UAS Support for Battlefields: Current and Future Weather Capabilities and Needs

Mr. David Knapp
Army Research Laboratory
david.i.knapp.civ@mail.mil

Army UAS – Today and Future


Hunter


Raven


Shadow

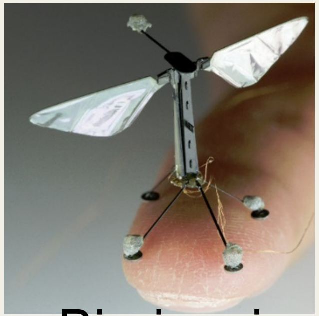

Puma


Gray Eagle


g-MAV

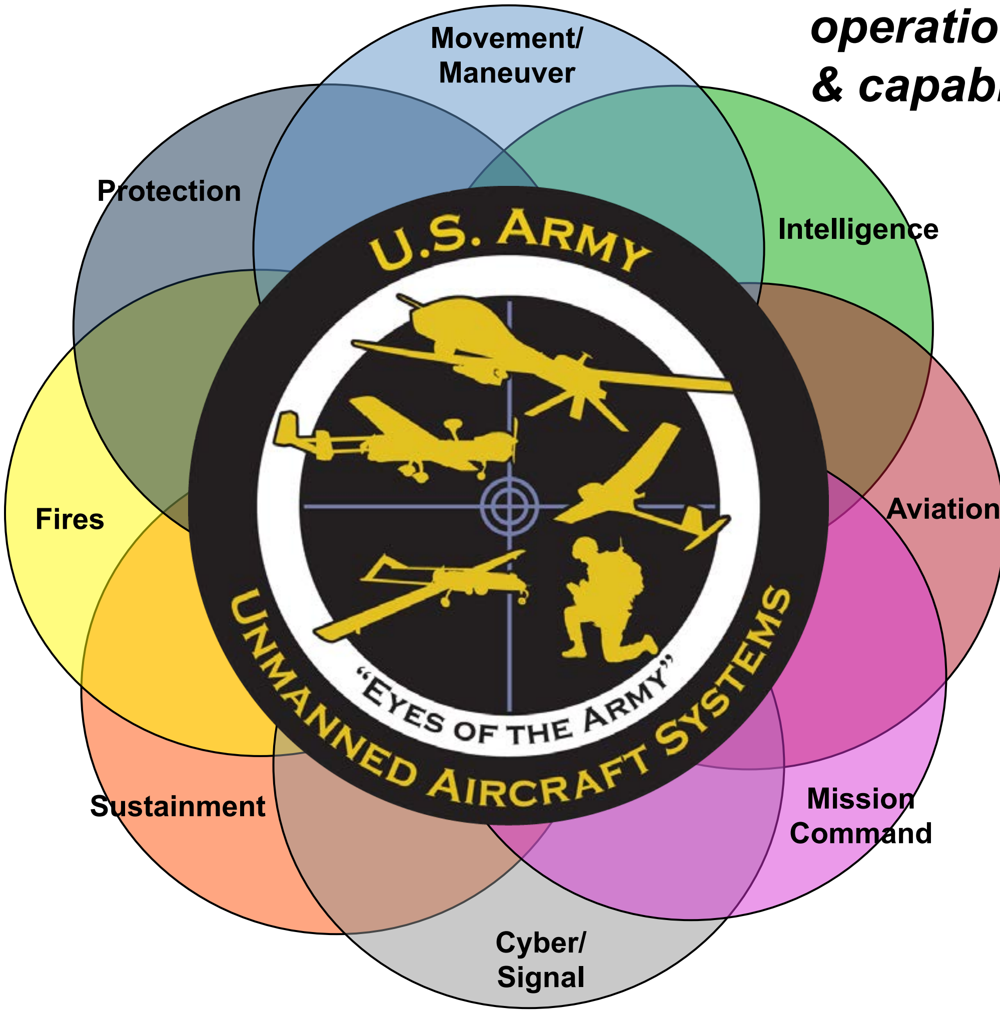

WASP

Quadcopter



Bio-inspired

UAS: Intersection of the Army

UAS interacts with all aspects of operations…mixing stakeholders, missions & capabilities



- **Recon/Surveillance/BDA**
- **Indirect Fire**
- **Data Dissemination**
- **Manned/Unmanned Teaming**
- **Electronic Warfare**
- **Special Operations Forces**
- **Comm/Data Relay**
- **Attack**
- **Cargo**

UAS has revolutionized how the Army fights…it will continue to do so

UAS…a Combined Arms Asset

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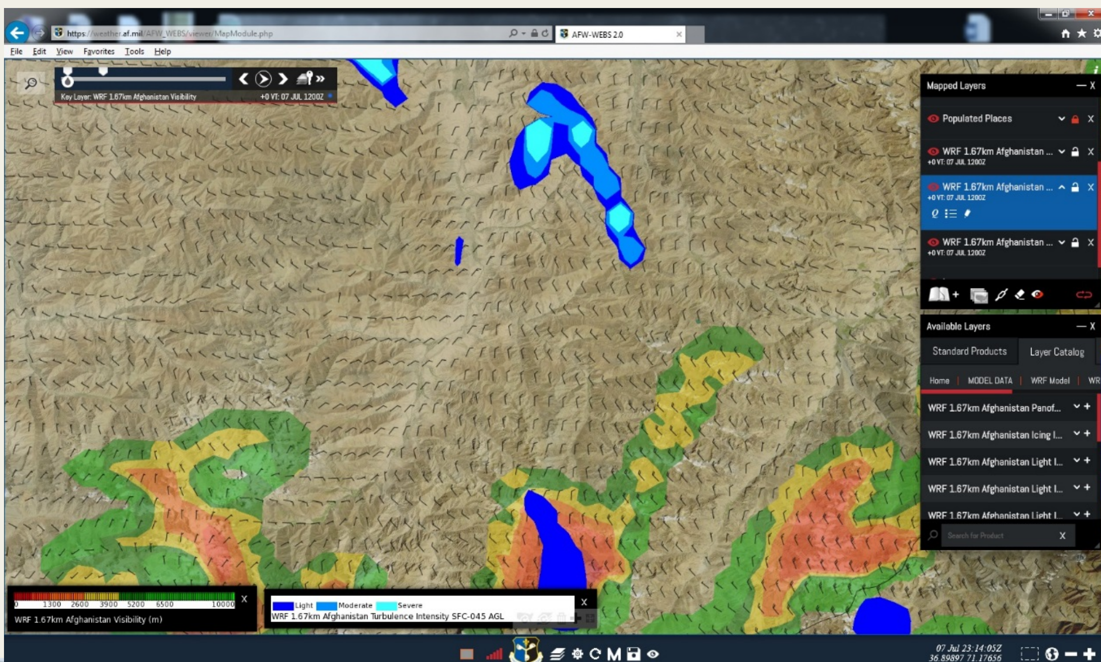
Army Operations Today

ARL

Operational weather support of manned/unmanned aviation operations

METARS
TAF
PIREP
Weather Depiction Charts
Area Forecasts
Satellite imagery
DoD Regional forecast products…

- Self-briefed via pre-flight planning tools
- Briefed by phone to Staff Weather Officer (SWO) at Combat Weather Team location
- Best: Face-to-Face SWO brief
- Worst: (sometimes no brief?)



