



Impact Planning Aids for Major Storms



(IPAMS)

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Presenter:

Dave Knapp
Chief, Atmospheric Modeling Applications Branch
Battlefield Environment Division
Army Research Laboratory
White Sands Missile Range, NM
(575) 678-4574
dknapp@arl.army.mil

Technical Leads:

Dr. Rick Shirkey (IPAMS)
Mr. Richard Szymer (IPAMS)

Mr. Terry Jameson (Aviation Weather Routing Tool)

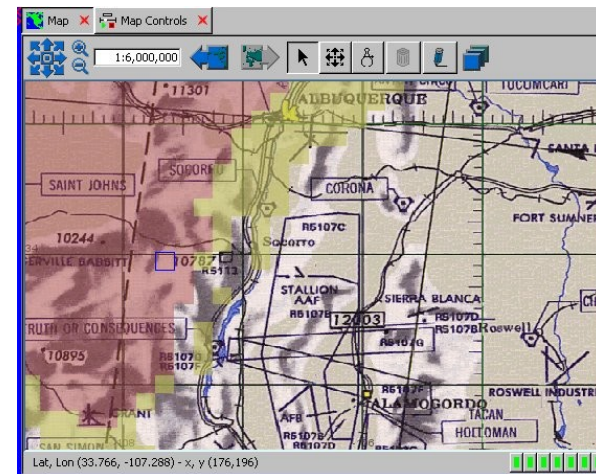
Outline

- Introduction
- Tri-Service IWEDA – The Army's Primary Weather Impact Tool
- IPAMS
- Aviation Weather Routing Tool
- Summary

Tri-Service Integrated Weather Effects Decision Aid (T-IWEDA)

Definitions

- Weather Impacts: Determined by comparing forecast data with system “rules” to create a 3-D grid of data.
 - Rules are simply a *threshold value* (max/min) associated with a specific system
 - Helicopters cannot hover if winds > 40 kts
 - Impacts are presented in the form of a stoplight chart overlaid on a map:
 - **GREEN** no adverse impact
 - System degradation < ~25%
 - **AMBER** for marginal impact
 - System degradation = ~25 to ~75 %
 - **RED** for significant impact
 - System degradation > ~75%



T-IWEDA Information Appearance

Asset list

Selected Assets

Impacts with Map Overlay

The screenshot displays the Tri-Service IWEDA software interface. On the left, the 'List' pane shows a hierarchy of assets, with 'RQ-5A HUNTER' selected. The 'Selected Assets' pane shows the rules for 'RQ-5A HUNTER', including 'Low Visibility', 'Heavy Rain', 'Low Ceiling', 'Very High Pressure Altitude', 'Extreme Cold', 'Icing', 'Severe Turbulence Aloft', and 'Light Turbulence Aloft'. The 'Map' pane shows a map of the Tucson area with a yellow and green overlay. The 'Forecasts' pane shows a list of time slots from 1200Z to 0900Z. The 'Impacts' table shows the impact status for 'RQ-5A HUNTER' across these time slots.

Name	25/1200	25/1500	25/1800	25/2100	26/0000	26/0300	26/0600	26/0900
Selected Assets	R	R	R	R	R	R	R	R
RQ-5A HUNTER	R	R	R	R	R	R	R	R

Available Forecasts

Asset Impacts as f(time)

IPAMS Concept and Objective

Using T-IWEDA as the foundation, IPAMS can

- Improve the ability to predict and assess weather impacts on the local environment associated with severe weather-related natural disasters and emergencies.
- Support a wide range of major applications pertaining to:
 - Transportation, logistics, and resource protection.
 - Population safety.
 - Hurricanes, severe weather, floods, etc.
 - Marine/coastal safety.
 - Marine Transportation System activities & operations.
 - Pipeline Systems activities & operations.
 - Rural and Urban Transit Systems activities & operations.
 - Airport Ground Operations activities.... and so on

