Xiomas Technologies
Briefing
for
Spring 2019 TFRSAC

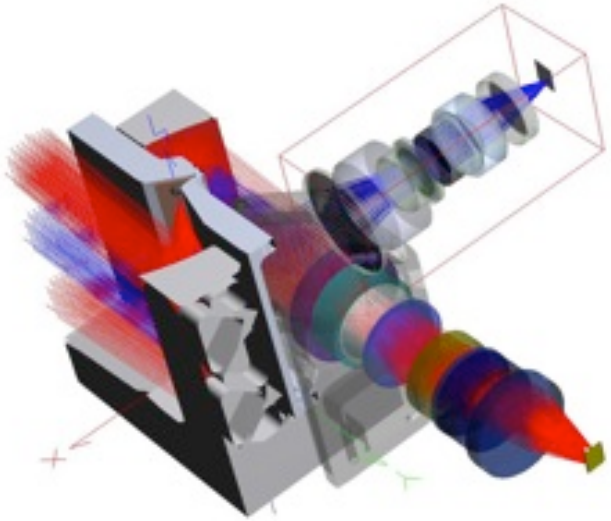
Wide Area Imager Phase III Update
Thermal Mapping Airborne Simulator (TMAS) Phase II Update
Three Band IR Detector (TBIRD) Phase II Update

Xiomas Technologies, L.L.C.
John Green
johngreen@xiomas.com
734-646-6535

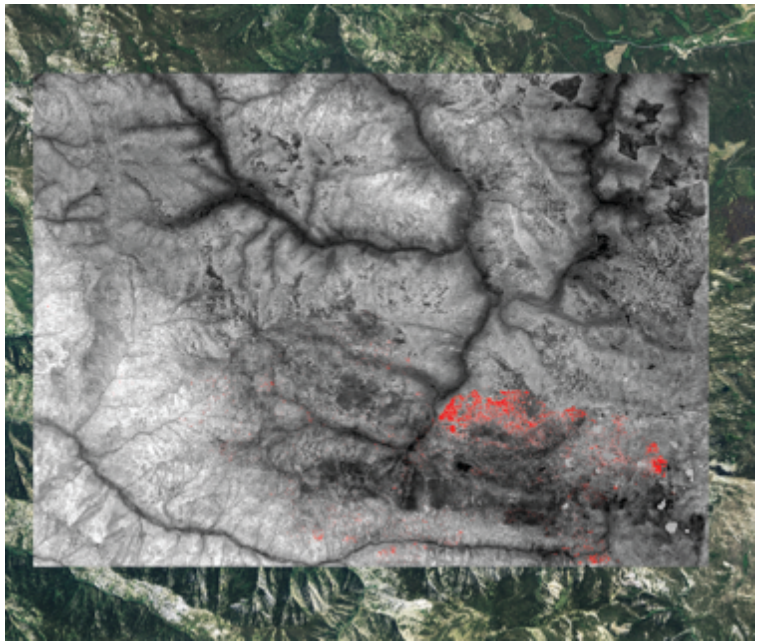
XIOMAS

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

XIOMAS

How are the Small Business Innovative Research programs structured?

"The structure of the SBIR and STTR programs reflects the Congressional understanding that the innovation process and bringing new products and services to the market takes time and has a high degree of technical and business risk."

The programs have three phases:

Phase 1 is the opportunity to establish the scientific, technical and commercial merit and feasibility of the proposed innovation in fulfillment of NASA needs. All Phase 1 contracts are selected competitively and require reporting on the work and results accomplished, including the strategy for the development and transition of the proposed innovation. NASA SBIR Phase 1 contracts last up to 6 months with a maximum funding of $125,000

Phase 2 is focused on the development, demonstration and delivery of the proposed innovation. It continues the most promising Phase 1 projects through a competitive selection based on scientific and technical merit, expected value to NASA, and commercial potential. All Phase 2 contracts require reporting on the work and results accomplished, and whenever possible, the delivery of a prototype unit or software package, or a more complete product or service, for NASA testing and utilization. Both SBIR and STTR Phase 2 contracts are usually for a period of 24 months with a maximum funding of $750,000.

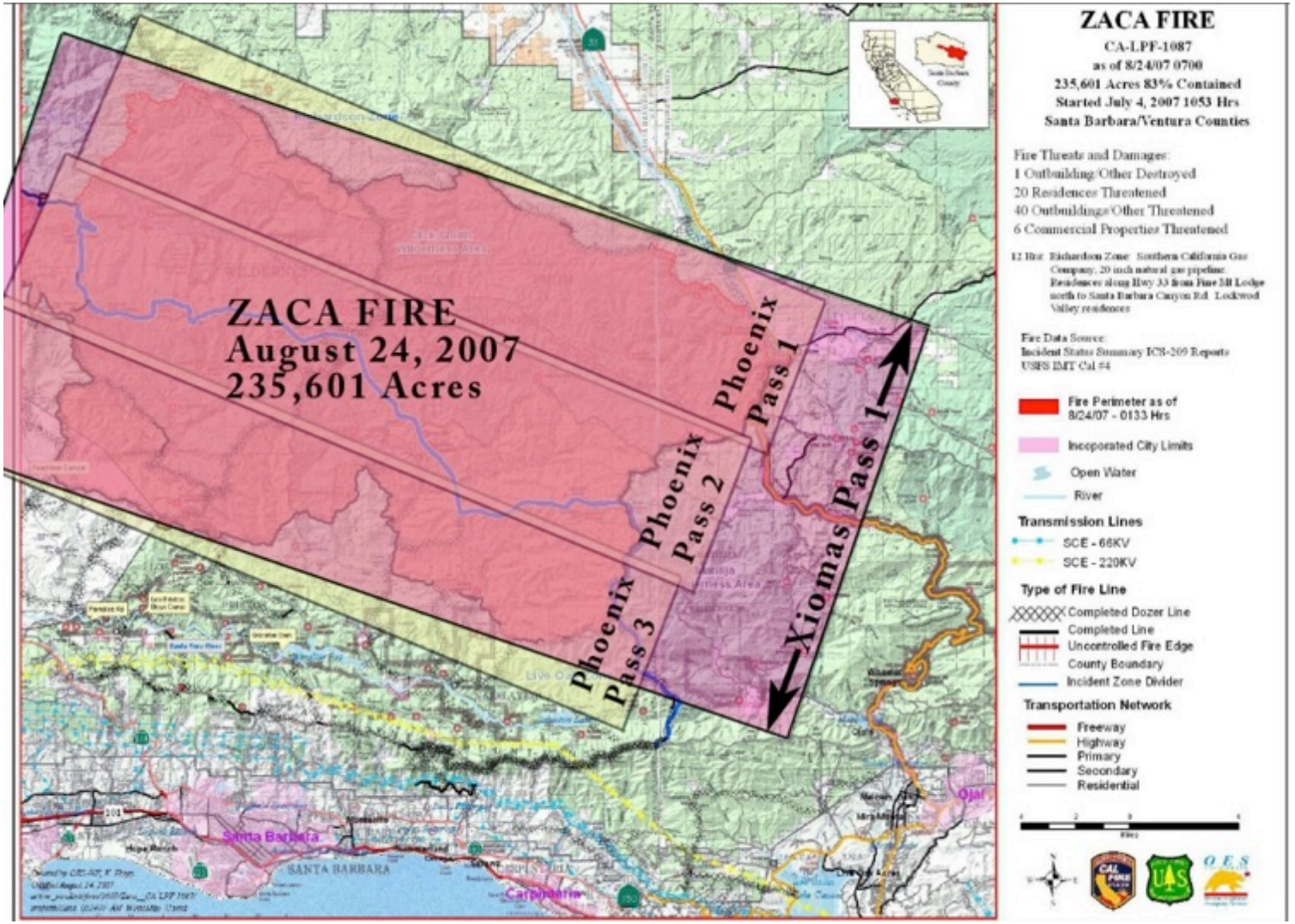
Phase 3 is the commercialization of innovative technologies, products and services resulting from Phase 2, including their further development for transition into NASA programs, other Government agencies, or the private sector. Phase 3 contracts are funded from sources other than the SBIR and STTR programs and may be awarded without further competition.