Access to AF Weather and Army-hosted model forecasts, graphics, etc.

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Staff Weather Officer Weather Flimsy

ARL

OL-C, 3d Weather Squadron WEATHER FLIMSY

Forecaster	[redacted]	Valid Time	[redacted] 14Z (07L) TO 24Z (17L)
Telephone	538-2865	Flimsy	09B
Sunrise	0722	Moonrise	2333
Sunset	1736	Moonset	1101

Illum.	Fzg Level
66%	13,900

FHU TAKEOFF/LANDING DATA

Valid Time Local/Zulu	ALSTG	PA	Temperature	
0700L / 1400Z	30.30 INS	4367 Ft	43 F	6 C
0800L / 1500Z	30.31 INS	4358 Ft	41 F	5 C
0900L / 1600Z	30.33 INS	4340 Ft	45 F	7 C
1000L / 1700Z	30.34 INS	4331 Ft	49 F	9 C
1100L / 1800Z	30.33 INS	4340 Ft	54 F	12 C
1200L / 1900Z	30.31 INS	4358 Ft	58 F	14 C
1300L / 2000Z	30.28 INS	4386 Ft	60 F	16 C
1400L / 2100Z	30.26 INS	4404 Ft	63 F	17 C
1500L / 2200Z	30.24 INS	4422 Ft	65 F	18 C
1600L / 2300Z	30.22 INS	4441 Ft	66 F	19 C
1700L / 2400Z	30.21 INS	4450 Ft	63 F	17 C

Flight Level Wind/Temp

6,000 Ft	1620/+13	18,000 Ft	1715/-12
9,000 Ft	1810/+09	20,000 Ft	1915/-17
12,000 Ft	1710/+03	25,000 Ft	2525/-28
15,000 Ft	1515/-05	30,000 Ft	2630/-42

BLACK TOWER DA/RH FCST

TIME	DA	RH
0700L / 1400Z	4500	35%
0800L / 1500Z	4600	35%
0900L / 1600Z	4800	30%
1000L / 1700Z	5000	25%
1100L / 1800Z	5300	20%
1200L / 1900Z	5600	20%

PLEASE CALL LIBBY METRO AT 122.95 FOR UPDATES/PIREPS

WEATHER WARNINGS / ADVISORIES

None

Refer to NTFS or contact Libby weather for current Watches, Warnings, and Advisories

MEF Heights are AGL

HUNTER / PIONEER MEF		KFHU MEF	
	08012KT 7+ SCT250		13009KT 7+ SCT250
BECMG 1718	09015G20KT 7+ SCT250	BECMG 1718	13010G15KT 7+ SCT250

Heights are in MSL (Mean Sea Level)

UAV Training Area	SEMA RC-12 Training Area
300SCT350 LGT TURBC SFC-120	300SCT350 OCNL LGT TURBC SFC-120

FLIGHT HAZARDS (TURBC, ICING, TSTMS) FOR KFHU AND HUNTER/PIONEER MEFS ARE INCLUDED IN TRAINING AREA FORECASTS

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Tactical Weather Data and Products

ARL

Theater-scale Forecast

>3-6 hr forecasts

Update >= 6h frequency

1.67-15 km grid res.

Must be able to relocate globally

Army Nowcasting

0-6 hr local tailoring of Theater grids

Update < 6h frequency

<1 km grid res.

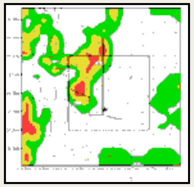
Weather Impacts/ Small Unit Decision Support Tools

Theater & nested grids for decision aids

Impacts/effects at each grid point

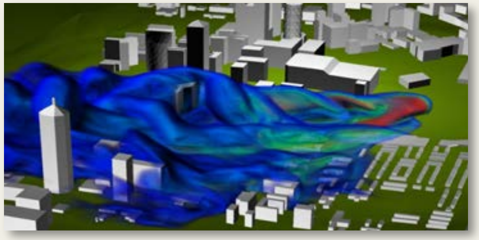
Local Battlefield Observations

Forward Area Observations

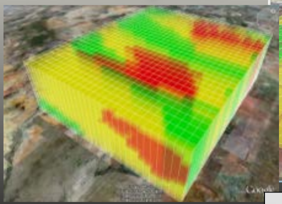


Weather Running Estimate-Nowcast Winds /Turbulence

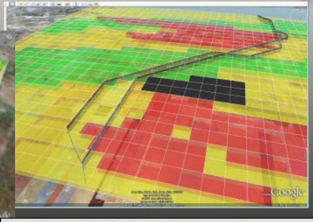
Physics-based Micro-MET & Effects Modeling/Simulation

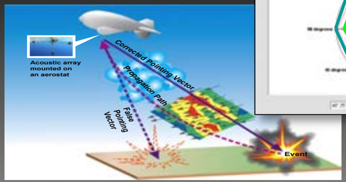


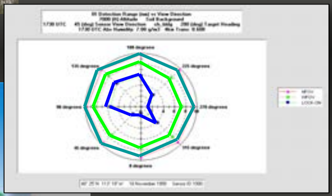
Wx Impacts



Wx Effects Routing







EO/IR (TAWS)
Acoustics (SPEBE)

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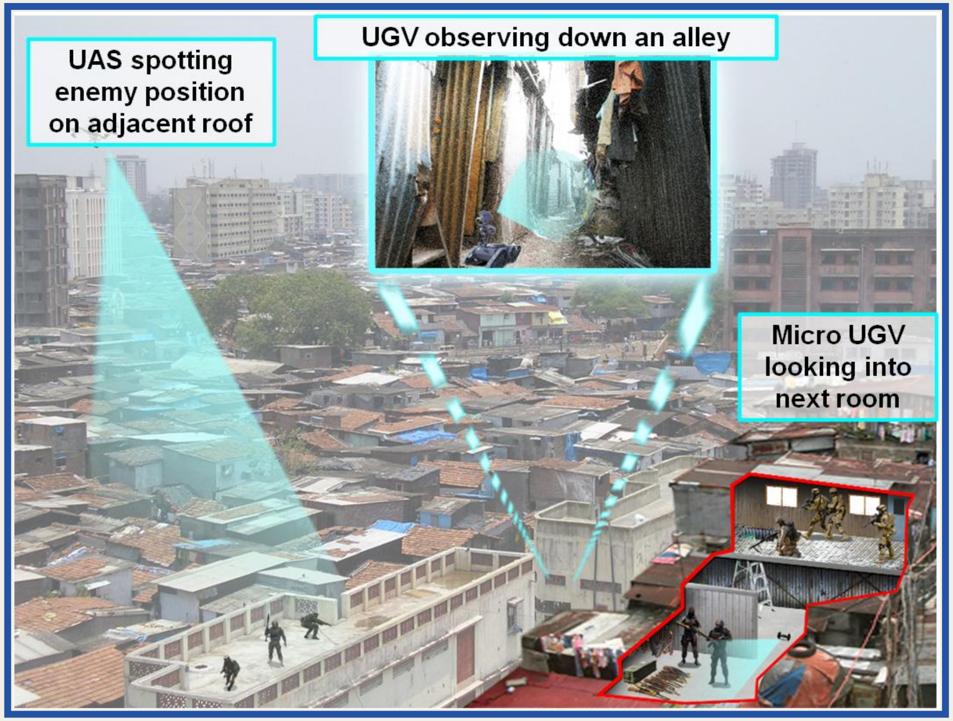
Research Direction: Battlefield Operations in 2040

ARL

Megacities/Dense Urban and Complex Terrain Areas;

Environmental Awareness for Autonomous Systems; Manned/Unmanned Teaming



Army Challenge

- Develop a suite of microscale (Spatial:1-100m, Temporal: minutes) Atmospheric Boundary Layer Environment (ABLE) models to predict mean wind, temperature, moisture and turbulence over urban and complex terrain in near real time.

