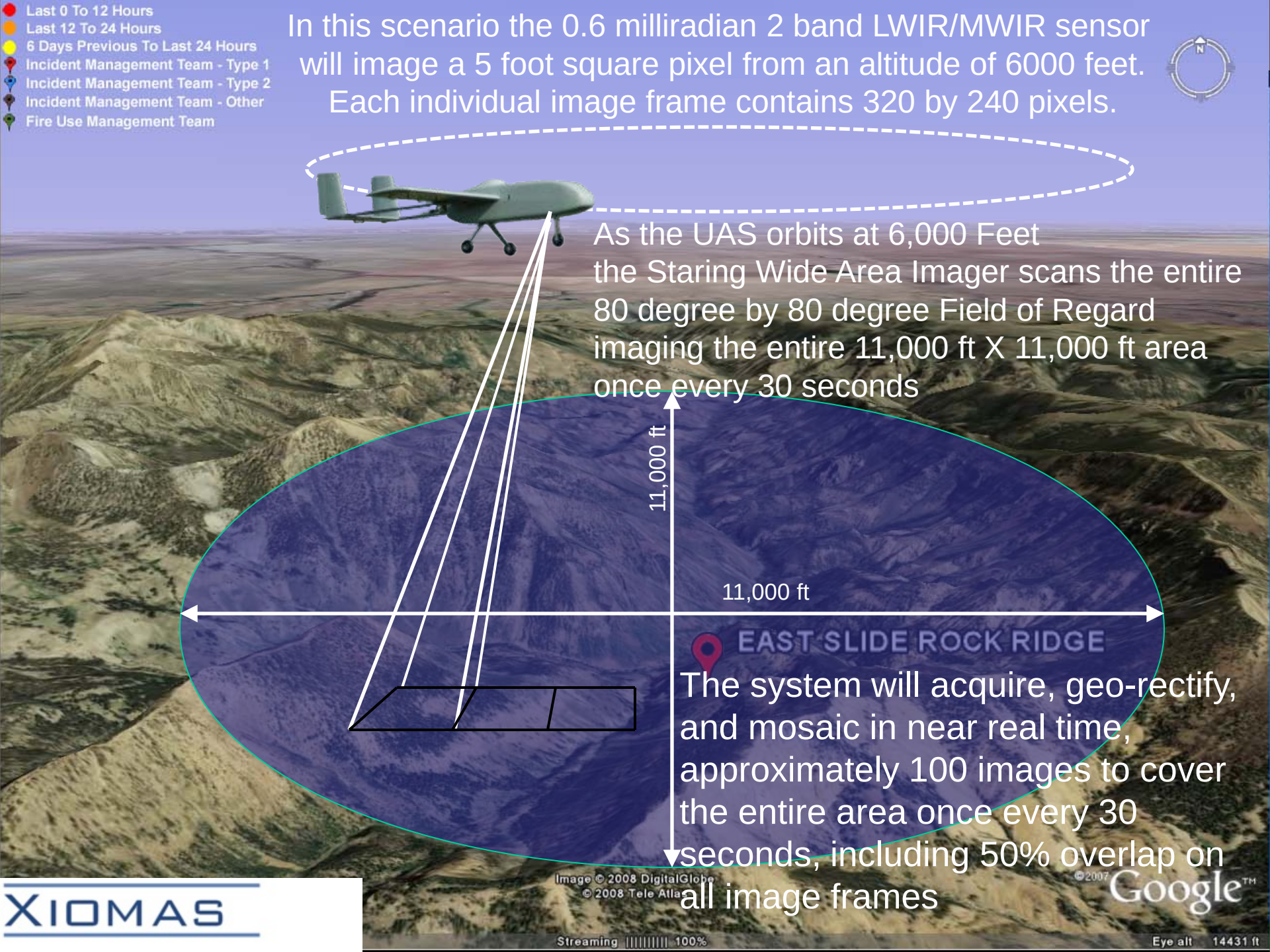
In staring mode, the aircraft will circle a flight path similar to a typical holding pattern while the Stare Wide Area Imager continually scans an area.

100 images will be mosaicked and placed on a map in real time
every 30 seconds

The result is a moving thermal map of the area under surveillance, similar to a moving weather map