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 --

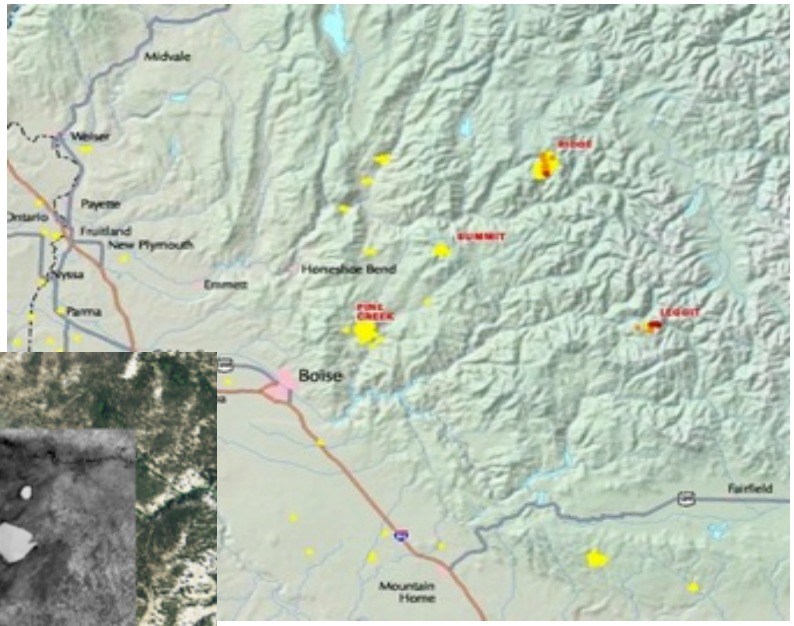
XIOMAS

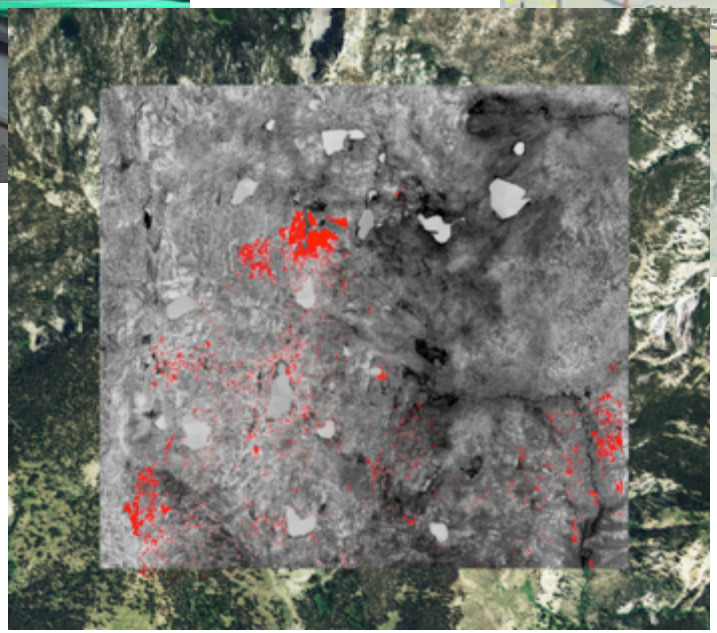
Goal is to reduce operational costs by a factor of 2X to 3X by increasing coverage rate and decreasing flight time



Coverage of the current Phoenix system operated by the U.S. Forest Service National Infrared Operations group. The Phoenix system has a 120 degree field of view and covers a swath approximately 6 miles wide from 10,000 feet. At this altitude the Phoenix system has a 12.5 foot pixel at nadir. The proposed Xiomas system will have a 12.5 foot pixel from 42,500 feet and approximately a 16 mile swath width resulting in a 3X increase in coverage.

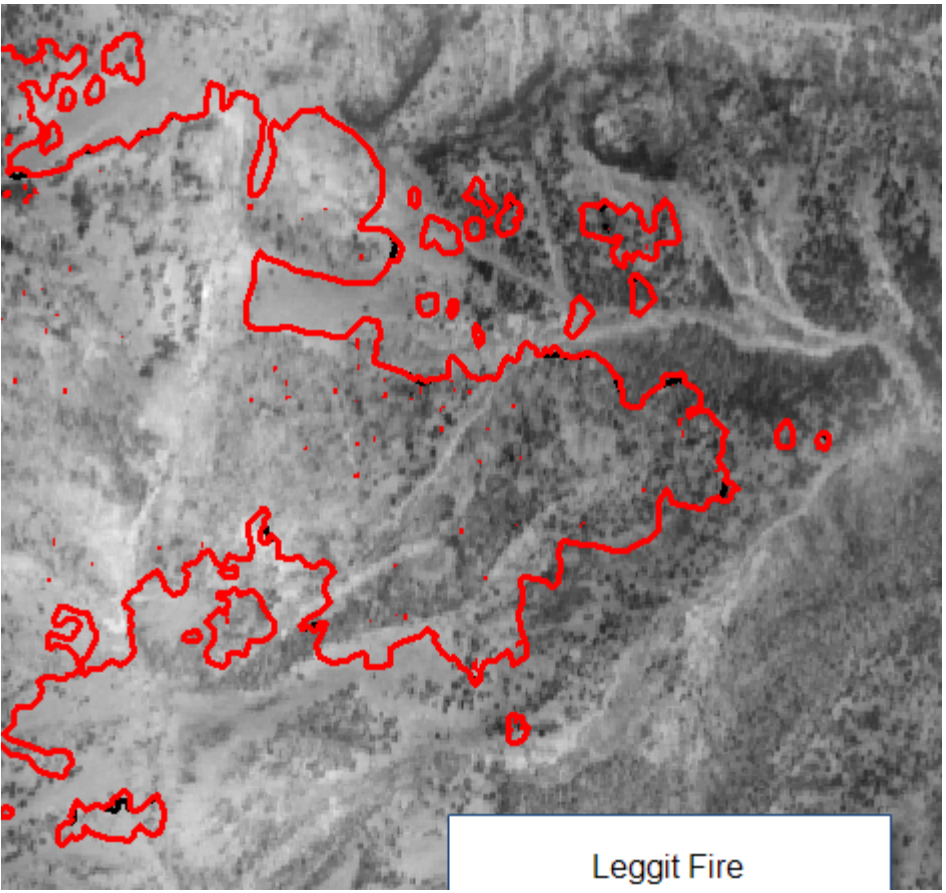
Wide Area Imager Fire Mapping Evaluation/Demonstration Mission --
Multi-day mission conducted July 23-26, 2013 over active fires near Boise Idaho