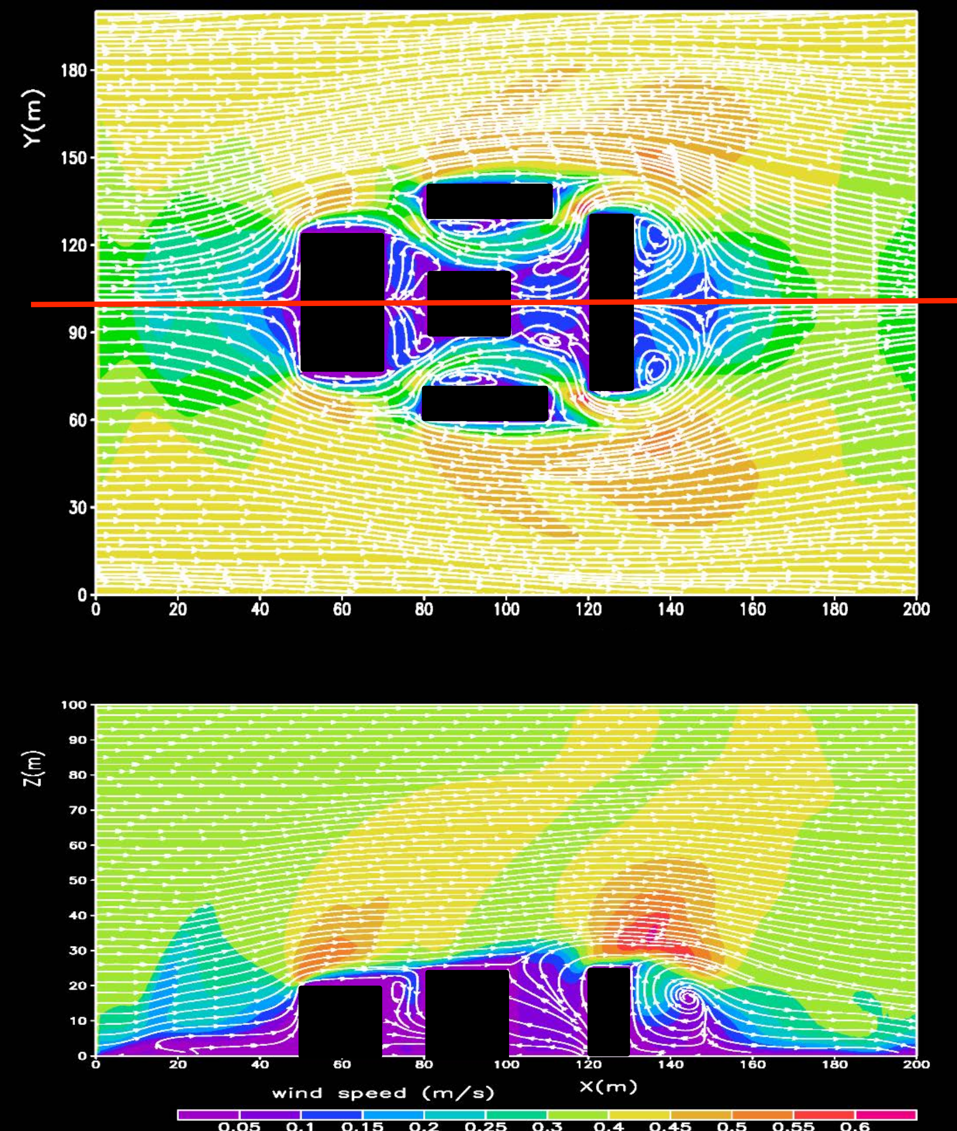
Key Technical Challenges

- The science of chaotic turbulent flows in forest, urban and mountain terrain is not well developed.
- Very complex boundary conditions for atmospheric boundary layer from computational science point of view.
- Requirement of near real-time performance from the microscale model.

ABLE

Top view of UV streamline field (at Z=10m) of five urban buildings

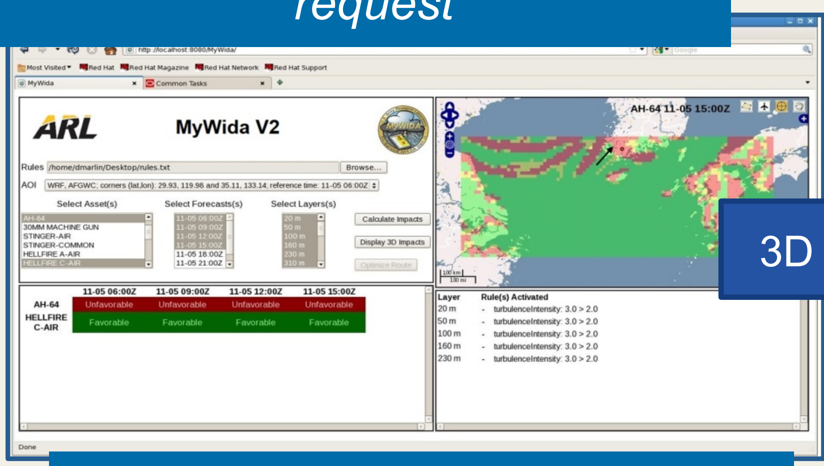
Side view of UW streamline at X-Z cross-section (at X=100m)



My Weather Impacts Decision Aid (MyWIDA)

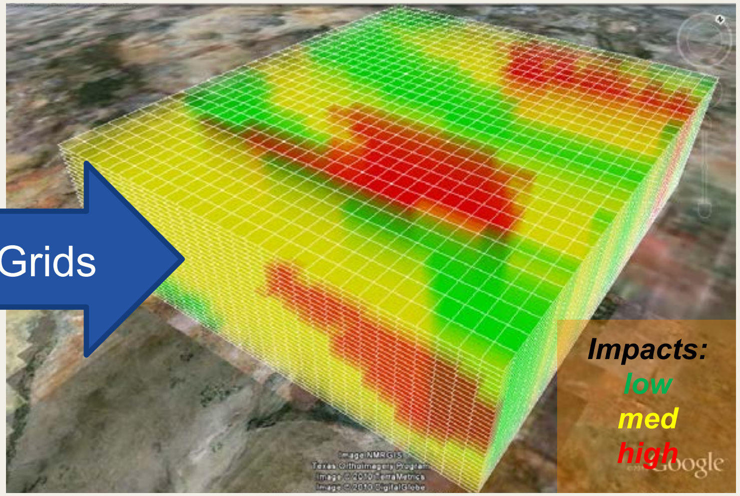
- User Inputs:
  - Platform/system/asset(s) to consider (defines *rules* used).
  - Location and time (*area of interest* and multiple-source *atmospheric forecast data*).
- Result: *Weather impacts* on selected system (3D grid).