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 30 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 30 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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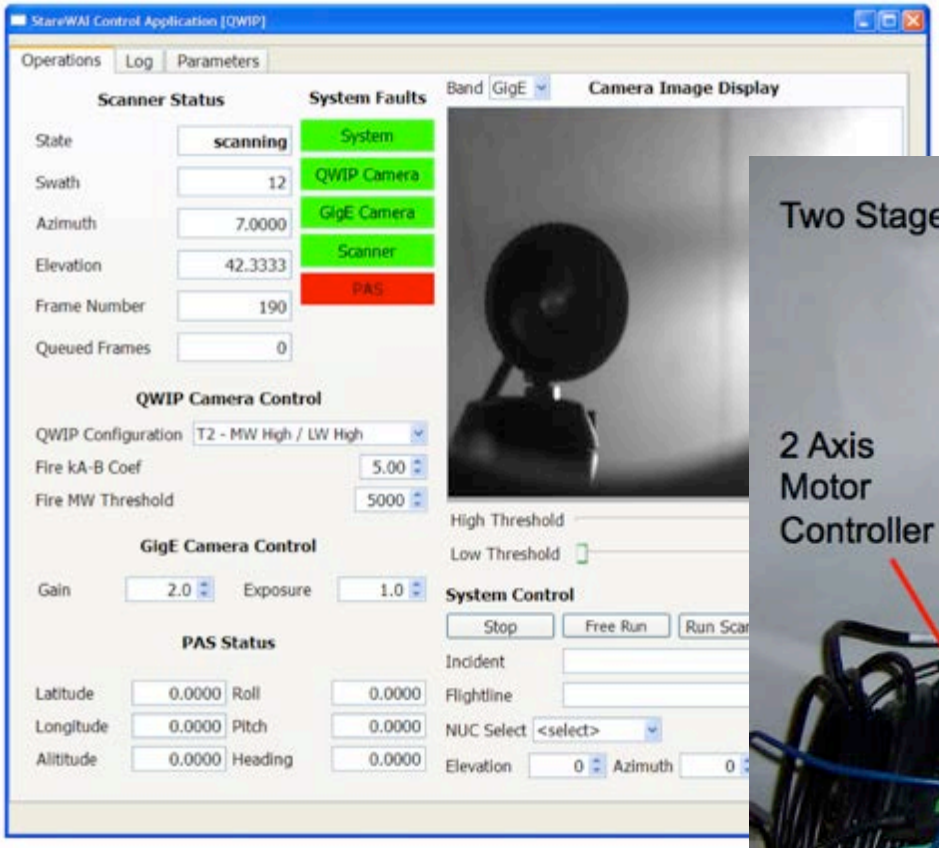
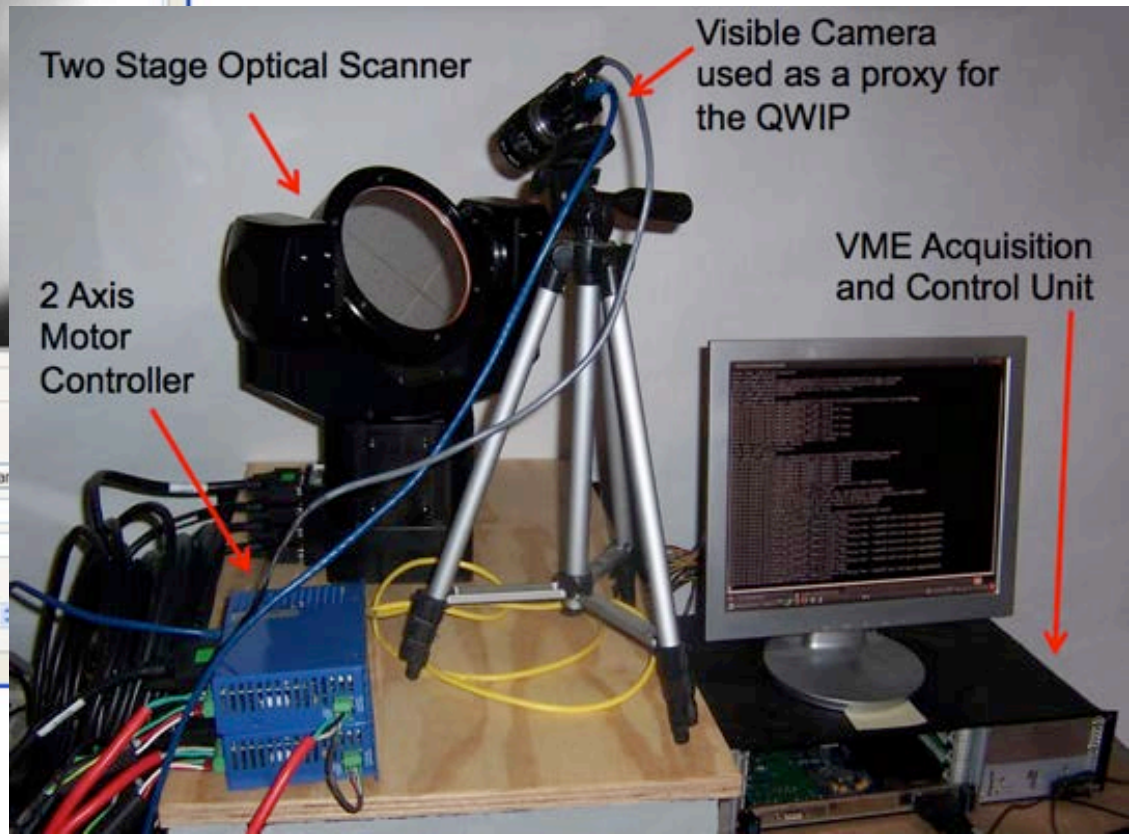
StareWAI Summary To Date:

- Development a prototype Acquisition and Control Unit (ACU) and key components of the StareWAI software
- Improved and finalized the design of the deliverable two stage optical scanner
- Procured and integrated the deliverable two stage optical scanner with the prototype ACU

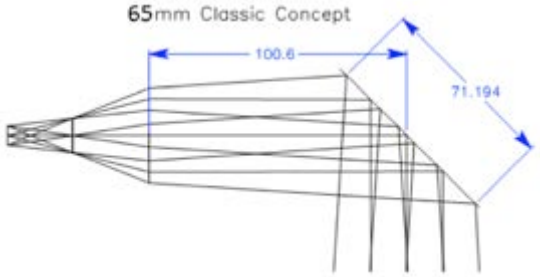


Screenshot of GUI during scanner operation

- Ordered the 2 Band QWIP Camera (delivery in August)