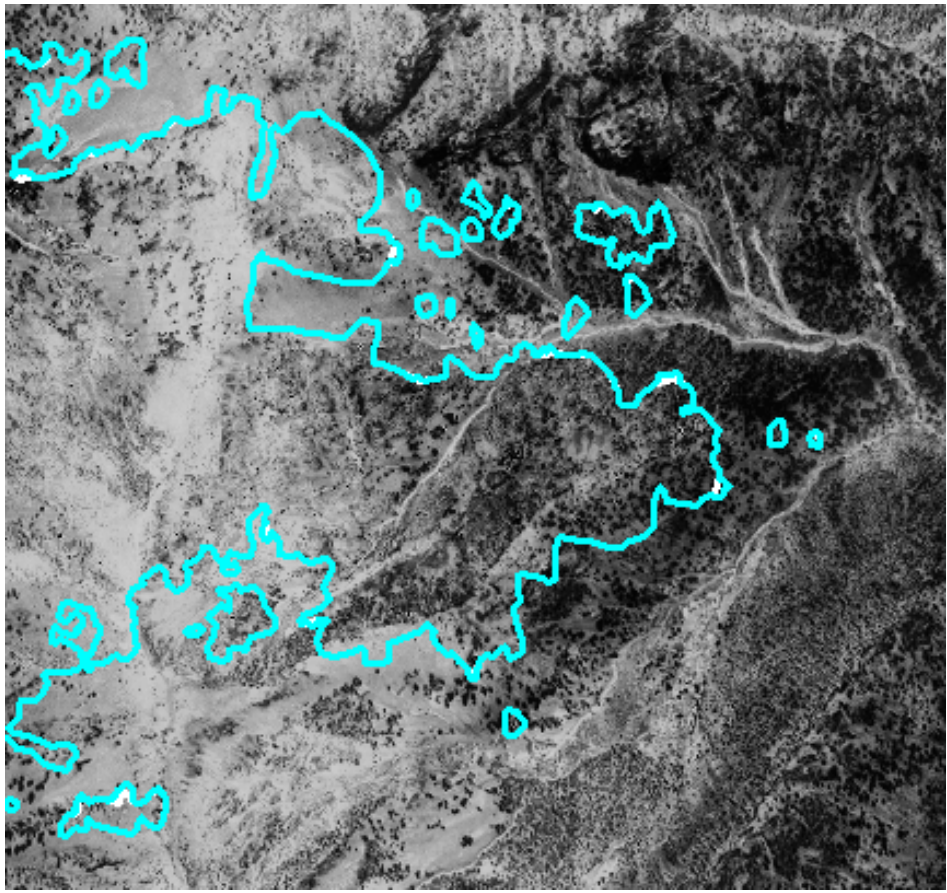


In total, the WAI has flown about 30 flights, including a number of engineering tests, calibration flights, several flights for two commercial imaging projects, and the fire mapping flights

2013 USFS Test Flights



Phoenix Imagery



WAI Imagery

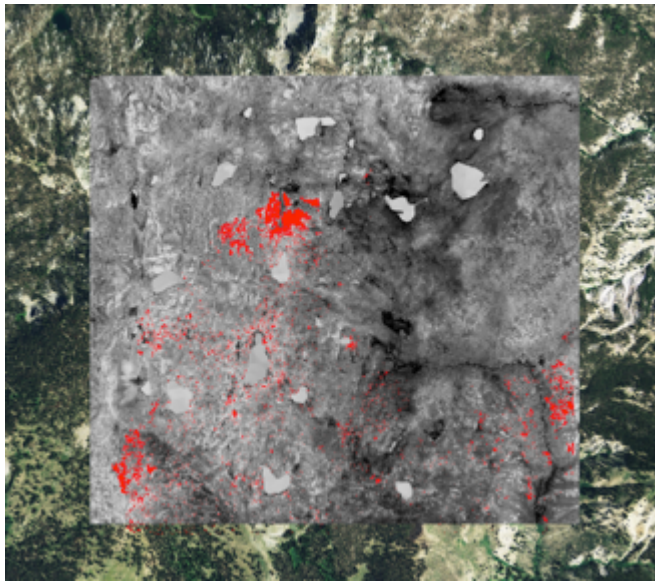
Both data sets are collected around the same time and from around the same altitude (9,000 foot AGL)

Note that the Fire Detection is very similar and that the Spatial Resolution of the Xiomas WAI is much higher. This will allow the WAI to be operated at a higher altitude and faster speed increasing coverage by a factor of 2X to 3 X.

In My 2014 we presented 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/

Conference Proceedings were published in July

Presenter: Green, John, Principle Investigator, Xiomas Technologies L.L.C.
Additional Authors
Quayle, Brad, USDA Forest Service
Johnson, Jan, Remote Sensing Specialist, Red Castle Resources Inc.
Hinkley, Everett A., National Remote Sensing Program Manager, USDA Forest Service
Ambrosia, Vincent G. Associate Program Manager - Wildfire, NASA Applied Science Program



Large Wildland Fires: Social, Political & Ecological Effects

Xiomas WAI 2015

Thermal Imaging project over Jefferson County KY for Quantum Spatial Inc.

Following the success of the 2013 mission, Jefferson County hired us again to fly the WAI over Louisville Kentucky in January and February 2015.
Following is some sample imagery from this mission.

XIOMAS

Xiomas WAI 2015

Thermal Imaging project over Jefferson County KY for Quantum Spatial Inc.

