Weather Effects Embedded within Net-Centric C2 System Workflows

Topic 10: Collaborative Technologies for Network-Centric Operations

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AFRL
Robert Farrell
Air & Space Command & Control Systems Branch
Information Directorate
Air Force Research Laboratory
315 330-3050
Robert.Farrell@rl.af.mil

ProLogic
Jeremy Loomis
(304) 333-2680 x306
jloomis@prologic-inc.com

Chetan Desai
(304) 333-2680 x303
chetan@prologic-inc.com

Robert Duncomb
(405) 391-6377
rduncomb@prologic-inc.com
Effect/impacts are hard to quantify and analyze

• **Strategic Decision**
  - Wait until after monsoon rainy season.
  - Win before severe winter sets in.
  - Build weapons that work in extreme cold.

• **Operational Decision**
  - Ensure parkas arrive in desert AOR before August (gets cold at night!).
  - Use PGM sensor X in morning (fog); sensor Y in afternoon (clear).
  - Expect/plan on slow sortie regeneration rates because it’s so hot.
  - Reserve airspace to east of city to ensure sensor cloud free line of sight.
  - Reserve air refueling airspace to east in morning and west in afternoon to synchronize with frontal passage (aviation hazards).

• **Tactical Decision**
  - Swing left around fields because the ground is soaked.
  - Ascend to get out of the icing; descending would be worse.
  - Move UAV south to avoid the approaching line of thunderstorms.
  - Descend to find favorable tailwind (fuel consumption).
Requirements Specification Completed

Reviewed 2,250 pages in 23 C2 requirements documents and extracted 1,170 weather incorporation requirements

Evaluated weather integration in existing C2 applications and documented best of breed

Interviewed C2 warfighters to obtain over 100 use cases

On-line Requirements Database
- Total Derived Functional Requirements: 241
- Total Derived Software Specifications: 627

Specifying Document 176 pages
Requirements Collection Document 110 pages
Challenge

- Much progress has been made in
  - Forecast accuracy
  - Dissemination
  - Machine to machine exchange

- But not much progress has been made in incorporating weather risk management into our computer-augmented decision-making processes

**Objective:** Incorporate weather advice in C2 Systems.
C2ISR applications are starting to ingest weather data/advice but efforts have mostly been cumbersome and ‘raw’

- Converting ‘raw weather data’
  (e.g., winds, rain, and clouds)
  into ‘actionable information’ for C2ISR
  (e.g., fuel consumption, lock-on range, cloud-free LOS)
  is not trivial
  (NBE effects are hard to quantify and analyze, data is complex)

To incorporate actionable advice within their applications, C2ISR developers require functionality that can:

- Retrieve, manage, analyze, and display weather data/rules
- Compute, optimize, and support exploration of effects

A “weather effects” software toolkit would enable developers to integrate verified, validated weather advice

- Within their cost and schedule and with minimal developer training
WxSTORM Toolkit Brings Weather Advice into C2 Applications

1. INGEST Wx
2. INGEST Thresholds
3. ANALYZE
4. VISUALIZE

Mitigate adverse effects and exploit the weather-delta

JMBL: Joint METOC Broker Language
IWEDA: Integrated Weather Effects Decision Aides
Why Hard: Weather Data Model

- Forecast data is extremely complex
  - 3-D Location
    - Latitude, longitude, level/altitude
    - Global scope
    - Multiple projections
  - Compound Time
    - Past/ "Present" / Future
    - Model run time
  - Thousands of Attributes (state and derived)
    - Examples: Temperature, humidity, salinity, pressure, rain, clouds
    - Units of measure
    - Text, imagery, numerical, raster, vector
  - Resolution
    - Nested, overlapping, multi-resolution (spatial and temporal)
    - Update frequency
    - Coordinate systems
    - Points not areas
    - Units, interpolation issues

1. Historical
   Archive of actual observations
2. Observation
   Measurement of what just happened
3. Near-term Forecast (Nowcast)
   What will happen within 1-6 hours
4. Long-term Forecast
   What will happen within 6-120 hours
5. Extended Forecast
   What will happen more than 5 days from now
6. Climatology
   Statistical analysis of historical

$t = \text{Time}$
Why Hard: Impact Determinations

• Impact determination is extremely complicated.
  – MANY unrestrained degrees of freedom
  – Very sensitive to context
  – Much of it is physics-based and very non-linear

• Information clutter and overload

• Warfighters are so use to doing without weather that they don’t know “what weather where.”
  – Expertise extraction has heretofore been difficult at best.

• Forecast accuracy
  – What decisions can we support?
  – Reasoning with uncertainty
Independent Struggles

Today, each C2 system has to implement its own weather components

C2 Program #1

Visualization Component

Analysis Component

Access Component

C2 Program #n

Visualization Component

Analysis Component

Access Component

JET Server

- Data Services
- Impact Services
- Threshold/Rules Service

Joint METOC Database

Unclassified
WxSTORM is a collection of verified, validated, and tested common components in SDK form made available to all C2 system developers.