User-Interface
or
Machine to Machine (M2M)
request



MyWIDA Reference Client screenshot

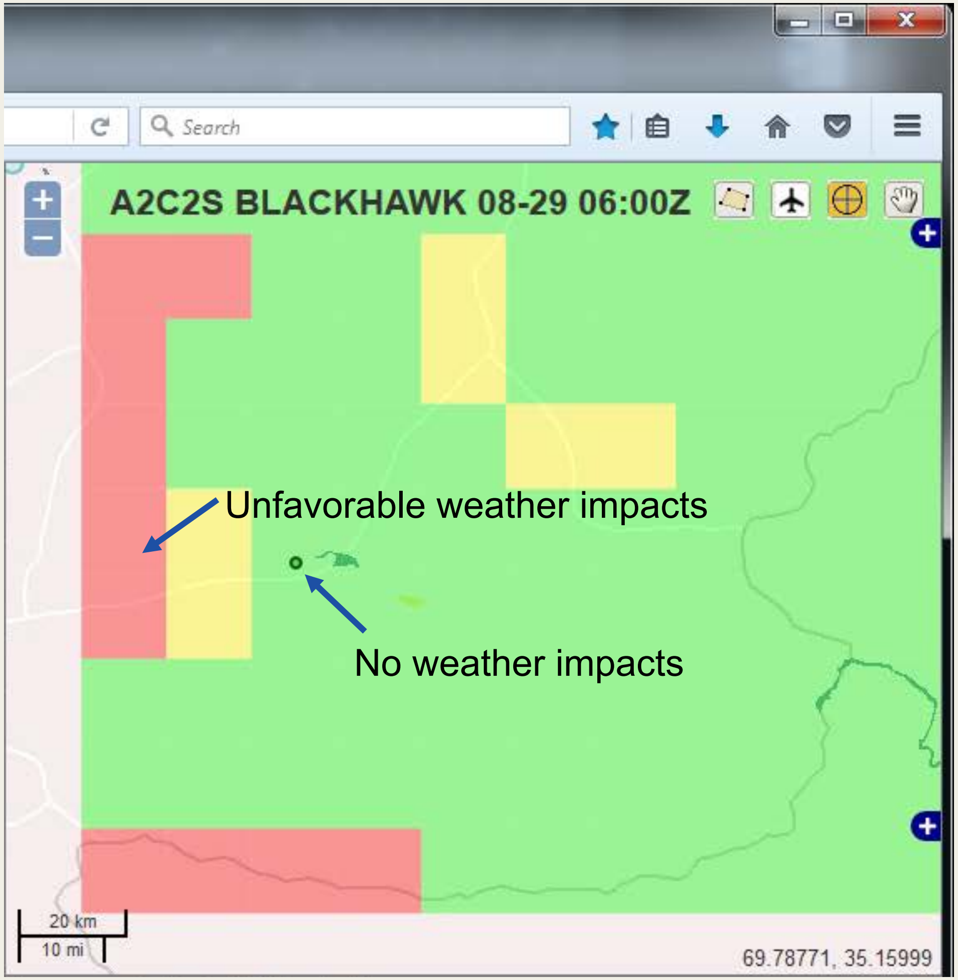
3D Impact Grids



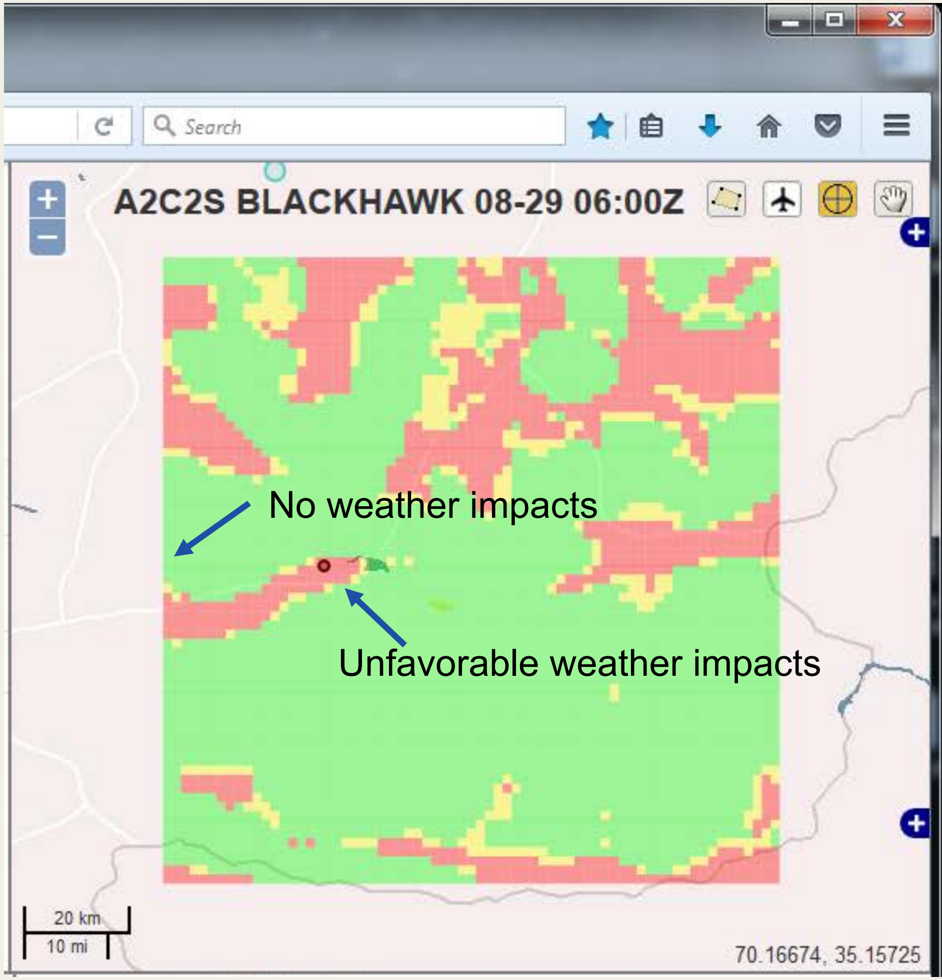
Finer-scale resolution modeling results

MyWIDA Application

15km WRF-ARW



1.67km WRF-ARW



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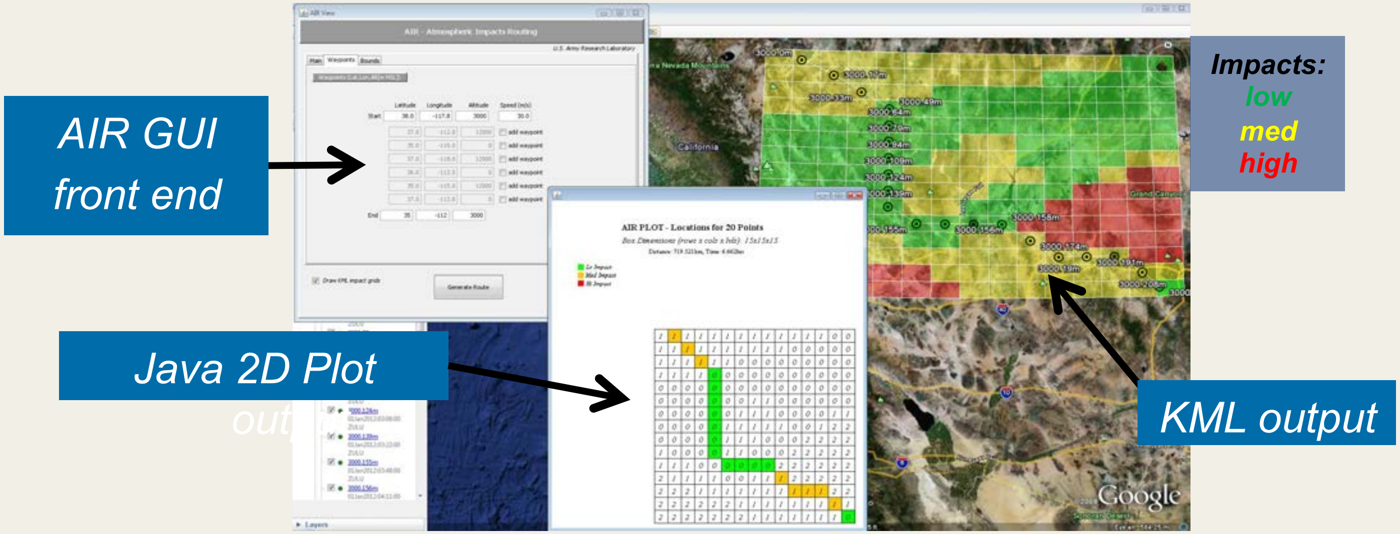
Automated Impacts Routing (AIR)

- AIR calculates an optimized air (or ground) system route based on impacts and obstacles along a path. *Path optimization employs A* (A-star) search algorithm.*
- AIR web service / desktop application:
  - Written in Java (platform independent)
  - Ingests 3D weather/other "impact" grid(s) – *from MyWIDA, IWEDA, or other…*
  - Allows *3D obstacles to be avoided*
    - E.g., areas of known Threat; conflicting Friendly activity; or other potential obstacles which may be represented as 3D volumes.