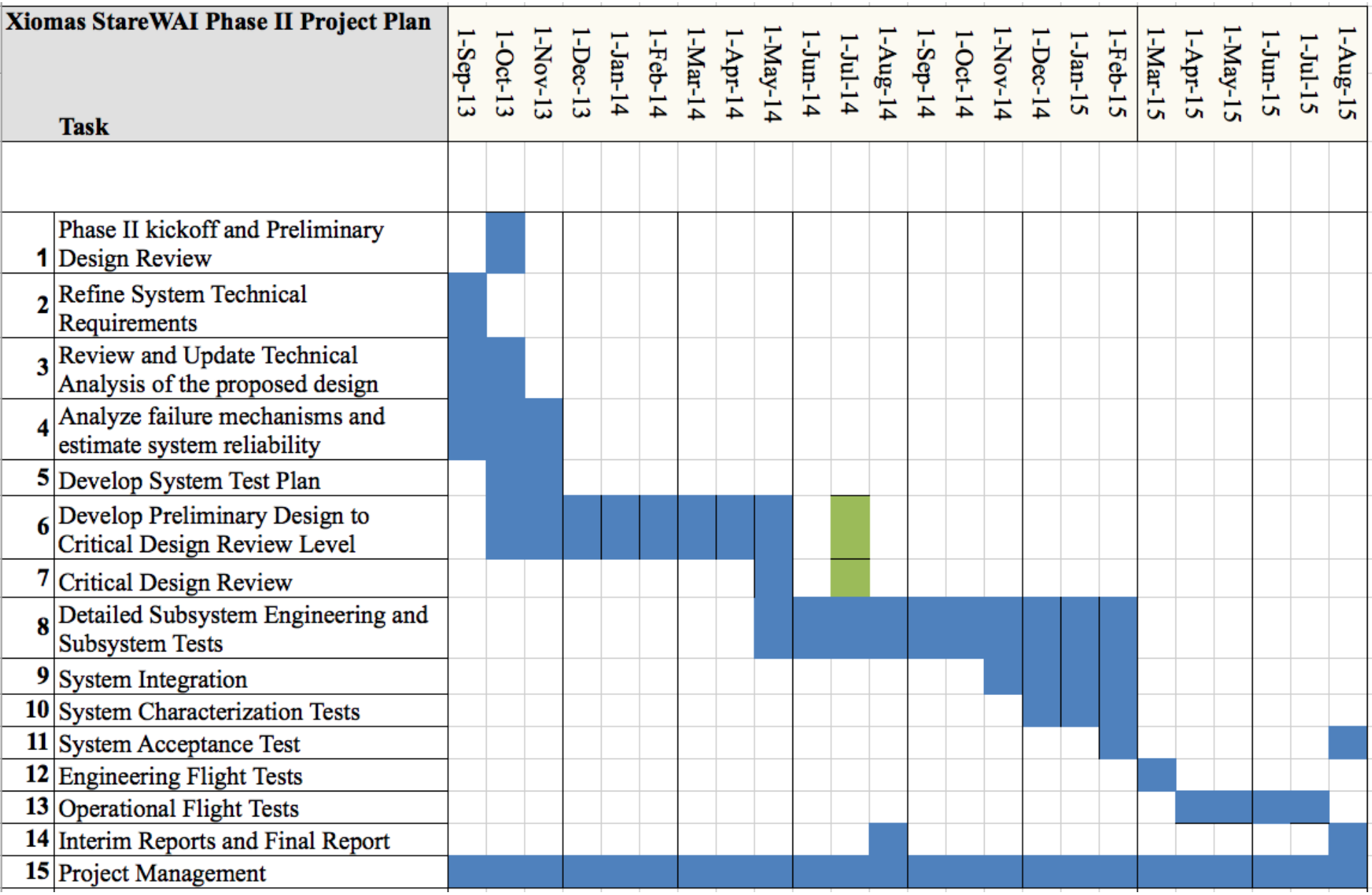


StareWAI Phase I Prototype



Basic Performance Parameters for the StareWAI Operating in Mapping Mode (aka Across Track Scanning)

% of Pixel Filled with 600 Degree C which can be thresholded above 400 Degree C Field filling False Target (est from % pixel fill Chart)		0.40%				
GSD (m)		4.30	13.975	ft		
Focal Length Len (mm)		66.05				
Fire detection limit (m squared)		0.07	0.78	ft	9.4	in
Swath Width (m)	14,200		46150	ft		
operating Altitude (m)	7,100					
Operating Altitude (ft)	23,075					
Operating Speed (kts)	200					
Operating Speed (m/s)	103					
IFOV (mr)		0.606				
FOV per frame across track degrees		11.07				
FOV per frame Along Track degrees		8.31				
Percent Overlap Across Track		0.2				
Percent Overlap Along Track		0.4				
Step Stare Mirror Optical Scan Angle (degrees)		90.00				
Across Track Steps		11				
Frame Rate (Hz)		3				
Mapping Rate (square miles per hour)		2029				


Xiomas StareWAI Phase II Project Plan
Task
1-Sep-13
1-Oct-13
1-Nov-13
1-Dec-13
1-Jan-14
1-Feb-14
1-Mar-14
1-Apr-14
1-May-14
1-Jun-14
1-Jul-14
1-Aug-14
1-Sep-14
1-Oct-14
1-Nov-14
1-Dec-14
1-Jan-15
1-Feb-15
1-Mar-15
1-Apr-15
1-May-15
1-Jun-15
1-Jul-15
1-Aug-15
1 Phase II kickoff and Preliminary Design Review
2 Refine System Technical Requirements
3 Review and Update Technical Analysis of the proposed design
4 Analyze failure mechanisms and estimate system reliability
5 Develop System Test Plan
6 Develop Preliminary Design to Critical Design Review Level
7 Critical Design Review
8 Detailed Subsystem Engineering and Subsystem Tests
9 System Integration
10 System Characterization Tests
11 System Acceptance Test
12 Engineering Flight Tests
13 Operational Flight Tests
14 Interim Reports and Final Report
15 Project Management

Airborne Wide Area Imager for Wildfire Mapping and Detection (WAI)
TFRSAC Update April 2014

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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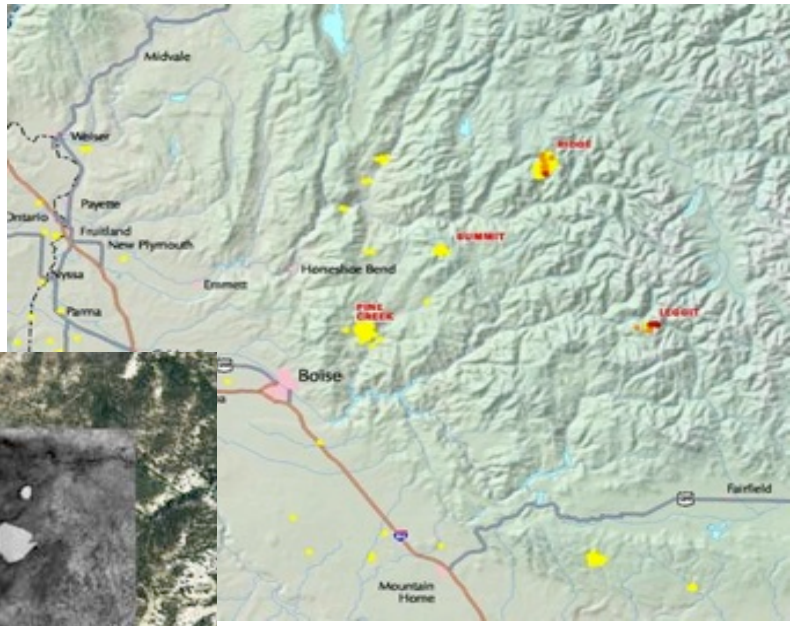
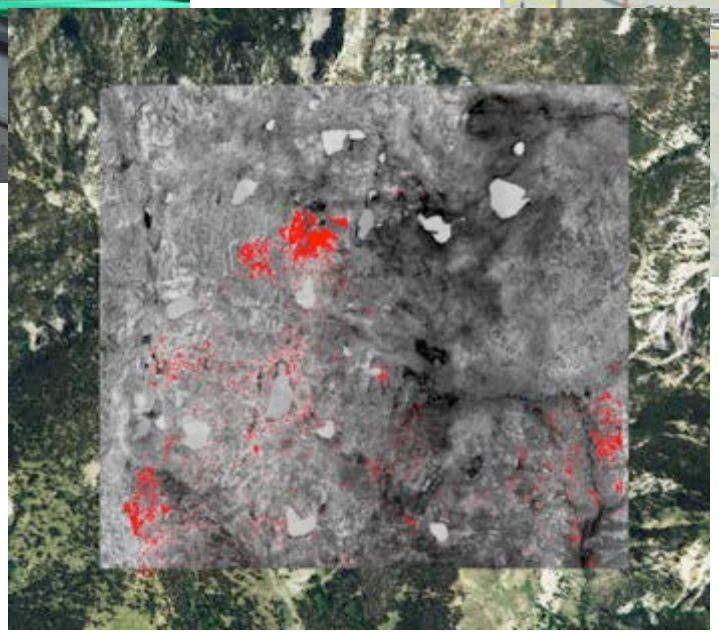
Wide Area Imager Fire Mapping Evaluation/Demonstration Mission --
Multi-day mission conducted July 23-26, 2013 over active fires near Boise Idaho