XIOMAS

Xiomas WAI 2015

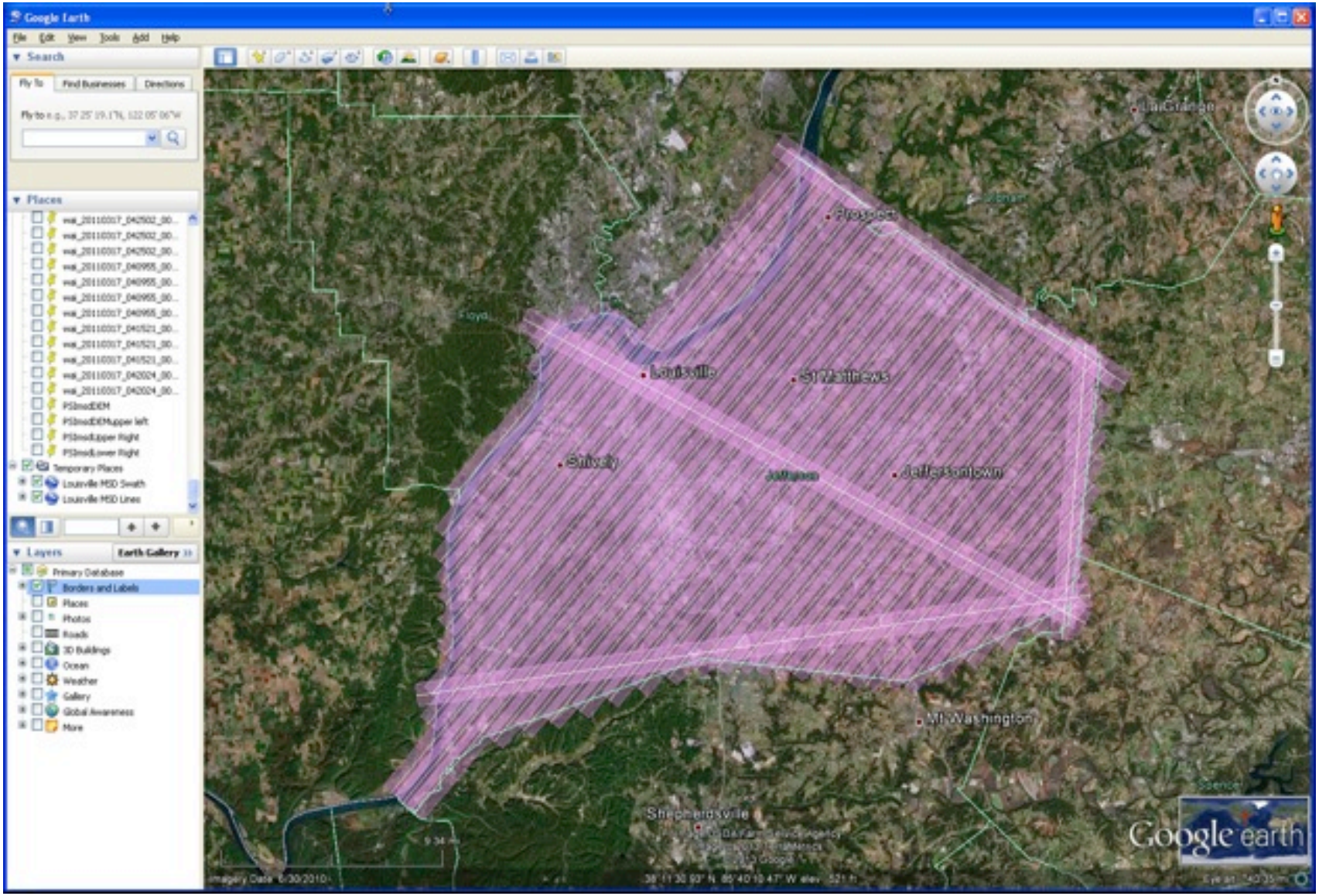
Thermal Imaging project over Jefferson County KY for Quantum Spatial Inc.

XIOMAS

Xiomas WAI 2015

Thermal Imaging project over Jefferson County KY for Quantum Spatial Inc.

XIOMAS



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

TMAS
Thermal Mapping Airborne Simulator
for
Small Satellite Sensor
Phase II
July 2013 to July 2016
Technical Monitor James Brass

Xiomas Technologies, L.L.C.

Phase II Contract Number: NNX13CA58C

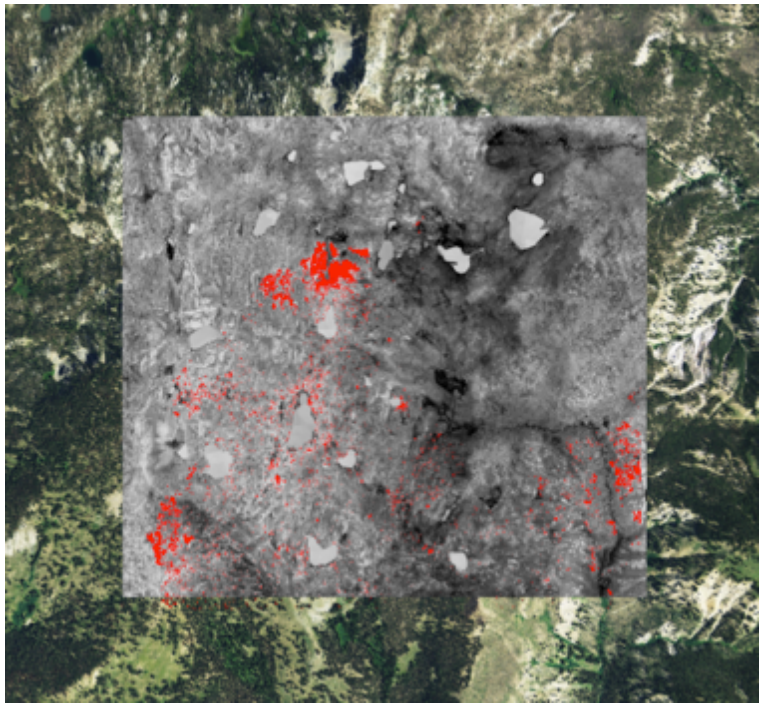
Principle Investigator: John Green
734-646-6535