If a Weather Threshold rule can be created, IPAMS can display impacts

Primary References for IPAMS

- FCM-P11-2001 National Severe Storms Operations Plan
- FCM-P12-2003 National Hurricane Operations Plan
- FCM-P13-2000 National Winter Storms Operations Plan
- FCM-R18-2002 Weather Information for Surface Transportation
- Weather Information for Surface Transportation (WIST) Initiative Document
- Joint Publication 3-26 Homeland Security
- Joint Publication 3-57 Joint Doctrine for Civil-Military Operations

Sample Weather Rules for Transport Applications

Weather Needs for Roadway Transportation

Weather Element	Threshold	Activity	Impacts	Action	Lead Time
Visibility, Including Restricting Conditions such as Fog, Haze, Dust, Smoke (statute miles)	<1/4 to ≤ 1/2 mile	Road maintenance	Safety risk, loss of visibility, impaired mobility	Provide early warning to operators and motorists. Take prescribed actions, advise operators and maintenance personnel. Modify operations, consider application of CO ₂ to disperse fog.	6-12 hours 3-6 hours and current observation
	<1/4 mile	Truck operations	Safety risk to operators, freight/cargo damage risk, schedule delays, increased risk of collisions/spills of hazardous cargo	Advise operators and managers, conduct risk assessment. Delay, postpone, reschedule, or reroute as appropriate. If underway, especially when hauling hazardous materials, find a safe stopping point.	6 hours
		Driveaway-towaway (manufactured home transport)	Ability to see and be seen within safe reaction distance greatly reduced	Stop travel.	3 hours
Wind: Head, Cross, or Tail (wind speed in miles per hour)	>30 and <50 mph	Road maintenance	Safety risk to personnel and motorists, increased roadway and lane obstruction (debris), reduced or lost visibility, drifting snow, loss of stability and maneuverability, road damage, loss of life or property, treatment chemical dispersion, loss of communications and power, toxicity and environmental damage (Speed and direction are most important when snow has accumulated.)	Predict threatened area, advise travelers, select treatment strategy, implement early warning procedures. Consider implementation of evacuation plans. Construct and place living and structural snow fences to manage snow drifting. Modify operations, prepare for snow drift removal. Manage traffic flow (restrict access to roadways and bridges, restrict access to specific vehicle types), remove debris, repair damage.	12-24 hours 6-12 hours and current observation
		Truck operations	Safety risk to operators, freight/cargo damage risk, schedule delays, increased risk of collisions/spills of hazardous cargo	Advise operators and managers, conduct risk assessment. Delay, postpone, reschedule, or reroute as appropriate. If underway, especially when hauling hazardous materials, find a safe stopping point.	12 hours
	>30 and <50 mph	Truck operations	Safety risk to operators, freight/cargo damage risk, schedule delays, increased risk of collisions/spills of hazardous cargo	Advise operators and managers, conduct risk assessment. Delay, postpone, reschedule, or reroute as appropriate. If underway, especially when hauling hazardous materials, find a safe stopping point.	12 hours
	>25 mph and gusty	Driveaway-towaway (manufactured home transport)	Difficult handling of trailer and load (manufactured home or section)	Stop travel.	6 hours

IPAMS Weather Effects Matrix Example

Impact warnings on
 assets in the AOI for
 3 hr forecast time
 steps

Explanations for each
 adverse warning

File DB Access

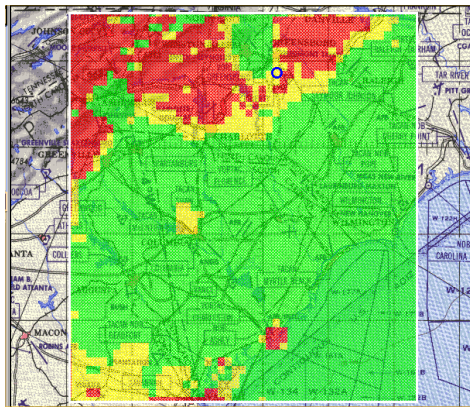
Systems WEM

Weather Effects Matrix

Sys Name	22/12	22/15	22/18	22/21	23/0	23/3	23/6	23/9	23/12	23/15	23/18	23/21
Water Consumption	R	A	G	G	A	A	R	R	R	R	R	R
Drainage Pipes	R	R	R	R	R	R	R	R	R	R	R	R
Fixed Bridging	R	G	G	G	G	R	R	R	R	R	R	R
Roadways	A	G	G	G	G	A	A	A	A	A	A	A
Plywood	G	G	G	G	G	G	G	G	G	G	G	G