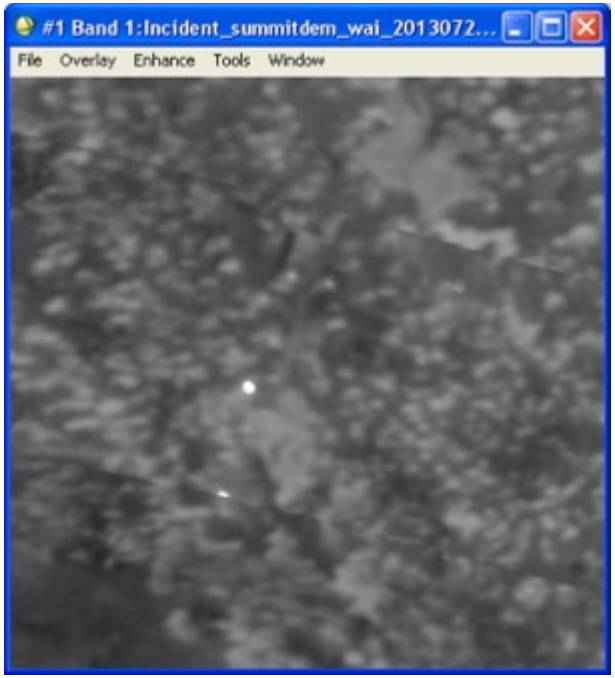


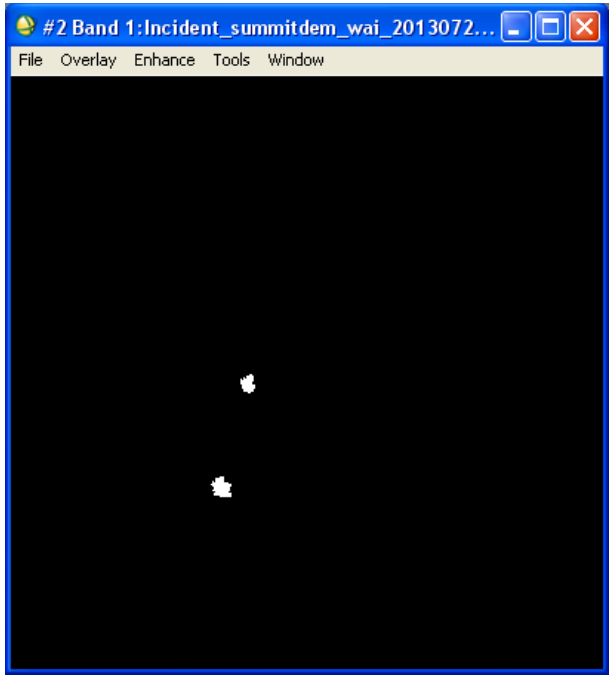


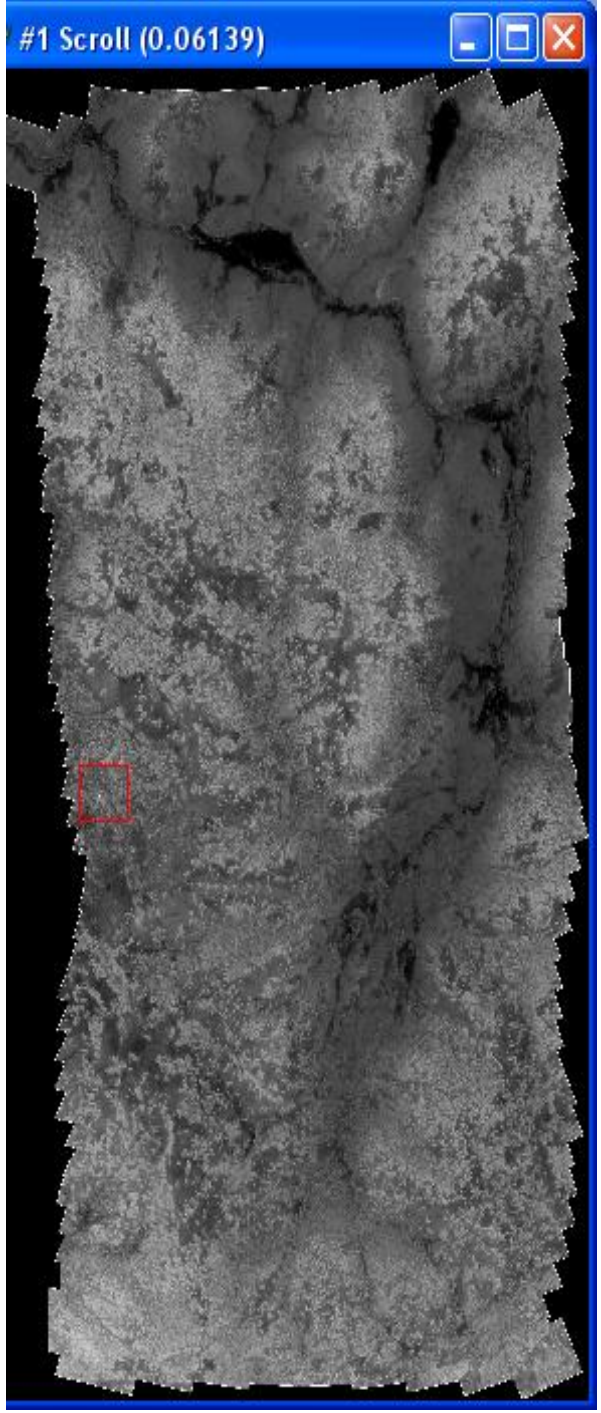
In total, the WAI has flown about 20 flights, including a number of engineering tests, calibration flights, several flights for a commercial imaging project,
and the fire mapping flights