  - *Output* format is Open Geospatial Consortium (OGC) standard Google Earth KML



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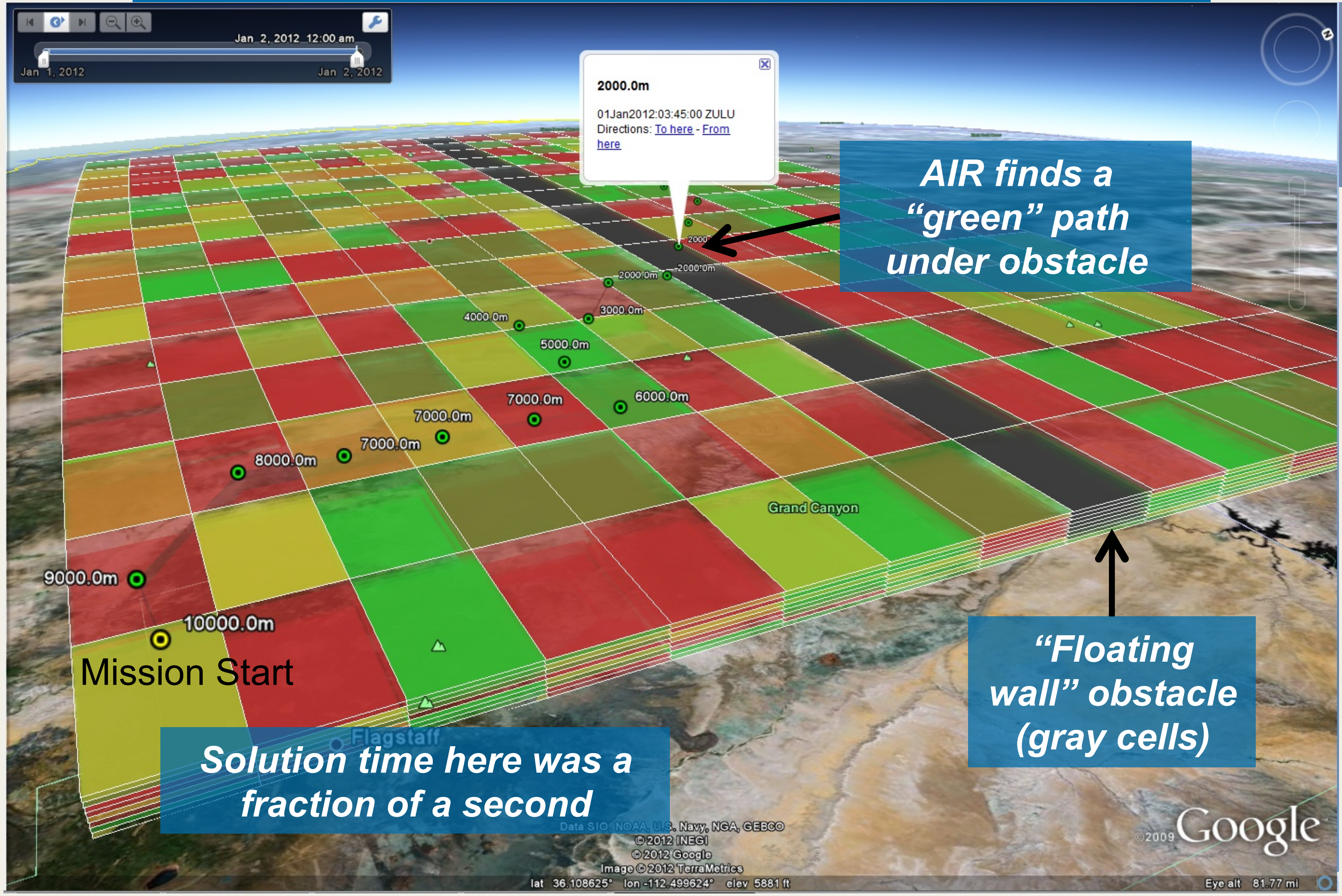
AIR 4D Output

ARL

AIR's fast execution path-finding solutions for complex impact arrays and obstacles



AIR finds a "green" path under obstacle

"Floating wall" obstacle (gray cells)

Solution time here was a fraction of a second

Impacts:
low
med
med high
high

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Meteorological Sensor Array (MSA)

- Once complete, the MSA will be the premier mesonet for atmospheric sciences research due to unprecedented resolution (spacing less than 2 km and sampling of f = 20 hz) and a domain which includes diverse topography ranging from a valley at 1300 m to a mountain which peaks at 2500 m.