Condensed Weather Impacts

- Component Potable Water has severe impact: High Temperature
- Component Maintenance Facilities has severe impact: Heavy Rain
- Component Bridge Footing has severe impact: High River State
- Component Tracked Vehicle has marginal impact: Flooding



Example map
 overlay shows
 where the impacts



UNCLASSIFIED



T-IWEDA/IPAMS Aviation Application

The Aviation Weather Routing Tool

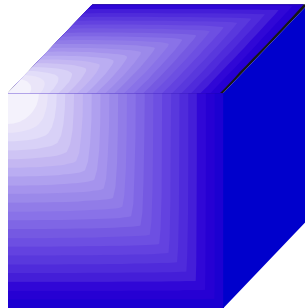
(AWRT)

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

UNCLASSIFIED

“Optimized” Flight Path Aviation Weather Routing Tool (AWRT)

New 4-D Weather Forecast Grid

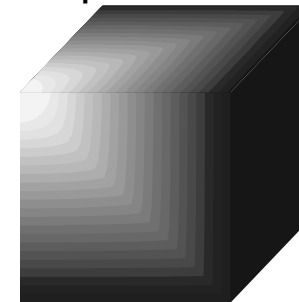


+

Aircraft-Specific
Weather Impacts

=

4-D Weather Impacts Grid



Threshold Rules

*(from Tri-Service Integrated Weather Effects
Decision Aid (T-IWEDA) database)*



+

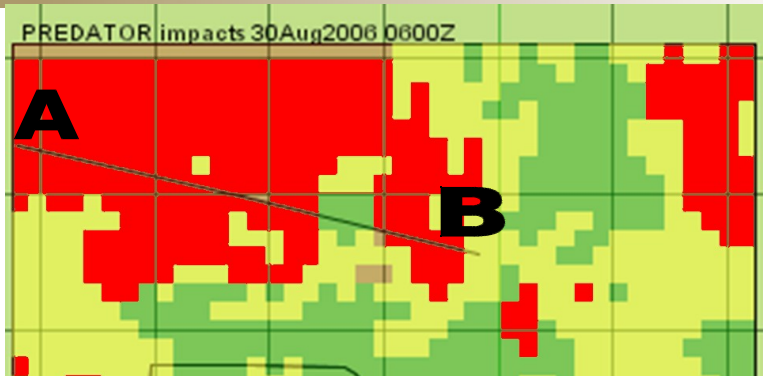
Initial/Current
Flight Path

Altered Flt Path (if needed)