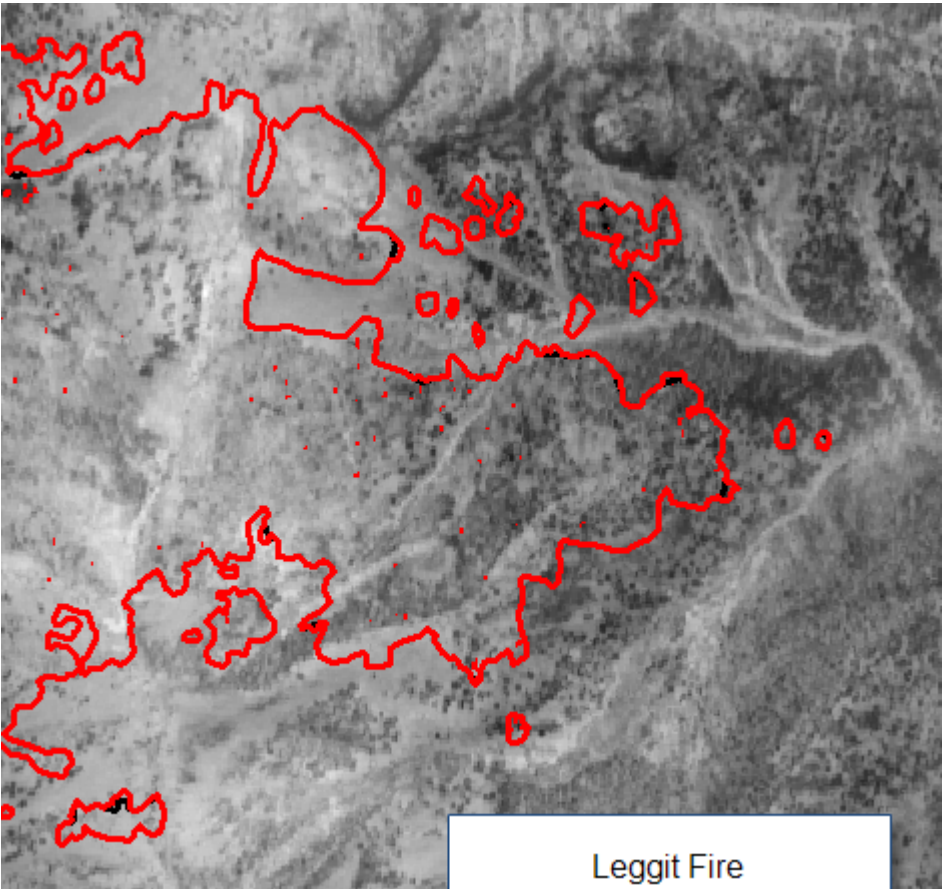
Flight operations generally occurred between 10:30 pm and 2:00 am. Immediately following the flight Xiomas delivered the orthorectified imagery to the USFS, briefed the USFS personnel on the flight and any items of interest in the imagery, and participated in the evaluation of the imagery by USFS personnel.

In general the USFS and Xiomas agreed that the registration of the WAI imagery to the reference base imagery (NAIP) was very good, with some occasional mis-registrations up to 10 meters, the detail in the LWIR WAI imagery was very good with small features such as drainages, structures, and roads, clearly visible, and the fire detection was very similar to the USFS Phoenix system.