- Data Services
- Impact Services
- Threshold/Rules Service

FIGURE IT OUT ONE TIME FOR EVERYONE
Paragraph: 6.4.1.1
Name: Integrated Prioritized ISR Plan
Description: The AOC WS requires ability to produce an ISR Plan overlaid with environmental conditions.
WxSTORM has the code to enable C2 applications to render clouds and other weather parameters on several different map displays and supplies the means to analyze CFLOS windows of opportunity, by altitude and time for any set of targets.
Summary

• Weather impacts military operations.

• We need to figure out how to INCORPORATE advice in C2 applications.

• Collecting C2 requirements and translating into specific solution modules.

• Doing the hard work and sharing capabilities via a Software Developers Toolkit.

• Continually inject better into SDK => All C2 apps.

• Funding was cut so we are spinning down until next time.
Examples of Incorporation

HOW MIGHT WE INCORPORATE ADVICE?
Tanker Support for Fighter Aircraft

Tanker Airlift Control Center (TACC)
Global Air Mobility Advanced Technology (GAMAT)
Work-Centered Support System For Global Weather Management (WCSS-GWM)

- Learn from and include this success

- HOW do we represent weather that would impact the success of ferrying fighters across the ocean for example?

Example courtesy of Sam Kuper, AFRL 711 HPW/RHC
Communications Impact

- Rain attenuation affecting communication.
- Limiting the downlink to ground station receiver and thus affecting the movement of collection to decision-maker.
ISR Support

Asset Allocation
- Satellite does not have Line-of-sight to the target for capturing the image.

- The UAV being lower and having more control of where it flies can capture an image of the target location.

Predictive Cloud-Free Line Of Sight (PCFLOS)
- Evaluate multiple ISR asset locations and “time-windows” based on cloud cover forecast effect on planned mission.

Got Comm?
Representing Wx Impact
Paragraph: 6.5.1
Name: Airspace Management
Description: AOC requires ability to plan and manage airspaces using a graphic display with ability to resolve conflicts in space and time.
Paragraph: 6.6.2
Name: Replanning/Retasking Capability
Description: AOC requires ability to replan and retask with consideration of weather as a key planning factor.
Examples of Incorporation

SUCCEEDEDS
WxSTORM-Enabled Situational Awareness

- Global Awareness Presentation Services (GAPS)
- User-Defined Operational Picture (UDOP)
  - Decision-focused view of the operational environment that organizes disparate data sources to support accurate situational awareness (SA) and timely decision-making in a distributed net-centric environment
- Web-enabled Data Sources
  - Satellites, Tracks, ISR, Intel, Events, Routes, ATO, Imagery, Weather, etc.

USSTRATCOM and STRIKE AOC

WxSTORM provides visualization components for C/JMTK, STK, GoogleEarth and others.
WxSTORM-Enabled Airspace Deconfliction

- **JASMAD Background:**
  - CJMTK-based airspace management
  - Being developed as an AOC weapons system net centric information capability
  - Manages battlespace with single joint airspace management and dynamic deconfliction capability
  - Coordinates real time ATO planning and execution
    - Minimizes conflicts and maximizes airspace usage
  - Enhance user's situational awareness
  - Automates and visualizes the Joint Air Tasking Cycle
  - Creates and processes ACMs, ACOs and the Airspace Control Plan (ACP)
  - Provides near real-time deconfliction during mission execution down to kill box level

WxSTORM provided analysis components which helped JASMAD create an airspace layout that avoids hazardous weather areas.
WxSTORM-Enabled Route Planning

- **Optimal routes**
  - Avoid hazards
  - Conserve fuel
  - Meet diplomatic clearance constraints

- **Requires spatial analysis to avoid conflicts between routes and hazards**

- **Requires spatial analysis of multiple possible routes against the 3D wind profiles**

WxSTORM enables analysis capabilities to find optimal air routes for mission success
WxSTORM-Enabled Trafficability

- Battlespace Terrain Reasoning & Awareness (BTRA)
- CJMTK-based trafficability
- Fast All Season Soil Strength Model (FASST) – WxSTORM enabled feed
- Requires spatial analysis to avoid conflicts between routes and impassable terrain

WxSTORM enables analytical capabilities to include weather effects when computing terrain conditions
In addition to providing situational awareness of airfield impacts, WxSTORM modules enable GRS/WIDE to dynamically build adverse weather constraint spaces used by their optimization algorithms for AMC mission planning based on weather, fuel efficiency, and diplomatic constraints.
FalconView Weather Prototype

- Special Operations Mission Planning Environment (SOMPE)
  - METOC Graphics Overlay
  - Partnered with GTRI
- Goals:
  - Integrate Weather Impacts Analysis and Visualization into FalconView
  - Weather Forecasts and Observations
    - GRIB parsing and visualization
  - Provides access to JMBL data
  - DoD Weather Data Sources:
    - JWIS
    - JET
    - WDAC
- Leverages Weather Toolkit for development of Overlay
Airborne Web Services (AWS)

- Many web-enabled data sources:
  - Air Tracks
  - ATO/ACO
  - Blue Forces
  - Munitions
  - GMTI
  - Weather

- AWS server uses JMBL

- Currently integrating *Weather Toolkit*