New Flt Path Options;
Avoiding Enrte Hazards

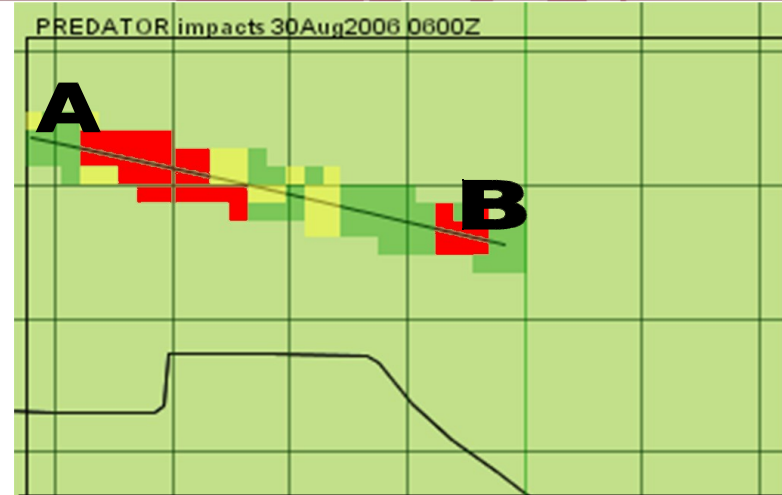
PATH
OPTIMIZATION

- Computes the “Lowest Cost” path between points.
- Cost function can represent fuel consumption, hazard to the aircraft, mission constraints, etc.
- Searches out from a starting point, storing partial paths after each step.
- The partial paths are stored in a prioritized list.
- A Cost Function then determines the “Lowest Cost” of the paths in the priority list.
- A* is guaranteed to find a lowest cost path and is usually computationally cheaper than an exhaustive (or breadth first) search.

