Presentation Outline

Background

WRAP Project TFRSAC Technology Development Sensor / R/T Data Communications CDE as DSS Long-Duration Airborne Mission Capability (UAS)

Western States Fire Mission Support to Esperanza Fire – October 2006 Four Western States Missions – Aug / Sept 2007

Southern California Firestorm Support

NASA Ikhana UAV Platform Mission Data Collections and Distribution

View from the Fire Community (USFS)

What worked? How well? Technology Integration Plan Future Collaborative Directions

Wildfire Research and Applications Partnership (WRAP)

2003 – 2007 (5 Year Effort) Supported By: NASA Applied Sciences Program

Collaborations

NASA-Ames Research Center (ARC)

Ecosystems Science and Technology Branch Airborne Sensor Facility Computational Sciences Division

USDA – Forest Service

Remote Sensing Applications Center (RSAC) National Interagency Fire Center (NIFC



UAV Applications Center – NASA Research Park





WRAP Background

The Wildfire Research and Applications Partnership (WRAP) is funded collaboratively between NASA (ARC) and USDA-Forest Service RSAC to explore, develop, demonstrate, and transfer NASA "capabilities to the USDA Forest Service, NIFC and other partner fire management agencies:

Specific Area of Focus: Tactical Fire Management



Objective:

- Provide mechanism for defining requirements for improving wildfire imaging;
- R & D of those required technologies;
- Demonstration and validation of those technologies;
- Technology transfer and training.

To:

- Increase information content;
- Reduce information delivery time;
- Simplify data integration processes.

Result:

Establishment of the TFRSAC.

Technology Development: Improved Sensing Systems

AMS Wildfire Sensor

Band	Wavelength µm	
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 (TM5)	
10	2.08- 2.35 (TM7)	
11	3.60- 3.79 (VIIRS I	M12)
12	10.26-11.26 (VIIRS M	/ 15)

Total Field of View:	85.9 degrees
IFOV:	2.5mrad
Altitude:	25000'
Spatial Resolution:	20m (at sea level





Technology Development: Real-Time Data Sharing

Over the five year efforts, team demonstrated progression: from 30-60 minute delivery of single-channel sensor data (non -rectified; rectification done "on- ground").

То.....

>5 minute delivery of terrain- and geo-rectified, multi-channel data, and shape-files, in various formats (KML, GeoTiff), meeting OGC standards.

All processing on-board!!

Integrate SRTM terrain data on on-board processing system to generate automated terrain-rectification processes.

Developed communications protocols using the C&C telemetry link of UAV platforms to distribute data to ground systems. Technology Development: Collaborative Decision Environment (CDE) as Decision Support System (DSS)

Collaborative Decision Environment Development

- FY2004 Intelligent Mission Management Project collaboration between codes TI, SG, AR to develop UAV autonomy for science applications
- User requirements based on NASA/USFS Wildfire Research and Applications Partnership (WRAP) western states fire mission
- Initial development based on MER/CIP software but changed technical approach after most Aero funding eliminated
- 2006: CDE selects Google Earth as visualization client for planning and monitoring UAV wildfire response missions.

CDE: A Multi-Capable DSS Client

Provide:

- Mission planning that aggregates science goals from remote users to enable payload directed flight.
- A secure mechanism to facilitate distributed flight planning for UAVs.
- Mission monitoring tools to provide situational awareness.
- Analysis tools to observe, visualize, and interpret sensor and external data.
- Automated mechanisms to generate data products (e.g. GeoTIFF, vector shapes for fire perimeter).
- Groupware-like collaboration in communicating and sharing data products.
- Interface to other IMM elements including on-board and ground -based components.

CDE: Dynamic Data Display and Real-Time Delivery



Real-time 3-D rendering and fly through of acquired fire imagery

CDE: R/T Data Integration Layers

WILDFIRES NIROPS IR Requests Inciweb National Incidents CONUS MODIS and Large Fires MODIS 1km Fire Detections (Last 0-12 hours) MODIS 1km Fire Detections (Last 12-24 hours) MODIS 1km Fire Detections (6 days to last 24 hours) CONUS Fire Perimeters (From RSAC) Alaska MODIS and Large Fires Alaska Fire Perimeters Hawaii MODIS and Large Fires Hawaii Fire Perimeters Canada MODIS and Large Fires

WEATHER

GOES IR NWS Fire Weather Forecast RAWS (Remote Automated Weather Stations) Global Cloud Top Temperatures NWS Warning Products Global Lightning Detection (Real-Time)

WESTERN STATES FIRE MISSION

COA Boundaries

Routes WSFM 2007 Backbones Keep-Out Zones Facilities (Locations Relevant to WSFM) Edwards Weather Station

Mission Plans

Current Mission Plan Flight Plan **Previous Missions Flown Target Template Aircraft Position** Current Position (R/T 1-minute flight location updates) **Previous Missions** Flight Date (archive of flight flown) Wildfire Sensor Data Sensor Images **Current Mission Previous Missions** Sensor-Derived Fire Perimeters Current Mission SGGATE WMS Image Overlays **MODIS Overpasses** Mission Date Periods TERRA / AQUA Pass date and time

NATIONAL AIRSPACE

FAA ARTCC Boundaries Temporary Flight Restrictions Special Use Airspace (Near Edwards Air Force Base)

Over 40 data layers included with additional layers easily integrated!!