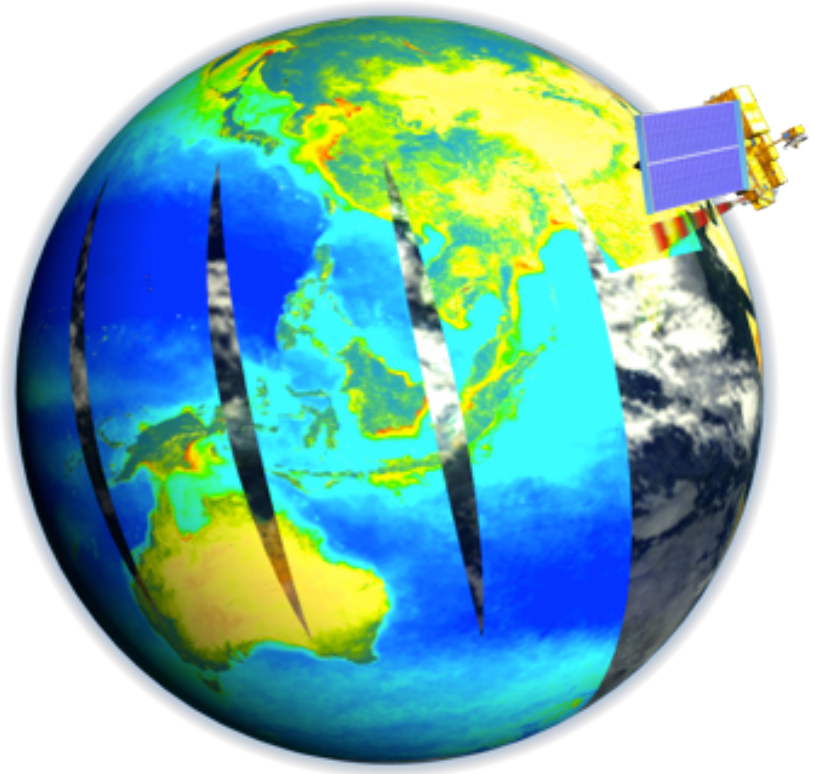
XIOMAS

TMAS

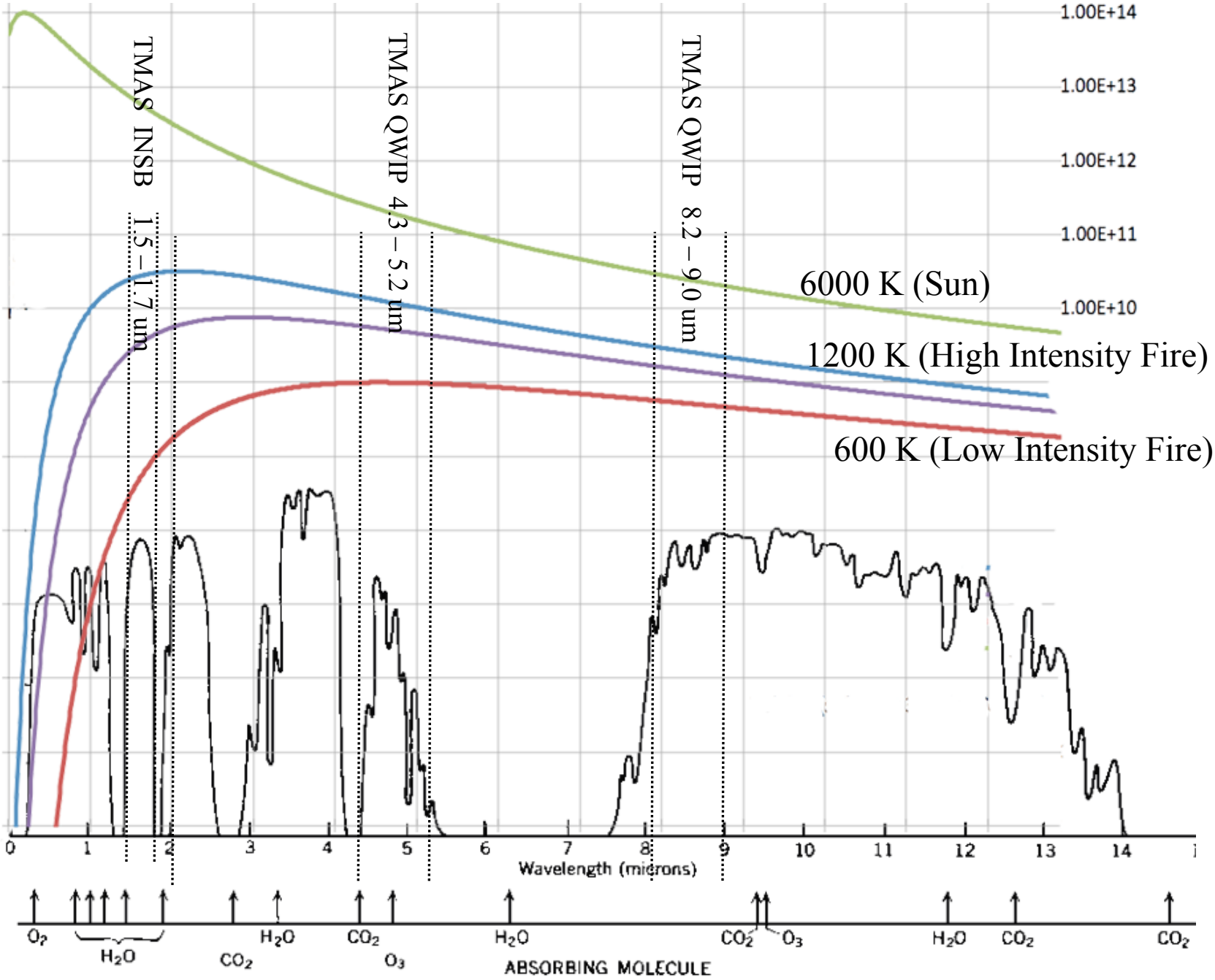
Operating at the same altitude and velocity as MODIS the TMAS will have the same capability to map the globe every one to two days

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)