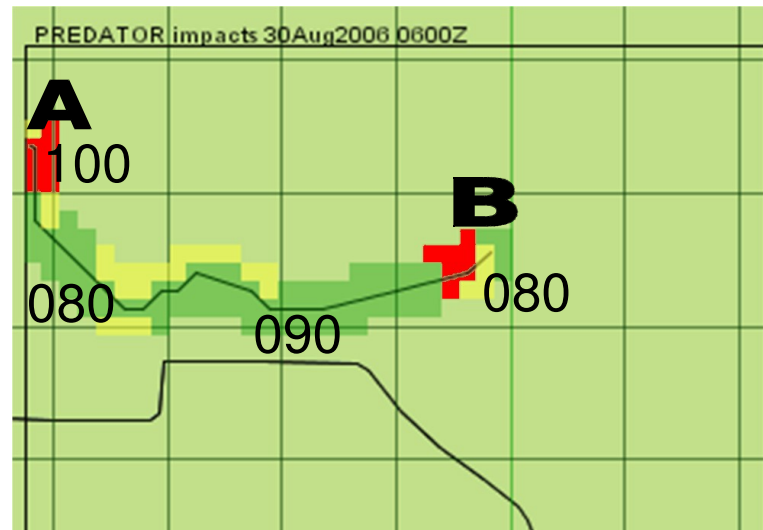


Worst conditions shown for all altitudes

Planned route from A to B at FL100 passes through unfavorable conditions

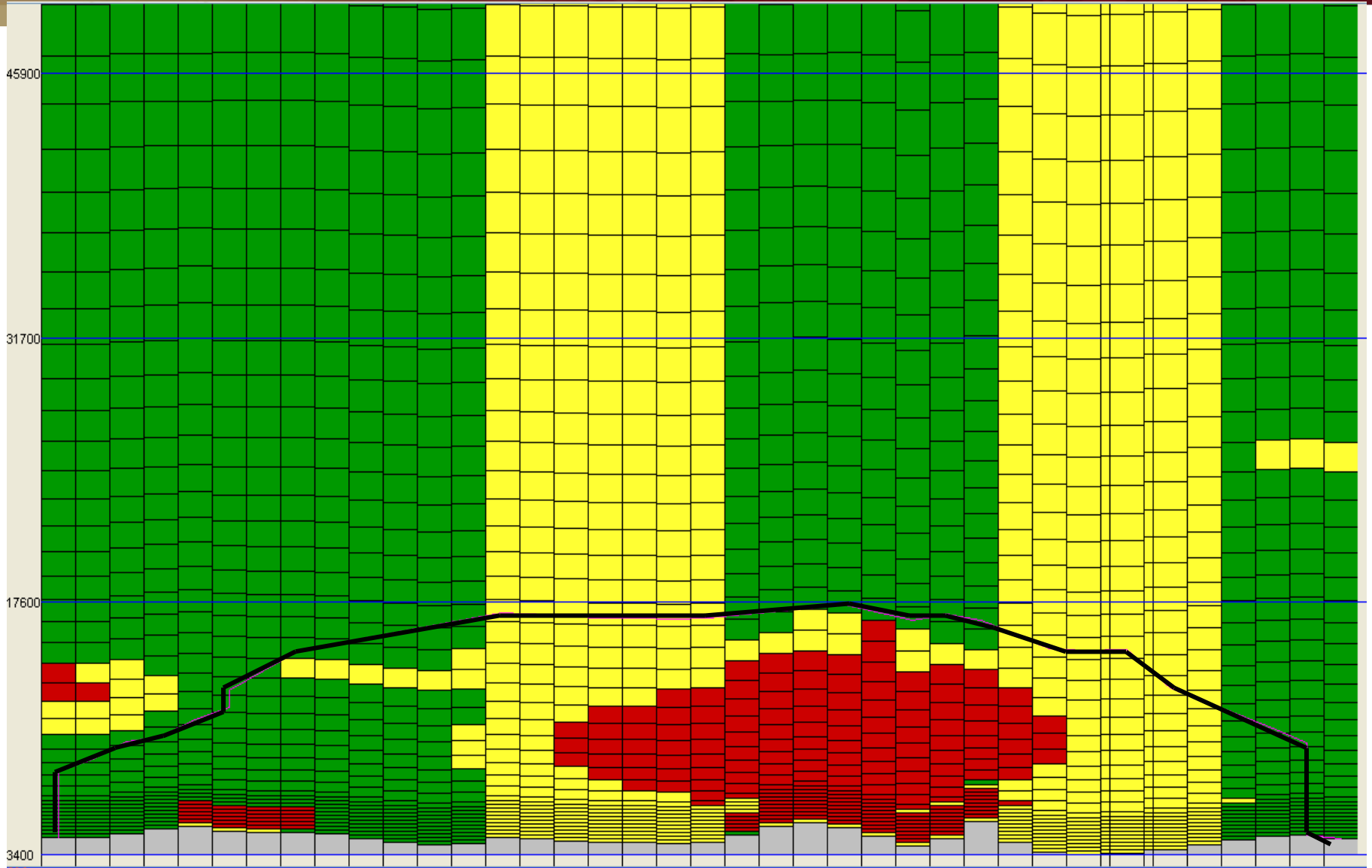


Worst Conditions at FL100 (+/- 500')



Optimized route at varying FLs

Optimized Vertical Slice



Define the Flight Path

The screenshot displays the Tri-Service IWEDA software interface. The main window is titled "Edit Subdomain 'New Flight Path Subdomain'". It features a "Subdomain Name" field containing "ScanEagle2" and a "Border Color" selection. Below this, there are tabs for "Area" and "Assets". The "Takeoff/Way Points" section contains a table with two rows of data:

Lat:	Lon:	Alt:	Unit
32.707	-114.657	<input type="checkbox"/> All	feet
33.459	-112.814	<input type="checkbox"/> All	feet

An arrow points from the "Takeoff/Way Points" table to a callout box. The map shows a flight path starting at a point labeled "Begin" and ending at a point labeled "End". The path is a blue line connecting the two points. The map also shows various geographical features, including rivers, lakes, and terrain. The interface includes a menu bar (File, Edit, Screen, Help), a toolbar with various icons, and a status bar at the bottom with a coordinate display: "Lat, Lon (33.135, -113.146) - x, y (553,451)".

Waypoints/times are entered via map clicks (or manually) – M2M in future release

Compute & View Impacts over Flight Path:

Selected Assets:

- Scan Eagle UAS
 - Rules of Scan Eagle UAS
 - Light Turbulence
 - turbulenceintensity = light
 - heightmsl < 16000.0 feet
 - Moderate or greater turbulence
 - heightmsl < 16000.0 feet
 - turbulenceintensity >= moderate
 - Moderate winds aloft
 - upperairwindspeed > 25.0 knots
 - heightmsl < 16000.0 feet
 - Strong winds aloft
 - upperairwindspeed > 35.0 knots
 - heightmsl < 16000.0 feet

Impacts include turbulence & high winds aloft

Numerous adverse impacts along FP:

Name	18/0000	18/0300	18/0600	18/0900	18/1200	18/1500	18/1800	18/2100	19/0000	19/0300
Selected Assets	R	R	R	R	R	R	R	R	R	R
Scan Eagle UAS	R	R	R	R	R	R	R	R	R	R

Impacts include turbulence & high winds aloft

Numerous adverse impacts along FP:

Flight Slice along Path:

Tri-Service IWEDA

File Edit Screen Help

List Selected

No special condition

Selected Assets

- Scan Eagle UAS
 - Rules of Scan Eagle UAS
 - Light Turbulence
 - turbulenceintensity = light
 - heightmsl < 16000.0 feet
 - Moderate or greater turbulence
 - heightmsl < 16000.0 feet
 - turbulenceintensity >= moderate
 - Moderate winds aloft
 - upperairwindspeed > 25.0 knots
 - heightmsl < 16000.0 feet
 - Strong winds aloft
 - upperairwindspeed > 35.0 knots
 - heightmsl < 16000.0 feet

Map Route Planning Impact Levels

Flight slice shows impacts at many levels – need to run the Route Optimizer!

Lat: 33.53
Lon: -112.75
Height AGL: 9997 feet
Height MSL: 11329 feet

Forecasts Subdomains

New Subdomain

Select All

Deselect All

- Predator (optimized)
- Predator (optimized)[1]
- Predator
- ScanEagle1
- ScanEagle2 (optimized)
- ScanEagle2

Name	18/0000	18/0300	18/0600	18/0900	18/1200	18/1500	18/1800	18/2100	19/0000	19/0300	19/0600
Selected Assets	R	R	R	R	R	R	R	R	R	R	R
Scan Eagle UAS	R	R	R	R	R	R	R	R	R	R	R

WEM Impacts

Optimized Flight Path Results:

*Optimized flight path waypoints
& times are viewable:*

Tri-Service IWEDA

File Edit Screen Help

List Selected Map Route Planning Impact Levels

No special condition 1:2,250,000

Edit Subdomain "ScanEagle2 (optimized)"

Subdomain Name: ScanEagle2 (optimized)

Border Color: [Color Picker]

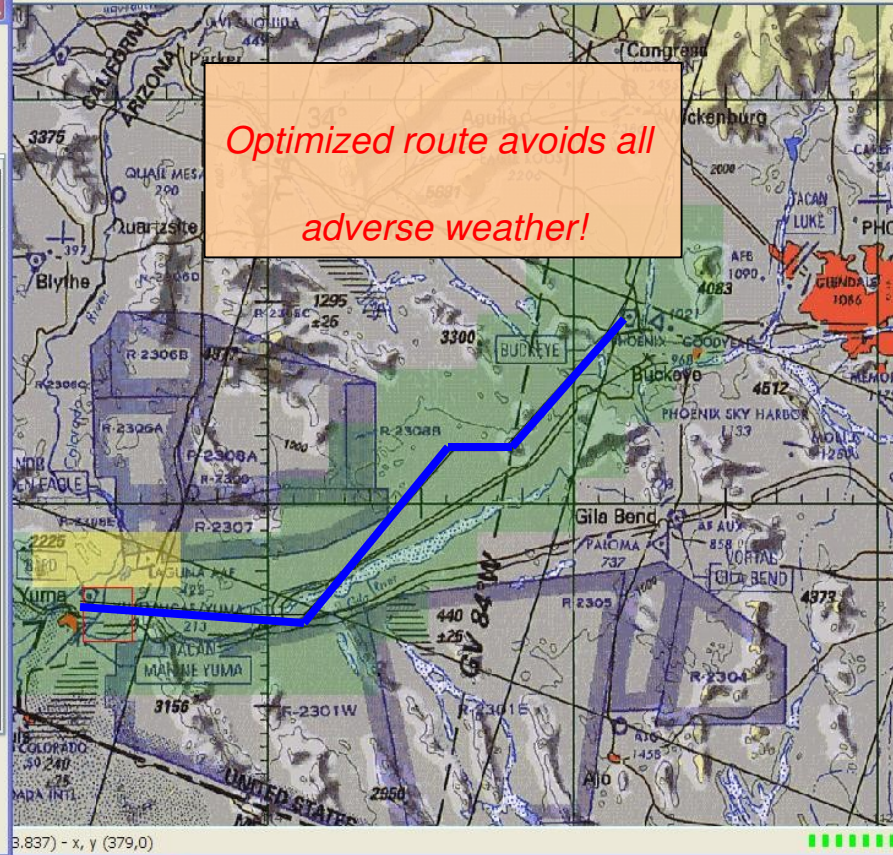
Takeoff Way Points: [Clear]