Additional CDE Tools: Instant Messaging and Real-time Video

APRIL IN Access	#CTCCC estimation beteffish and sena total	1	0.000	when Chight Jack		
and an and the second second	Diar Members Denar			The second se		
	And werents Party	The Average of the State		Statement of the local division of the local		
Buddes (*)	1992 - 1992 - 1993 - 1994 - 19	Penomote 0 ran				
Francia Enormetto	still have one of the spectrographs? But sounds like an interesting	and change of the				
joe Tatale	applicationSED	a that				
Stave Wegener	to shack in looks like we not hard into the meno.	Totah Goe Total				
Vince Ambrosia	TO 477 AM Recomments in Risson, they've inless fore of images	aveganer Goeve				
TE-AD (D)	1-03 XM featurety if you use the Experience Massim and the Lempler	100000000000000000000000000000000000000				
Mam Linese	out yniteropy you'l see that I add the CA-OES fee persector that Tim					
ffine	Ball sort ma					
ARC	14:S7 AMI samplemen. The fire is huge! This is as cool					
Buddies	(3.04 AM; swogener has left					
TL-KI	15-31 /UK) renormatio: Whole and Blows, are you gays bill awaker					
	which address much state for address of Westmann					
	12-20 AMI Rehomotry IN Ched. Japping should have a smart 7 AM					
	28-26 AMC effect thanks, delyou get to along at al7					
	[8-27 AM] fenomoro; took a 60 minute nap in my office					
	16:28 AMI chost: I have an awful let of ecreenabotal					
	IS 28 AM ferrorroto, it will be interesting to bok at the POS flight dataIt					
	seemed that the aircraft slowed down during the last few laps around the					
	meeor I could just have been imagining it					
M I GOA	9 Jo 19 AM, Renomento: theirs good, benduse-Long took & couple with the ball classes i for and a transmission ways for 560° of the					
Contraction of the local division of the loc	11.11 AM fenometry if use look at the entries by Tax, he had some					
O O CHEMIS C	Informative interpretations of the data					
(🗭 🖭	(6.10) AM; chost, fit easilitiesk and read the log. (6.41 AM; totaly hiss entered the room	1				
Avelable	K 32 AM cfroat 1 read Tim's comments, very interesting it's not too hard		1000			
NATI I	The spid the fires that are outside the CES permitter, I hope the anagery		1010107	Line Broothard		
What many	THE STAND REPORTED TO A REAL PROPERTY AND THE TOP 2 AND ADDRESS OF		and the second se			
Francis Enternolog	anow about Tom 2			() (a) (1) (a) (1)		
Prosty	(6:33 AM) awaysener hap entered the room		CONTRACTOR OF CONTRACTOR	Construction of the Advantage	providently and	
A (Address of the state of the	10.33 AM) feromoto: Good Moning Joe and BleveJust in time for the		000 R	moss Sensing Applications Center - US	SDA Feneral Service	
b Sevin Prest	andeg		4 + 6 + 2	http://jactk-effinemages/ts/feel.as/	POP with the	
Parlamiting	pulling AM proton basic moning, guts a ld has happing		The state of the local division of the local		A CONTRACTOR OF A CONTRACTOR	
A deal finder spini	C TO YOU HANDLING HOM		TO CASE LOOVING	modules have solvered and re-	serves massimples metals	191
ALCONG MULTIPLE	- · · · · · · · · · · · · · · · · · · ·		INDUSCRIST SERVICE	REMOTE SENSING APPLICATIONS C	INTER	
Plant bridge		1 1		MODIS Active	Fire Mapping Prog	rar
				and the second s	CONTRACTOR ADDRESS	
			Search	Distance Page Arrit	Wi Mark Imagers	
			The second se	Contraction of Contract		
			· BSAC House	Fire locabors are bee Nove pour most	ed on data provided by the Nation or even the first indicators or click	al treat
		and the second	· Centers Un			
	(Sent)		0			
		and the second second				

Long Duration Airborne Mission Capability (UAS)

IKHANA CO

To Support Airborne Wildfire Monitoring Capabilities, a Number of Key Variables Were Identified:

Ability for long endurance / long legs.