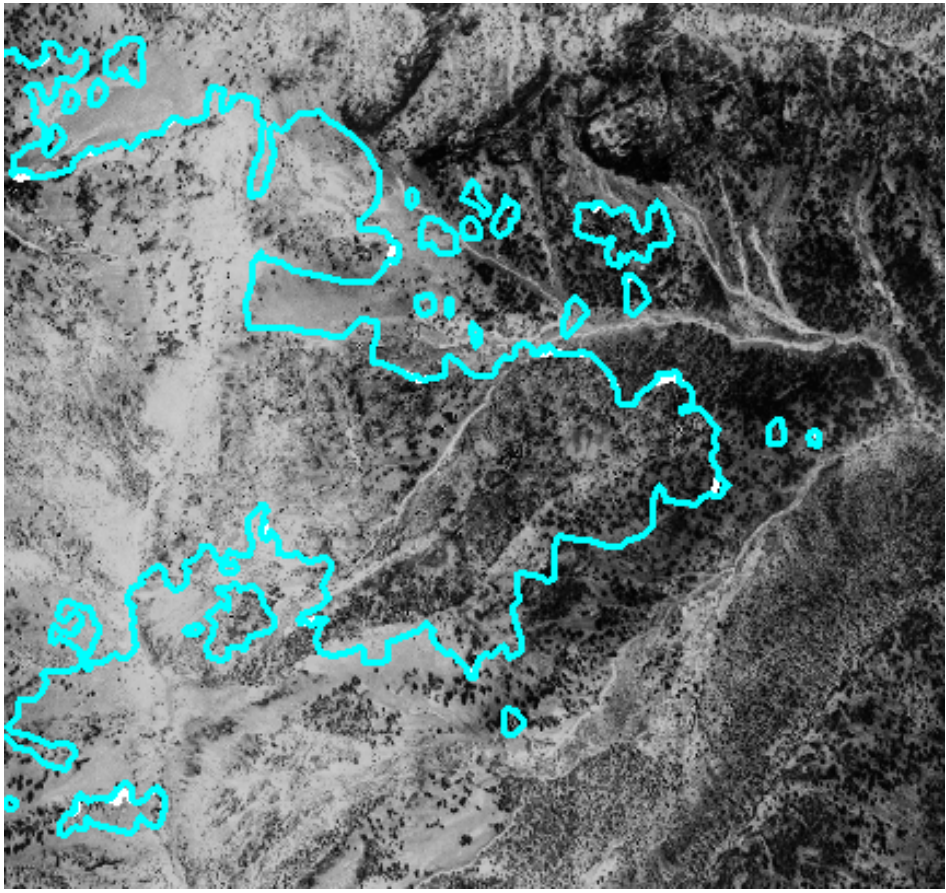








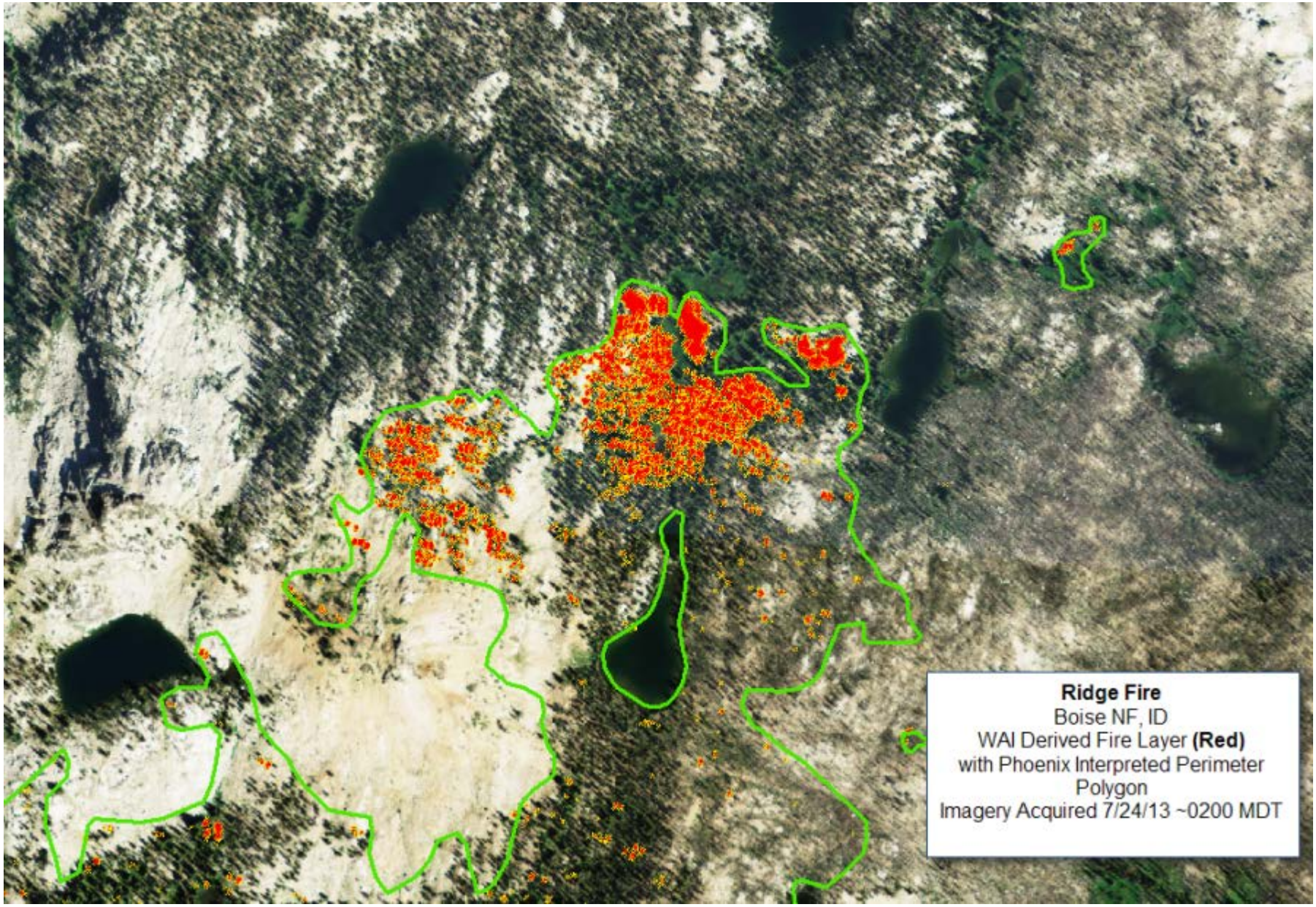
Phoenix Imagery



WAI Imagery

Both data sets are collected around the same time
and from around the same altitude (9,000 foot AGL)

Results of Wide Area Imager Fire Mapping Mission in Boise Idaho July 2013

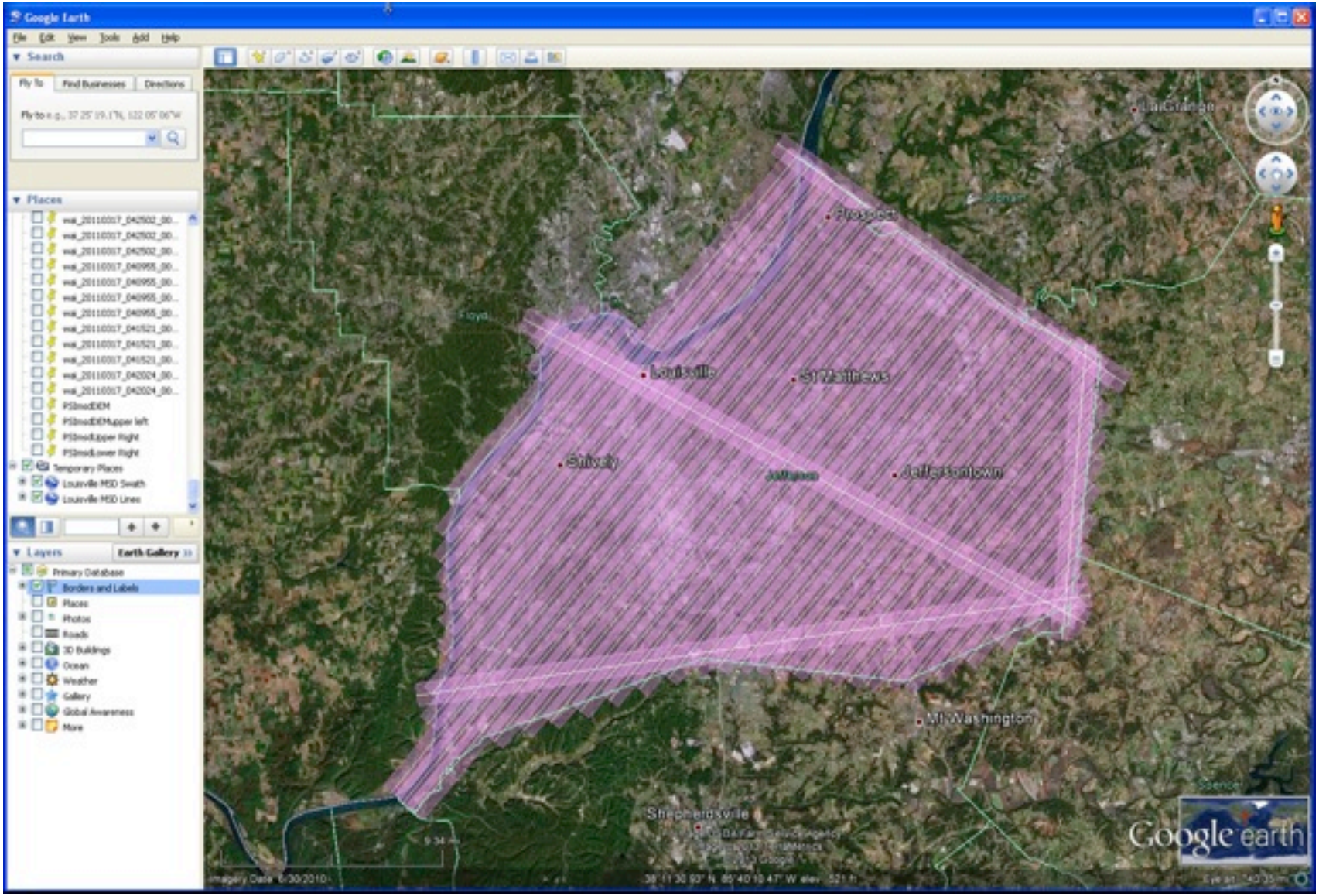


Xiomas WAI Thermal Imaging project over Jefferson County KY for Photo Science

The project was flown over three nights, January 4, 7 and 8, 2013.

The WAI performed reasonably well, we had some system faults that caused us to repeat or partially repeat 10 flight lines over the three nights (10 out of 70 total flight lines).

WAI Long Wave IR Image after processing. This is typical of the image quality of the data set.



Screen Shot of Flight Plan
The longest line is about 32 miles
Total of about 650 flight line miles

Wide Area Imager samples
January 4 to 8
Altitude is approximately
6300 feet AGL
aircraft speed is 140 knots.