Lat: 32.759	Alt: <input checked="" type="checkbox"/> 295.276	feet
Lon: -114.611		
Lat: 32.726	Alt: <input checked="" type="checkbox"/> 770.672	feet
Lon: -114.039		
Lat: 32.726	Alt: <input checked="" type="checkbox"/> 961.739	feet
Lon: -113.877		
Lat: 32.996	Alt: <input checked="" type="checkbox"/> 1,417.516	feet
Lon: -113.554		
Lat: 33.131	Alt: <input checked="" type="checkbox"/> 1,464.675	feet
Lon: -113.393		
Lat: 33.131	Alt: <input checked="" type="checkbox"/> 1,562.648	feet
Lon: -113.232		
Lat: 33.4	Alt: <input checked="" type="checkbox"/> 1,366.165	feet
Lon: -112.909		
Lat: 33.51	Alt: <input checked="" type="checkbox"/> 1,332.021	feet
Lon: -112.82		

AGL MSL

Time Sensitive

Commit Cancel



*Optimized route avoids all
adverse weather!*

WEM Impacts Forecast Data

Name	18/0000	18/0300	18/0600	18/0900	18/1200	18/1500	18/1800	18/2100	19/0000	19/0300	19/0600
Selected Assets	X	X	X	X	A	X	X	X	X	X	X
Scan Eagle UAS	X	X	X	X	A	X	X	X	X	X	X

Flight Slice along Optimized Path:

Tri-Service IWEDA

File Edit Screen Help

List Selected Map Route Planning Impact Levels

No special condition

Selected Assets

- Scan Eagle UAS
 - Rules of Scan Eagle UAS
 - Light Turbulence
 - turbulenceintensity = light
 - heightmsl < 16000.0 feet
 - Moderate or greater turbulence
 - heightmsl < 16000.0 feet
 - turbulenceintensity >= moderate
 - Moderate winds aloft
 - upperairwindspeed > 25.0 knots
 - heightmsl < 16000.0 feet
 - Strong winds aloft
 - upperairwindspeed > 35.0 knots
 - heightmsl < 16000.0 feet

Select Save

Forecasts Subdomains

New Subdomain Select All Deselect All

- Predator (optimized)
- Predator (optimized)[1]
- Predator
- ScanEagle1
- ScanEagle2 (optimized)
- ScanEagle2