Linger ability

Medium to High Altitude

Autonomous Payload Capability

Operate in Hazardous Conditions (if necessary)

NASA Ikhana with Sensor Pod under-wing mount

WSFM Flights

Missions:

August 16 (10 Hrs) CA

August 29-30 (16 hours); CA, NV, UT, ID, MT, WY

September 7-8 (20 hrs) CA, OR, WA Sept 27(10 hrs) CA BAER Imagery



WSFM Flights – Aug / Sept 2007

Delivered real-time data to Incident Command on Zaca; helped save resources and team deployments, clamored for more data:

Director, Fire and Aviation Management, USFS, R5: "I was standing in Area Command for the Zaca incident on the morning of the first flight. Our conversation surrounded the "fog of war" existing due to an inversion on the southeast corner of the fire... the incident management teams did not know where the fire was, and that information was critical to modify their strategy and initiate action. The intel provided by the UAV, real time and geospatially oriented, answered that critical question and saved precious hours. Yes, indeed, it was a success. I look forward to the eventual inclusion of this technology and platform as a standard component of our arsenal. The reduction in cost, exposure to air crews currently flying infrared sorties, and the real time and extended nature of the intel provided are all advantageous to our mission. Thank you and all those with the foresight before who saw the potential and reached out in cooperation to make it a reality."







WSFM Flights – Aug / Sept 2007

Delivered real-time data to Incident Command on Castle Rock; used for operations and redeployment of resources on the fire based on our data.

Collected coincident UAV data with a MODIS satellite data overpass on Castle Rock...major science accomplishment!







Summary of WSFM - 2007

Mission Number	Mission Endurance	Date	Fire Imaged	Location of Fire
WSFM#1	10 Hours	8/17/2007	Zaca Fire	California
			Tar Fire	California
			Colby Fire	California
			Babcock Fire	Yosemite NP, CA
WSFM #2	16.1 Hours	8 / 29-30 / 2007	Jackrabbit Fire	California
			Trapper Ridge Fire	Idaho
			Castle Rock Fire	Idaho
			WH Fire	Montana
			Columbine Fire	Wyoming
			Hardscrabble Fire	Wyoming
			Granite Creek Fire	Wyoming
WSFM#3	20 Hours	Sept 7-8 2007	Butler Fire	California
			North Fire	California
			Fairmont Fire	California
			Grouse Fire	California
			Lick Fire	California
			Bald Fire	California
			Moonlight Fire	California
			GW Fire	Oregon
			Big Basin Fire	Oregon
			Domke Lake Fire	Washington
			South Omak Fire	Washington
			Zaca Fire	California
			BAER Assessment	
WEEN #4		0/27/2007	Butler, LICK,	Colifornia
VV 3F IVI #4	9.9 Hours	9/2//2007		Camornia
Total Mission Time:	56 Hours			
Total Fires Flown:	26			
States Travesed During	g Missions: shington, Nevada	Utab Idaho Mont	ana. Wyoming	

WSFM Modifications

0

AMS - Wildfire

Scanner



Back-up battery power increased to 3 hours

Wiring connections from pod to power distribution, GPS antenna, and SatCom system



Payload Areas



Ground Systems

- **Mobile Ground Control Station**
 - Dual pilot control station
 - Electronic navigation charts
 - Weather
 - 6 Engineering/Science workstations
 - Range safety workstation
 - Intercom system throughout
 - Overhead mission displays
 - Telephones
 - Remote video from aircraft start-up /shut-down site
 - Downlink video and data recording
- Mobile 2.4m Ku SatCom Antenna
 - Dual redundant receiver/transmitters





Ground Control Station Positions

Mission Manager

Pilot and Co-Pilot

Sensor Engineer Station



Science Lead Investigator Station

Image / Data Engineer Station

Certificate of Authorization (COA) Boundary Request

3 Operational Zones

Each zone includes no more than 3 Air Route Traffic Control Center (ARTCC) areas

Example : Zone A includes Los Angeles Center Oakland Center Seattle Center





Primary Emergency Landing Sites

Radius =400 nmi

Minimum Range on Battery Power

Aircraft has single generator

Landing agreements negotiated with each site



Secondary Emergency Landing Sites

Radius=50 nmi

Minimum glide distance from 23,000 ft

Over 280 sites identified

Categorized Green, Yellow, Purple, Red by pilots

Selected in unpopulated areas. Abandoned runways, dry lakebeds, flat ground, ditch areas

Primary purpose is to protect public

Actively managed during each mission



COA: Special Provisions

- Somewhat restricted flight area
- Point to point flight plan
- 3 business day mission notification to FAA
- No flight in to forecasted "moderate or severe" turbulence
- No flight in area where convective SIGMET has been issued
- No flight in area of known or forecast icing
- Lost link procedure: continue on route for 15 min
- No flight in area of affected by GPS testing, solar storms or RAIM outages

Approved COA Area

0

0 0

0.0

00

ο

•

0

G

6

820

 \odot

0

0

200 Europa Lechnologies

0 A20

0

0

00

0.00

0

10110



ormie





















A few (personal) observations and/or opinions SPS horribly broken; WNS extremely valuable, needs work; A completely new approach to catalogues/registries is needed; Let requirements drive, don't use SOS when WCS is right. Lastly, we need greater Private Sector/VAR involvement. Don Sullivan NASA Ames Research Center Moffett Field, California, USA 94035-1000 +1 650 604 0526 donald.v.sullivan@nasa.gov