Aviation Weather Routing Tool: A Decision Aid for Manned/Unmanned Aircraft Routing

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### Aviation Weather Routing Tool: A Decision Aid for Manned/Unmanned Aircraft Routing

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Standard Form 298 (Rev. 8-98)  
Prescribed by ANSI Std Z39-18
What the User Currently Receives

Text Information

Broad Area Maps

What the User Must Decide

- Are the mission waypoints/altitudes OK?
- How might the weather situation change?
- How will the vehicle and its sensors be affected?

What the User Needs

An Automated Route Optimization System
Theater-scale forecast model database…
“Weather Data Cube”
→ 4-D gridded fields of weather parameters

LOCAL SENSORS
Surface Data Sensors
Upper-Air Sensors
Aircraft MET Sensors

Weather Decision Aid Products for manual and automated applications.

Nesting → Nowcast 0-3hr Database.
Automated refresh of forecast 4-D cube for pre-mission & enroute updates.
New 4-D Weather Forecast Grid + Aircraft-Specific Weather Impacts Threshold Rules (from Tri-Service Integrated Weather Effects Decision Aid (T-IWEDA) database) = Altered Flt Path (if needed)

New Flt Path Options; Avoiding Enrte Hazards

4-D Weather Impacts Grid + Initial/Current Flight Path = PATH OPTIMIZATION
“Optimized” Flight Path
Aviation Weather Routing Tool (AWRT)

- Original planned flight path routes through “red” or “unfavorable” conditions

- Automated flight route optimization algorithms to provide alternate routes around, over, under unfavorable conditions

- Look for the “greenest” or “most favorable” path

- Solution is an “all-weather” routing option to increase mission success rates.

- Technology applicable to ALL aircraft
• 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.
A* on a 2-D Grid

The numbered squares are the searched squares with the costs to reach them. The yellow path is the “least cost” path.
Applying A* to Flight Route Optimization

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
1. Web-Enabled/Net-Centric (Thin Client)

AWRT Server – access to 4-D Weather data cube:
1. Receives route request
2. Calculates weather effects data cube based on aircraft & restrictions
3. Meshes route with weather effects data cube
4. Derives initial weather effects on route
5. Calculates AWRT optimized route options
6. Creates display and A/N output of route options
7. Data and display available to Operator/Planner/GCS/M2M to Aircraft

Via web page interface, enter:
- Aircraft info
- Route waypoints & altitudes
- Enter restrictions
- Send request

Operator/Planner/GCS: PC/Laptop with SIPRNET/NIPRNET connectivity
2. Autonomous (Local) Capability (Thick Client)

Operator/Planner/JMPS/GCS/??: 
**Server/PC/Laptop hosts**
1. Comm. connectivity to ingest 4-D Weather Grids
2. Weather Effects Grid Creator
3. AWRT Route Optimization capability
4. A/N & graphics output of route options

- Calculates weather effects data cube based on aircraft & restrictions
- Meshes route with weather effects data cube
- Derives initial weather effects on route
- Calculates AWRT optimized route options
- Creates local display and A/N output of route options/M2M to Aircraft
AWRT DEMO
Select Asset(s) from List:

- Available Forecast Times (all selected)
- Available Asset List
- User Selected Asset List (ScanEagle UAS)
Compute Weather Effects Matrix:

Geospatial Area of Interest (AOI):

ScanEagle color coded WEM over forecast times (red=unfavorable, amber=marginal impacts)
View ScanEagle Impacts over AOI:

Geospatial impacts at 1200 GMT on the 18th
Define the Flight Path (FP):

Waypoints/times are entered via map clicks (or manually) – M2M in future release
Compute & View Impacts over FP:

Numerous adverse impacts along FP:

Impacts include turbulence & high winds aloft
Flight Slice along Path:

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

ScanEagle max ceiling and speed along with begin time and risk tolerance are set here.
Optimized FP Results:

- Optimized route avoids all adverse weather!
- Optimized flight path waypoints & times are viewable.
Flight Slice along Optimized Path:

Optimized Flight Slice shows no adverse impacts!
UAS flight through unfavorable weather conditions (depicted in red) such as Severe Turbulence.

Optimized flight route, automatically routed UNDER the hazardous weather levels.
CAPABILITIES: Current and Future

CURRENT:

- PC-based & IMETS/DCGS-A Hosted
- Hard-wired to T-IWEDA
- Map GUI = Open Map
- User input of route and flight levels
- Routing rules (cost functions) include:
  - Weather hazards
  - Air speed
  - Head wind component
  - Forecast periods corresponding to flight times

FUTURE:

- Browser version
- Platform independent
- JAAWIN-hosted (Experimental use)
- No-fly zones/restricted airspace considered in routing calculations
- Multiple route options (associated with varied risk levels) displayed or toggled
- Multiple missions displayed at once or toggled
- Automated weather data/flight plan ingest
- Machine-to-Machine capabilities
- Live enroute updates as often as weather data cube updates
- Visualizations: Satellite Tool Kit (STK), FalconView, Google Earth, others?

• USER INPUT FOR OTHER IDEAS???

QUESTIONS???

COMMENTS???