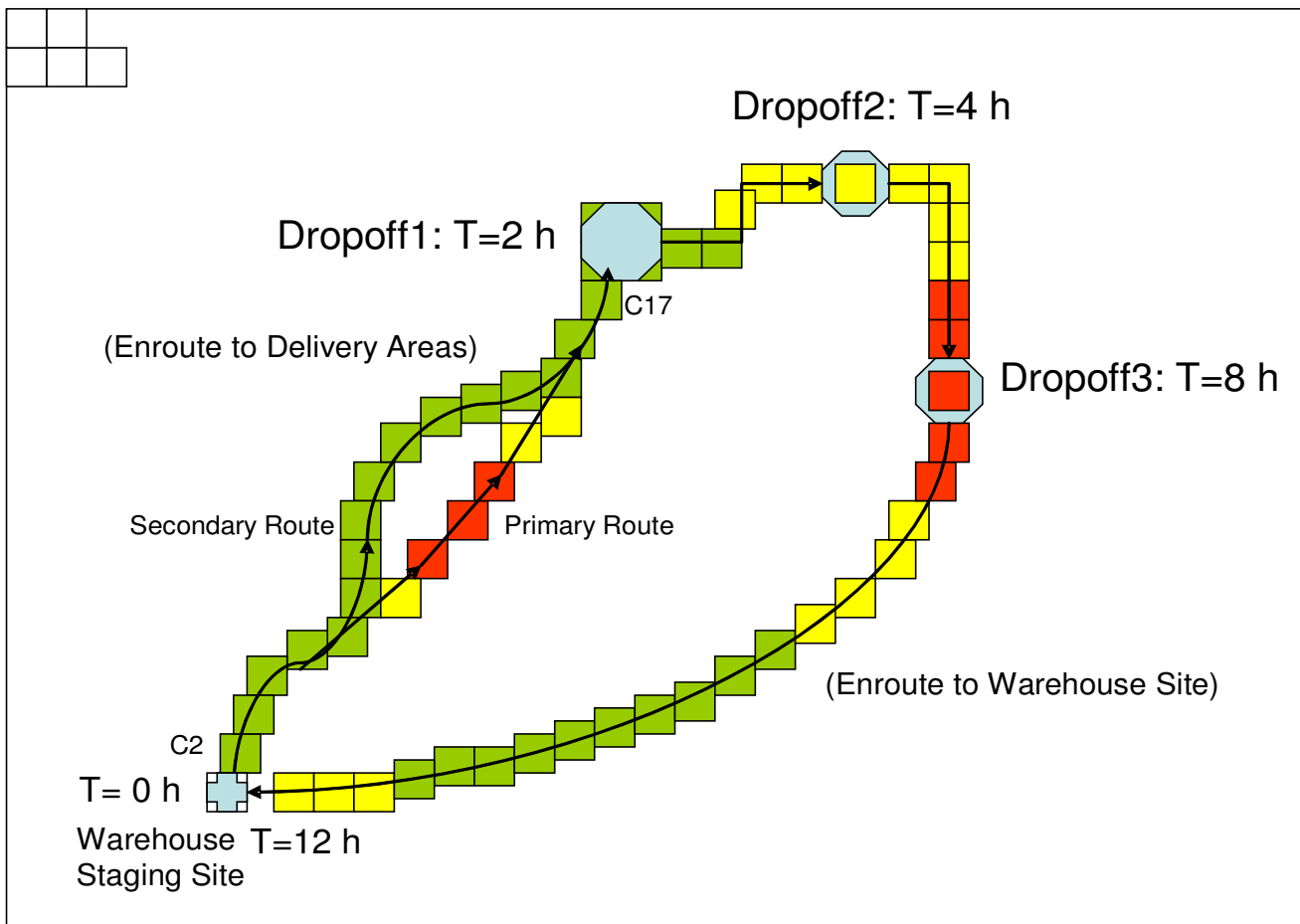
WEM Impacts

Name	18/0000	18/0300	18/0600	18/0900	18/1200	18/1500	18/1800	18/2100	19/0000	19/0300	19/0600
Selected Assets	X	X	X	X	A	X	X	X	X	X	X
Scan Eagle UAS	X	X	X	X	A	X	X	X	X	X	X

Optimized Flight Slice shows no adverse impacts!

IPAMS Weather Impacts on Routing

Surface Transportation Vehicle Delivery Mission Profile



Mission: Delivery of Emergency Relief Supplies to Weather Disaster Areas.

Summary

- ARL has developed a variety of adverse/severe weather impacts planning tools applicable to civilian use.
- T-IWEDA and the AWRT are part of the operational Army and AF forecaster/decision-maker's "intelligence" capabilities. Suitable for civilian applications
- IPAMS technology is appropriate for disaster response applications
- AWRT technology is appropriate for any aviation application.



UNCLASSIFIED

Tornado Alley: White Sands Missile Range, NM



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

UNCLASSIFIED