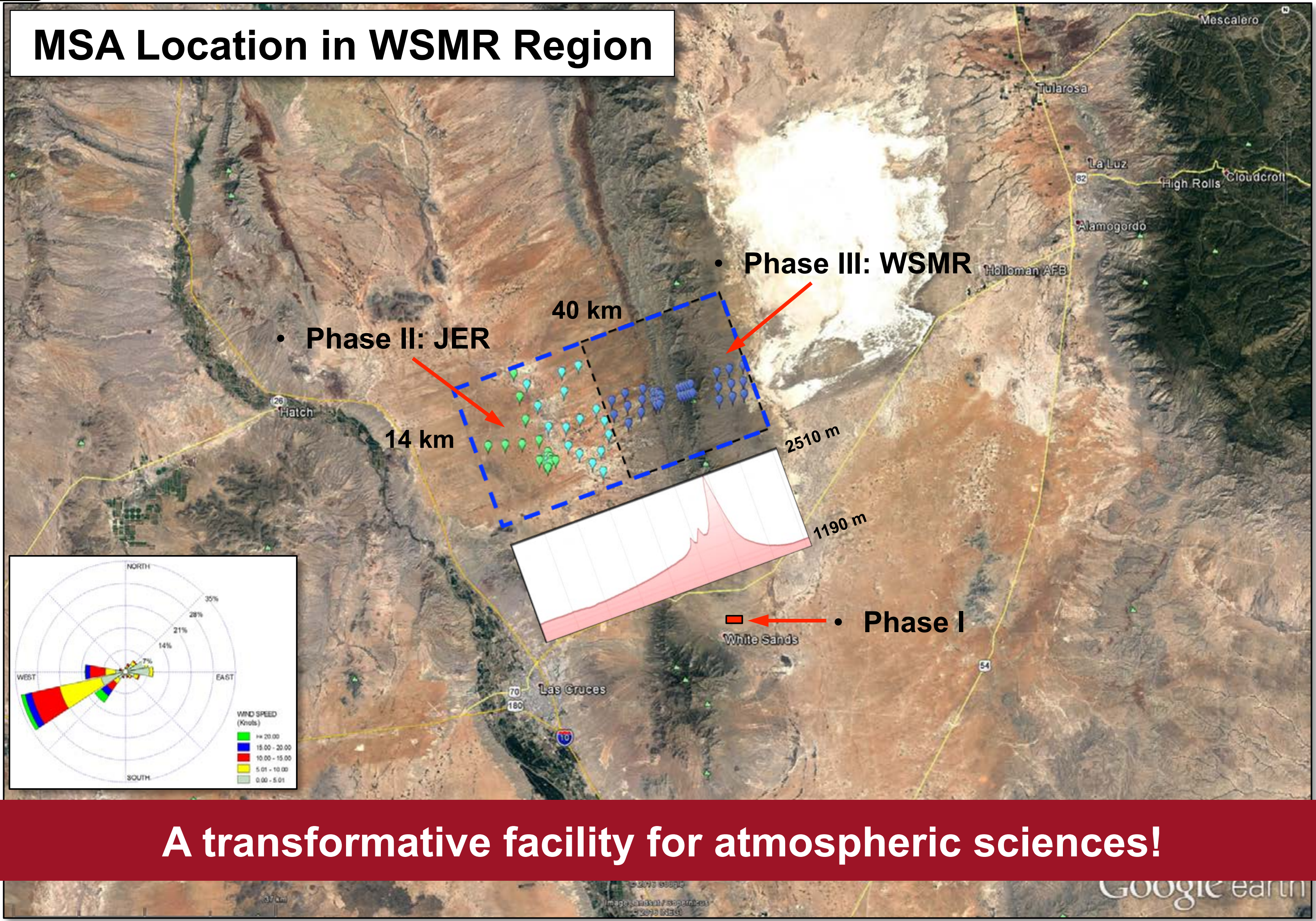
Impact to Scientific Community

- Addresses a community need for high-resolution observational data for advancing the state of the science in development, verification and validation of fine-scale atmospheric prediction models and decision aids, and provides a testing ground for atmospheric sensor development.
- Atmospheric modelers in the Air Force, Navy, NOAA, NCAR, DOE and academia will have access to a very unique multi-scale source of boundary layer atmospheric data for their research efforts targeting future improvements to operational weather forecasting capabilities.

Impact to Army

- Will provide the warfighter with more accurate weather information and advanced decision aids to ensure Army mission success.

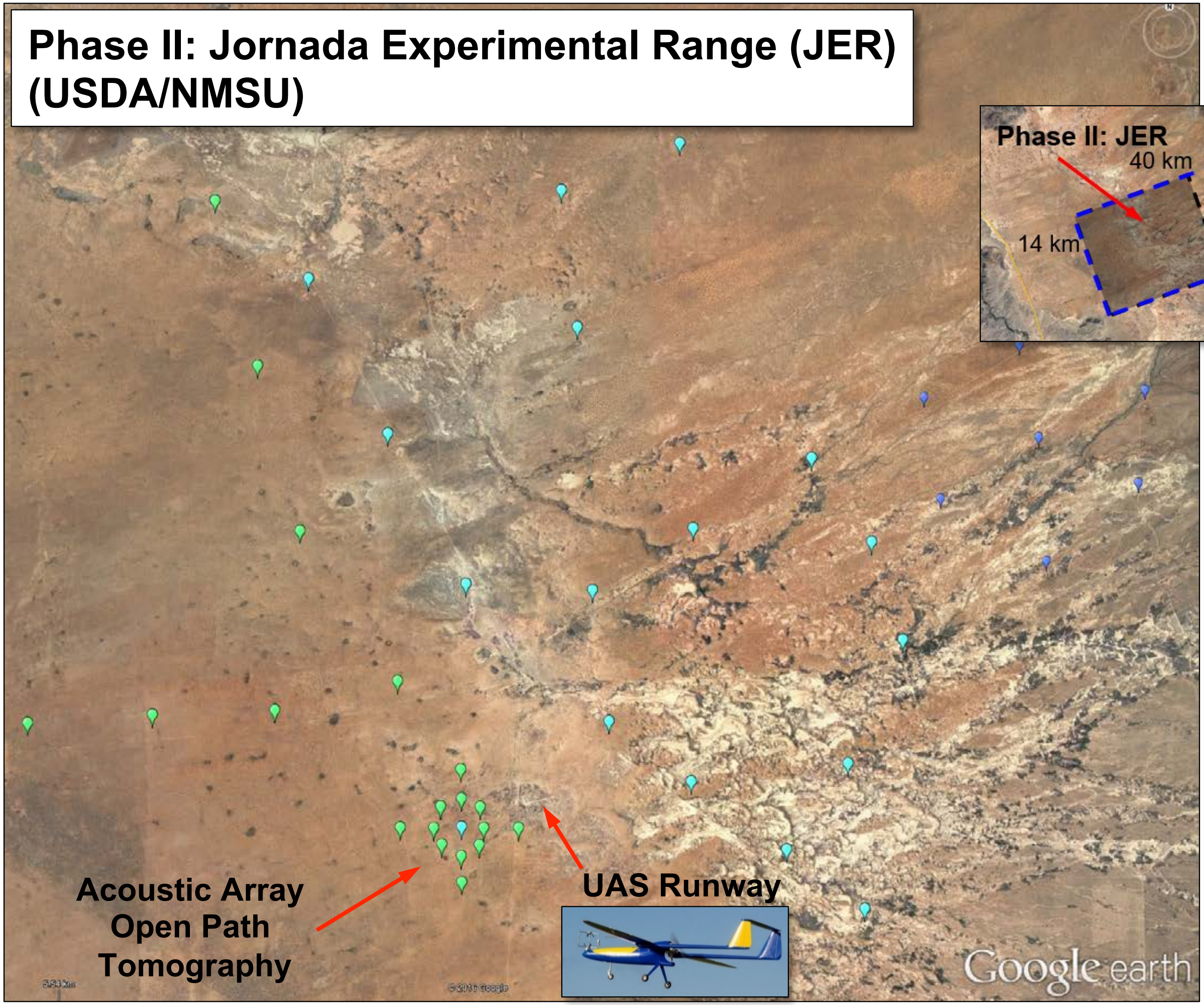
Technical Approach

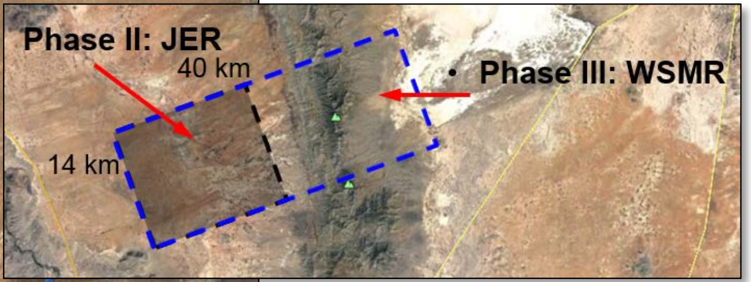


A transformative facility for atmospheric sciences!