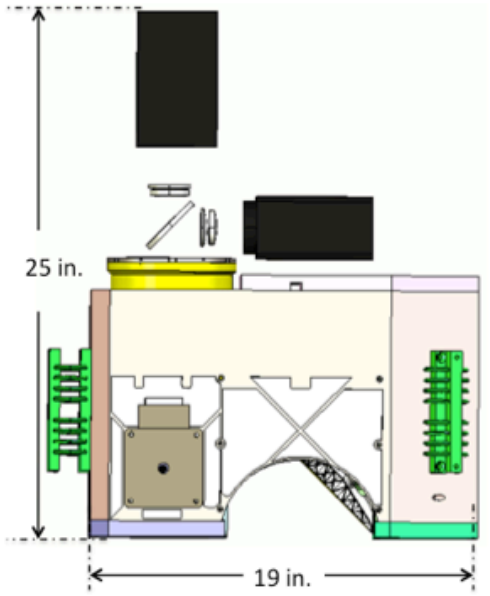
XIOMAS

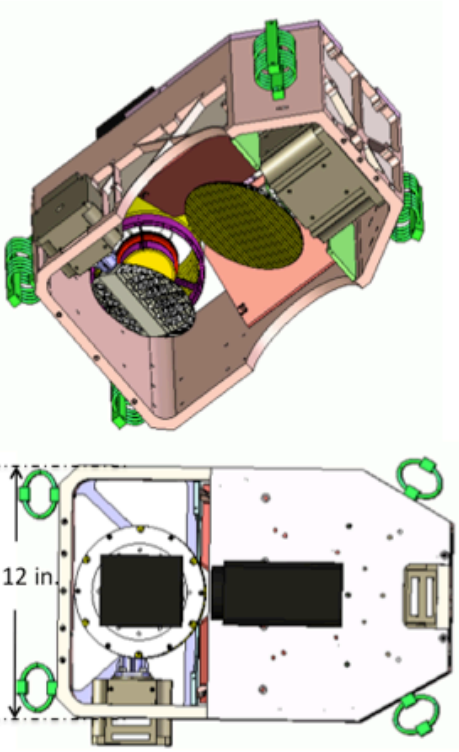


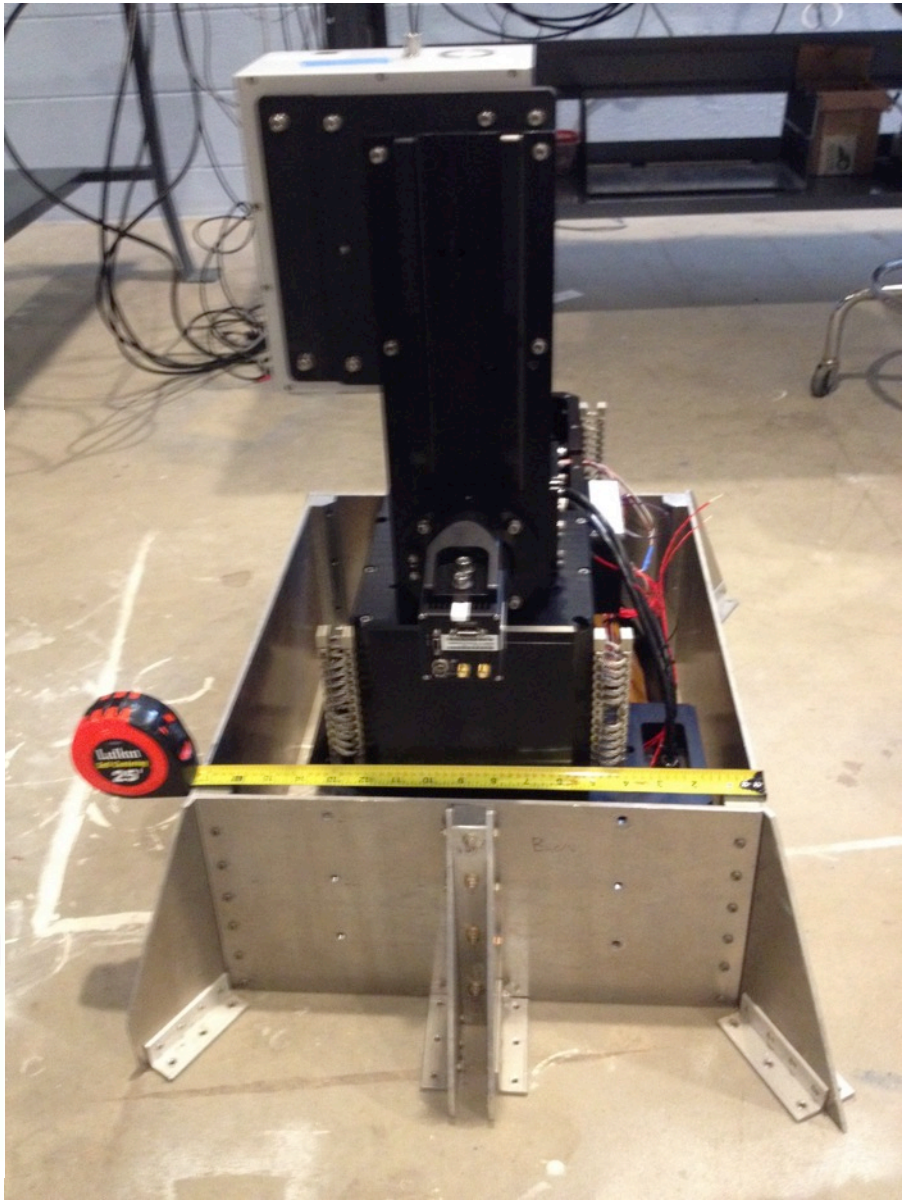
TMAS Spectral Bands and Black Body Curves

TMAS Status
May 2017

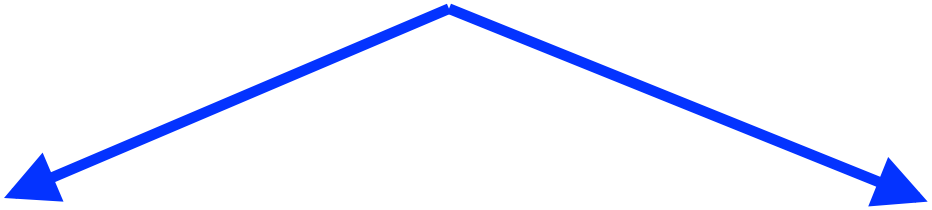
TMAS has been delivered to NASA Ames and we're looking for opportunities to get it operational







Next Steps for TMAS



Airborne

- SW Testing and Bug Fixes
- Modification to match ACFT Flight Profile (Replace TMS Telescope with WAI Lens)
- Environmental Tests (Shock, Vibration, Temperature)
- Flight Tests and Calibration

Space

Major Engineering Effort to meet Environmental and Reliability Requirements

TMAS and WAI Performance at 18,000 Feet AGL

TMAS vs. WAI -- This is an example, other flight profiles are easily accommodated by changing the system set up through the user interface						
	Acft. Speed (kts)	Swath Width (feet)	Acquisition Rate (acres/hr.)	Altitude (feet)	FOV (degrees)	GSD (feet)
TMAS	180	11,350	282,000	18,000	35	2.4
WAI	180	51,400	1,278,000	18,000	110	6

XIOMAS

TBIRD
Three Band Thermal Infrared Detector
for CubeSats and UAS

Contracting Officer Representative: Kim Hines

Xiomas Technologies, L.L.C.

Phase I Contract Number: 80NSSC18P2044

Principle Investigator: John Green
johngreen@xiomas.com
734-646-6535

Performance Characteristics and Technical Requirements

In developing the notional design for this proposal, we have patterned the platform characteristics on Terra and Aqua satellites and have analyzed the design to determine system performance on a CubeSat in a similar orbit.

Note that minor changes in TBIRD operating parameters will easily accommodate flight profiles of suitable UAS and manned aircraft.