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Interesting LWIR image of Electrical Power Substation with two contrast stretches

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Pretty LWIR picture of the river

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Interesting warm water outflow into the river from a facility

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Interesting warm water outflow into the river from a facility

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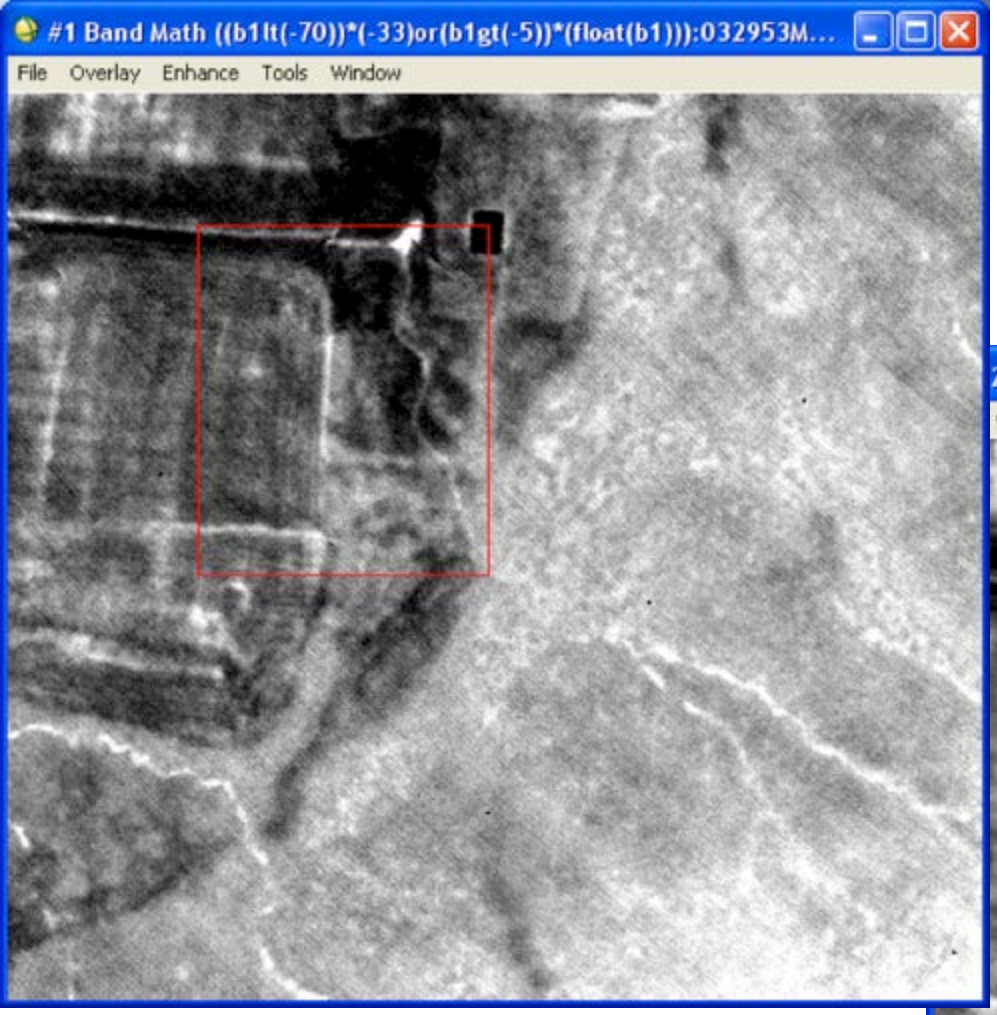
Interesting LWIR Image of water treatment plant

WAI Long Wave IR Image after processing. This is typical of the image quality of the data set

XIOMAS



MWIR Image

LWIR Image

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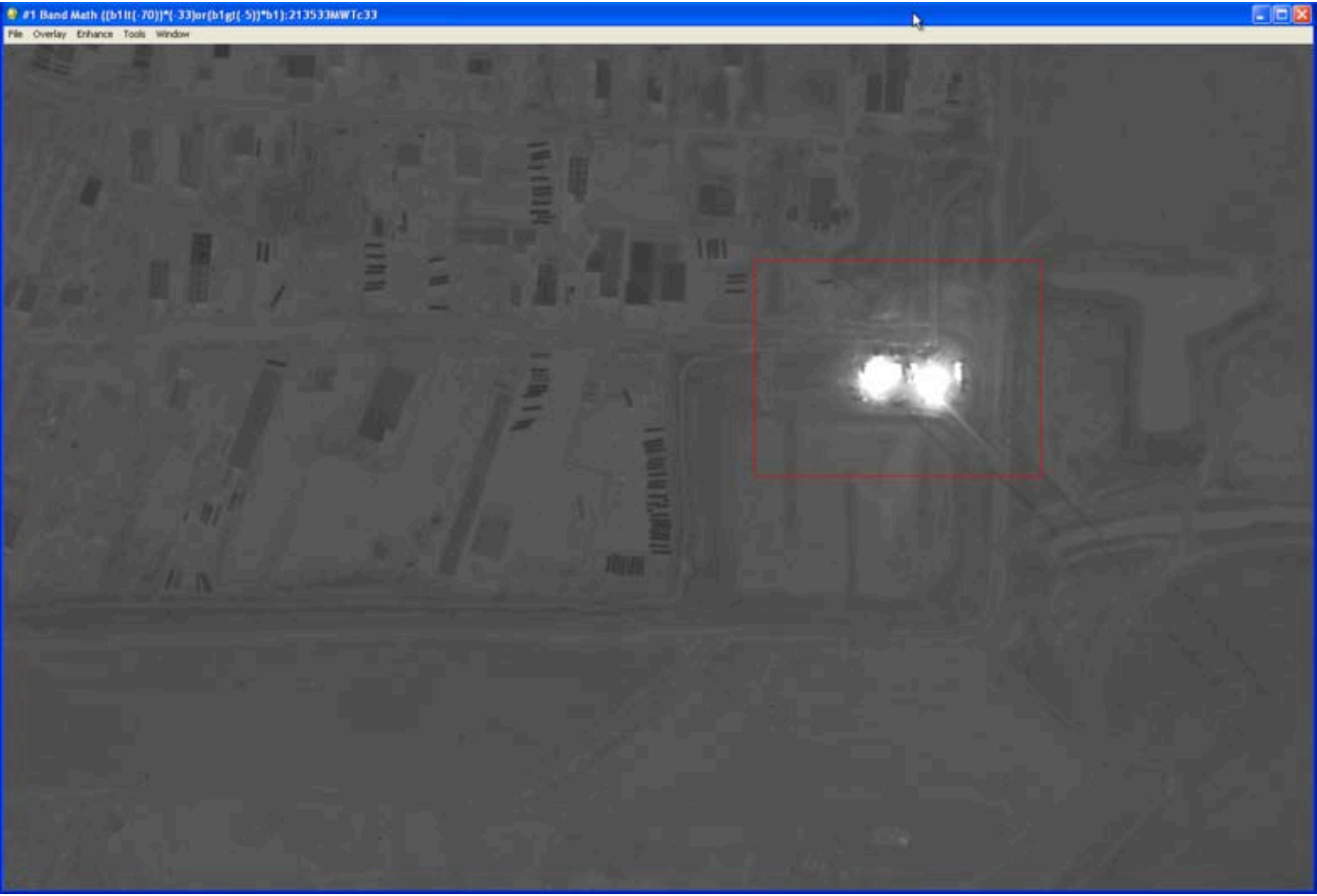