Technical Approach

Phase II: Jornada Experimental Range (JER) (USDA/NMSU)





1st tower installed
1 Dec 2016

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Technical Approach

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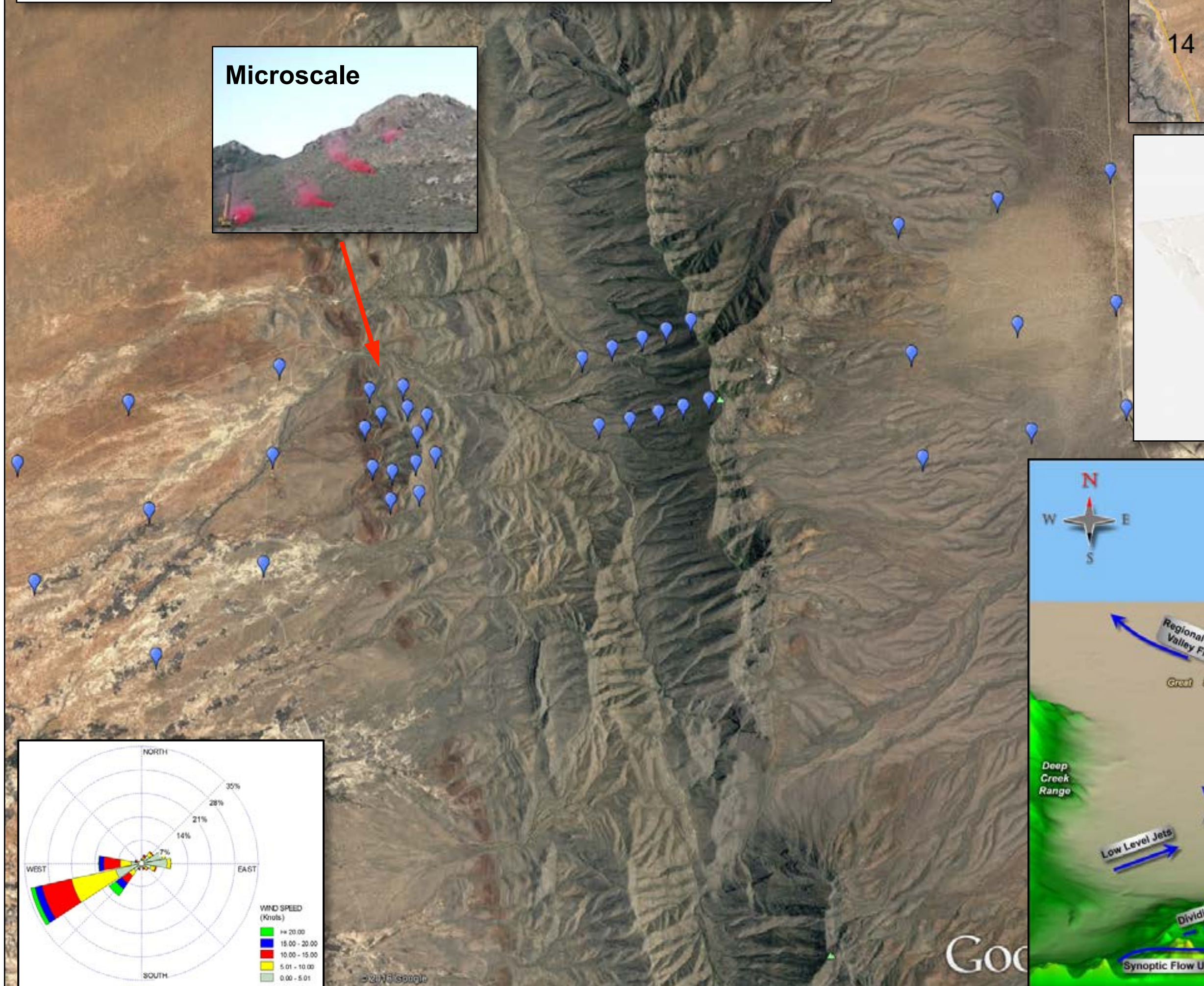
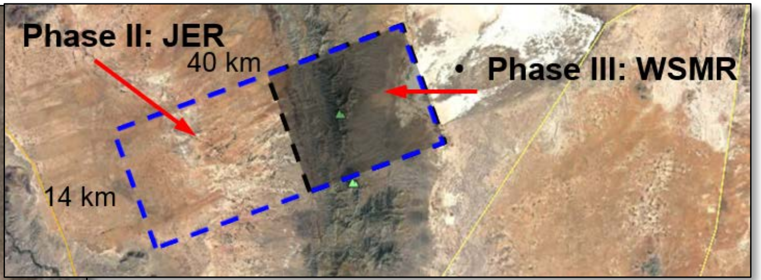
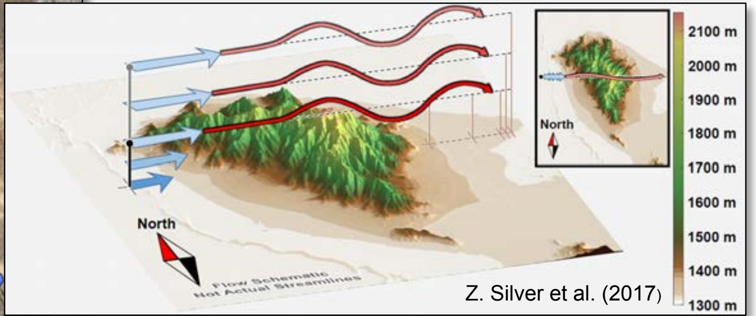
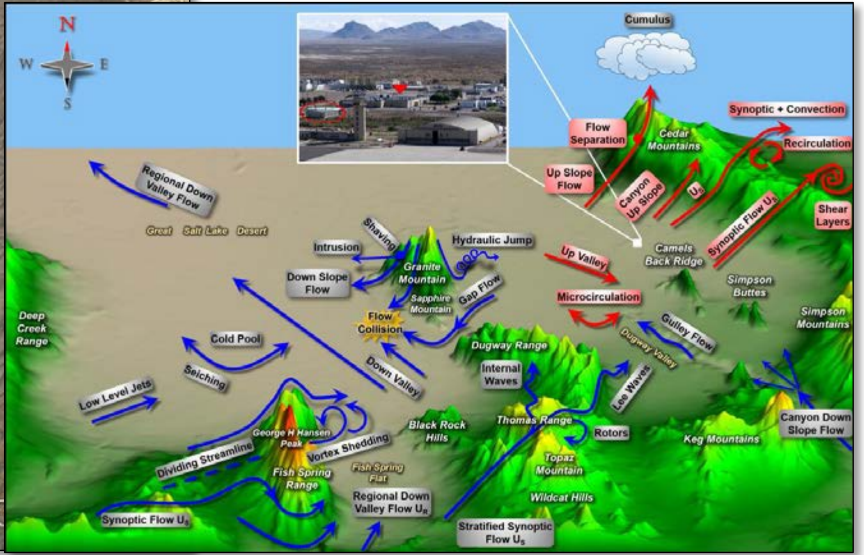
Phase III: JER/WSMR - San Andres Peak: 2510 m / 8235 ft