	Description	Proposed Design	Comment
1	Size Weight and Power	3 unit to 6 unit CubeSat	In phase I we will develop a couple of preliminary designs ranging in size from 3U to 6U
2	Spectral range	MWIR – 3.4 to 4.1 um LWIR – 8 um to 10 um LWIR – 10 um – 12 um	This notional band selection is based on a considering both the application needs and an estimate of COTS technology performance
3	Across Track Field of View	110 degrees	The step stare mirror motion parameters are flexible and the across track field of view can be adjusted
4	Spatial Resolution	213 urad	Generates approximately 150 meter GSD from 705 km
5	Platform Speed	Low Earth Orbit -- 7504 m/s	Estimates based on the candidate platforms
6	Platform Altitude	Low Earth Orbit – 705 km	Estimates based on the candidate platforms
7	Raw Data Rate	5.8 Mbytes/s	
8	Down link data rate	1 MBits/s	Estimate based on current published state of the art
9	Shock, Vibration, and Environmental	Per D0-160	We propose to conduct DO-160 shock, vibration, and temperature tests and determine conformance to other DO-160 specifications by analysis.
10	Applicable standards		California Polytechnic State University CubeSat Design Specification

Technical Requirements – continued

Draft Technical Specifications for TBIRD operating in Low Earth Orbit with 150m spatial resolution and global daily coverage

Note – This table refers to CubeSat configuration.

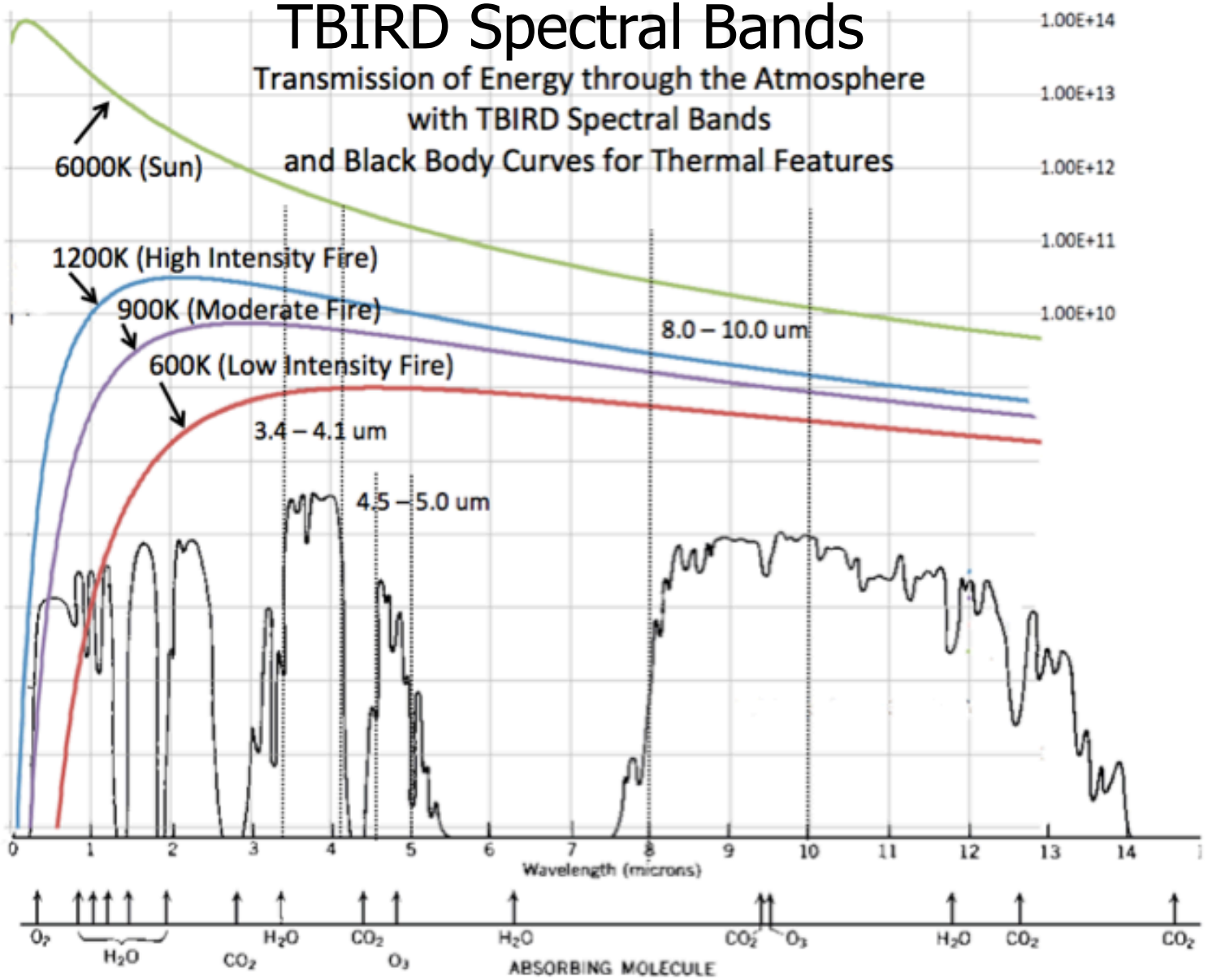
During the Phase I we will develop similar Technical Specifications for UAVs

Camera --Three Band IR Detector TBIRD		Raytheon SB450
Spectral Response	MWIR/LWIR/LWIR	
Pitch (um)		17
Pixels Across Track		2048
Pixels Along Track		1536
GSD (m)		150
Focal Length Len (mm)		79.9
IFOV (urad)		212.765957
Fire detection limit gsd (m)		9.48683298
Swath Width (m)	2013688.69	
operating Altitude (m)	705000	
Operating Speed (m/s)	7504.4	
FOV per frame across track degrees		24.5821199
FOV per frame Along Track degrees		18.5606688
Percent Overlap Across Track		0.2
Percent Overlap Along Track		0.2
Step Stare Mirror Total Scan Angle aka Field of View (degrees)		110
Across Track Steps		6
Step Angle adjusted using integer Across Track Frames (degrees)		18.3333333
Total Step Stare Time Across Track based on speed and forward overlap (s)		24.9064642
Step Time (s)		3
Available Integration Time (s)		0.15107737
Frame Rate (Hz)		0.31735178
Retrace Time (s)		6
Pixel Smear due to forward motion During Dwell Time (FMC Lens removes this)		1.50088
Data Rates (kBytes/s)		5849.42793

TBIRD Flight Profiles and Performance

	CubeSat	Ikhana	King Air B200	Comment
GSD (m)	150	1.5	1.6	
Fire detection limit With Super Resolution	9.5 m by 9.5 m 6.7 m x 6.7 m	9.5 cm by 9.5 cm 6.7 cm x 6.7 cm	10 cm by 10 cm 7 cm x 7 cm	Approximate based on updated radiometric models using kA-B fire detection algorithm. We make the assumption that SR will improved detection by 2X
Swath Width (km)	2013	14	15	
Operating Altitude (feet)	2,291,250	22,750	24,375	
Operating Speed (kts)	14,600	180	240	
Step Stare Mirror Total Scan Angle aka Field of View (degrees)	110 degrees	90 degrees	90 degrees	
Frame Rate (Hz)	1	1	1	