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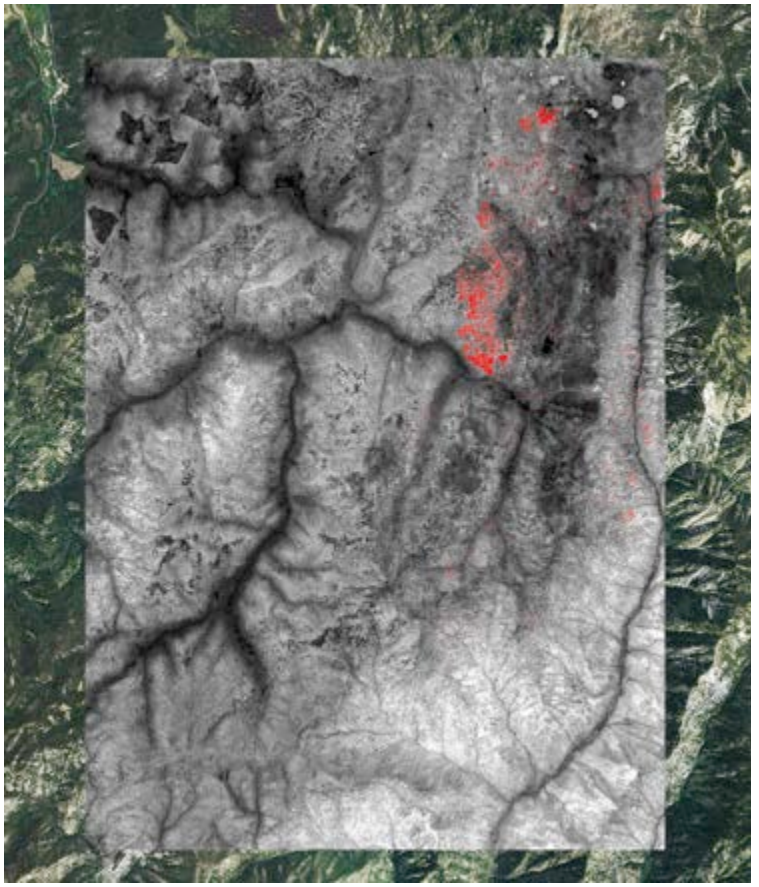
MWIR Image with something hot

Discussion of Ongoing Development

Proposed further development of the Wide Area Imager

1)Hardening the system -- In general the system has performed well. In the long term we would like to upgrade the WAI phase II prototype to the new TMAS data system architecture.

2)Improve frame to frame registration – We see several examples where the imagery is shifted frame to frame. This mis-registration does not prevent the system from serving the fire mapping mission, but does raise some concerns as it is outside the expected performance.



3) Automation and Remote Control of the operation – There are a number of features and planned improvements that we believe will essentially eliminate the need for an airborne operator, further reducing the cost of operation.

We will be presenting a paper titled:

Operational Test Results and Technical Description of the Xiomas Airborne Wide Area Imager

at the Large Wildland Fires: Social, Political and Ecological Effects Conference in Missoula

http://largefireconference.org/proposalspresentations/call-for-presentations/

Presenter: Green, John, Principle Investigator, Xiomas Technologies L.L.C.

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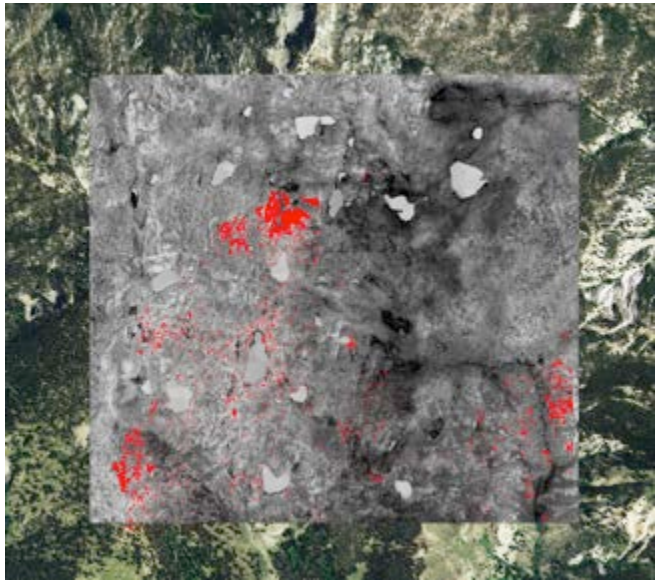
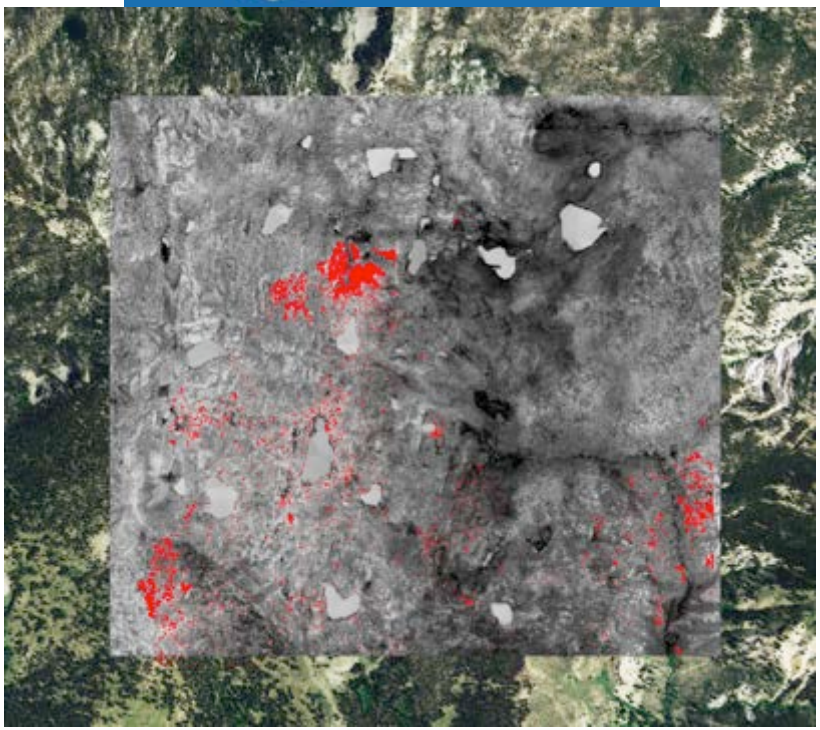


Large Wildland Fires: Social, Political & Ecological Effects

University of Montana, Missoula, USA. May 19-23, 2014

Questions?



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Research and Development of
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