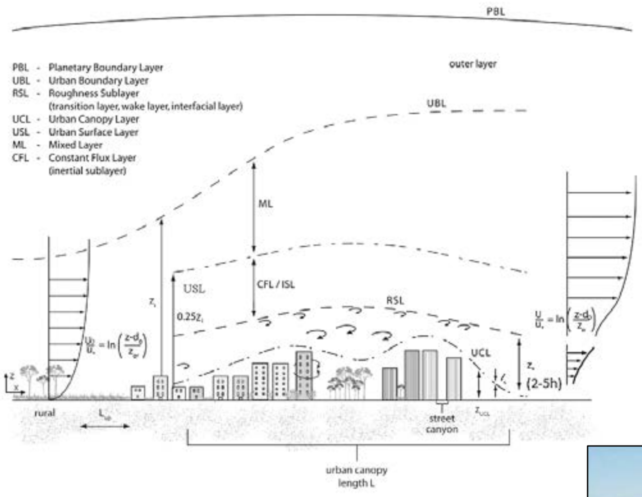
Z. Silver et al. (2017)



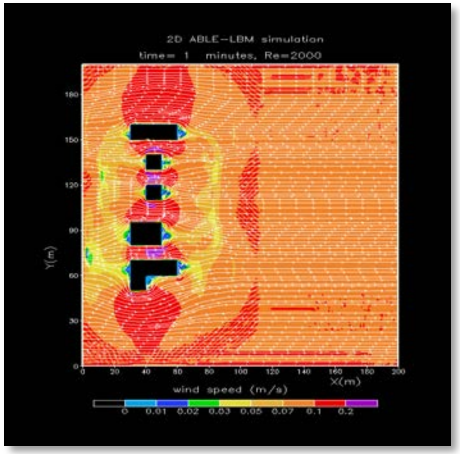
Path Forward – Urban Domains

Future Plans

- Instrumented UAS: multi-agency kick-off experiment with NMSU, UND, NOAA, UVA, and Va Tech to test aerial platforms, instrumentation, sampling methods, etc.
- Urban Environments: laboratory wind tunnel experiments at NMSU, then mock urban building cluster experiments at MSA:JER. Designed as a precursor to a full-scale urban experiment.



Zajic et al. Environ Fluid Mech (2015) 15: 275. doi:10.1007/s10652-013-9311-6



Dr. Yansen Wang: ABLE-LBM

Thank YOU! Questions?

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Crowdsourcing met data: Soldier/Platform-level

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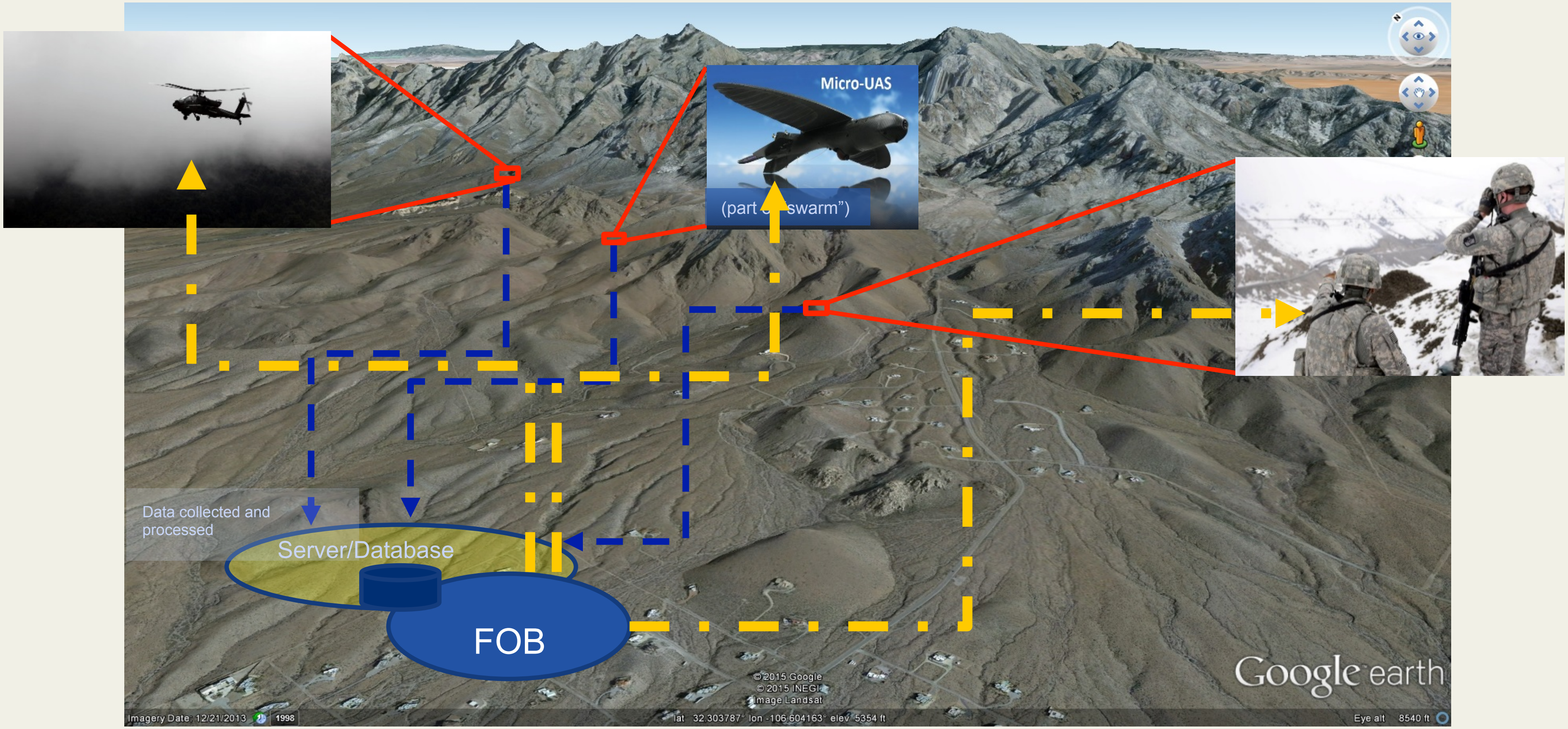

Crowdsourcing: Soldiers and systems act as battlefield sensors.

- Mounted sensors (on Soldiers and battlefield systems) – **auto-collecting meteorological (met) data**.
- Met data sent through command network to server @ Forward Operating Base (FOB).
- Data collected and processed on server -> Used as **input to hi-res forecast models**.
- Updated forecasts feed into Tactical Decision Aids (TDAs) -> **Output is effects on operations**.
- **Effects of weather** pushed back out to Soldiers/systems.