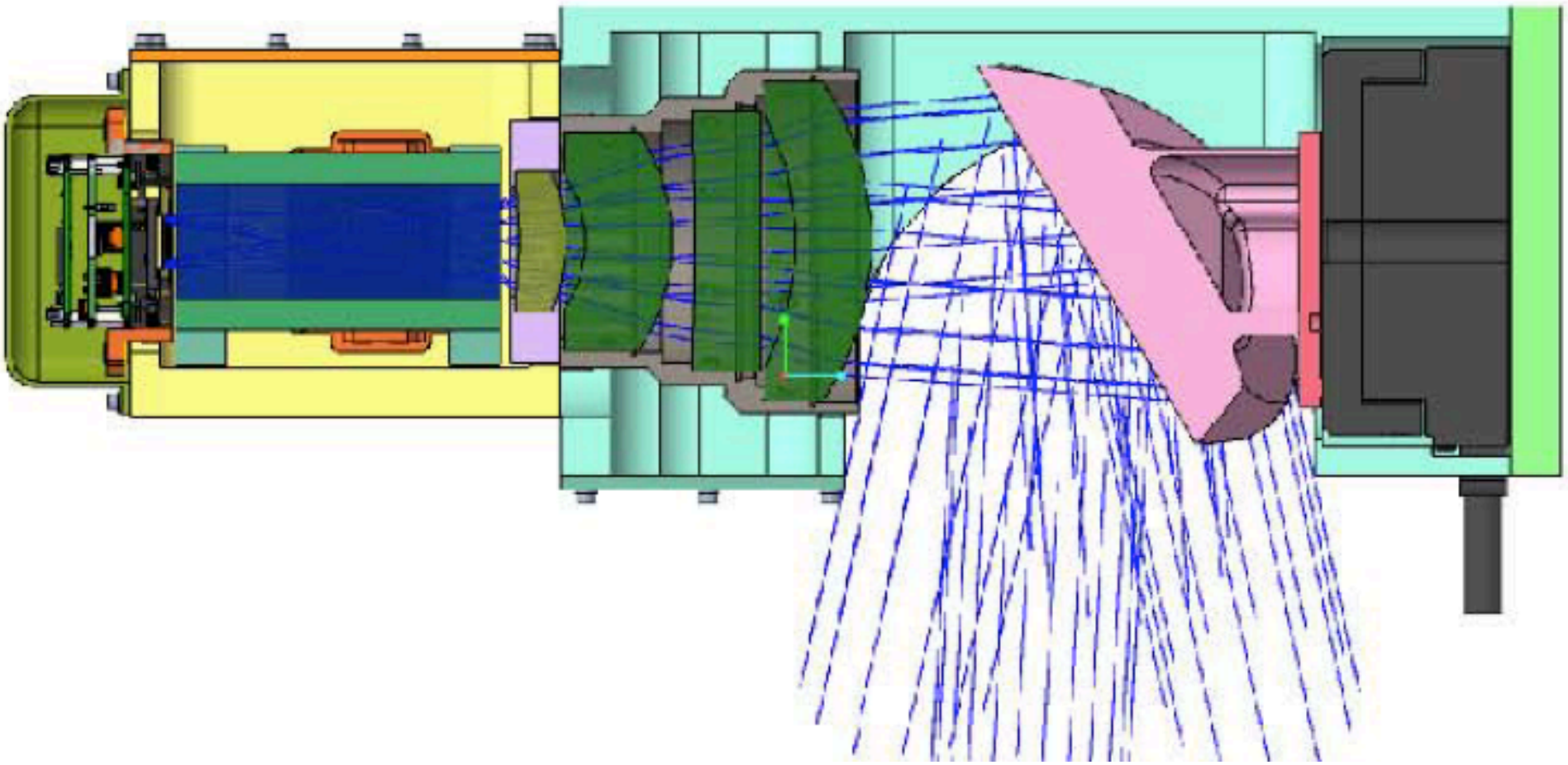
TBIRD Spectral Bands



TBIRD Spectral Bands Overlaid on Atmospheric Windows with Black Body Curves

XIOMAS

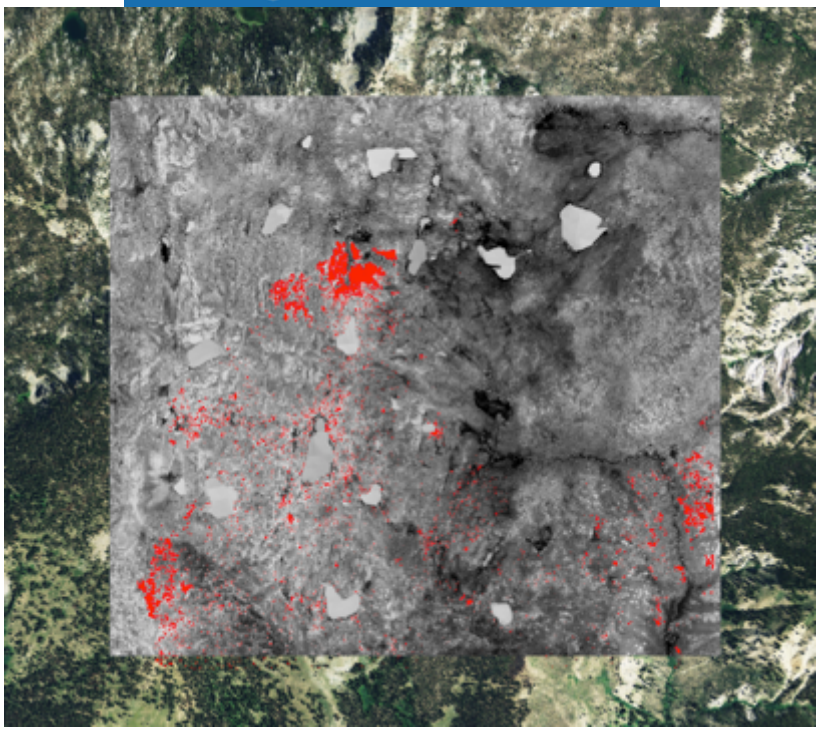
TBIRD Sensor Head



Length 277 mm in the Phase II and 237 mm in the Phase III
Height and Width 90mm

XIOMAS

Questions?



XIOMAS

JOHN M. GREEN
JOHNGREEN@XIOMAS.COM
734-646-6535

Research and Development of
Imaging and Data Acquisition Systems

WWW.XIOMAS.COM