Decision Support for Time Critical Strike: Land Based Target Area Of Uncertainty (LBTAOU) Prototype

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Partnership

NAVSEA NEWPORT Undersea Warfare Center Division

Research and development center for submarine systems, autonomous underwater systems, and undersea offensive/defensive weapons

UMASS DARTMOUTH ADVANCED TECHNOLOGY & MANUFACTURING CENTER

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Objectives

- To evaluate the application of Geographic Information Systems (GIS)-based decision support technologies to address Naval Capability Gaps
  - Persistent ISRT for accurate target discrimination and location (gap no. 5)
  - Rapid movement of mobile/emergent target data to shooters (gap no. 7)
  - Persistent high speed strike weapon to engage time critical targets (gap no. 12)

Key To Time-Critical Strike Capability

"We need a decision-making aid with software where we can tie in ISR and factor in such things as rules of engagement and other sensitivities, blast fragment pattern [to avoid collateral damage], target priority, target location, etc. That would really shorten the time between identifying a target and getting permission to drop.... "

Rear Adm. (select) Joseph F. Kilkenny,
Office of the Chief of Naval Operations
www.navyleague .org

Areas of Interest

- Time-critical, mobile targeting
  - Support High Speed Weapon and advanced versions of TacTom
- Integrated Land Attack
  - Assess tactical application for mission planning, loiter planning, and increasing situational awareness for the shooter
- Common Human Computer Interfaces (HCI)
  - Evaluate the use of GIS as a common presentation layer for complete situational awareness
- Develop solutions that extend to other tactical areas
  - Unmanned Aerial Vehicle (UAV) search planning
  - Unmanned Combat Aerial Vehicle (UCAV) targeting
- Examine and apply Artificial Intelligence to GIS applications
  - Apply Fuzzy Logic to spatial analysis
  - Predict target movements based on mission/intent

Tomahawk Background

- Block III
  - Used against high-priority, long-dwell targets
- Block IV or Tactical Tomahawk
  - Initial Operational Capability FY04
  - Additional capabilities
    - Satellite communication
    - In-flight retargeting
    - Loiter capability
    - Health and status reporting

The Problem

Limited capability against mobile, time-critical targets

- Weapons cannot be recalled, unlike an Unmanned Aerial Vehicle (UAV)
- Short endurance limits ability to loiter
- Call-For-Fire (CFF) requests
  - Require detailed mission planning
  - Response time may be significant
- During in-flight time, a target need only move a short distance to evade strike

Approach

To provide a tool that allows mobile targets to be quickly relocated/retargeted via an optimized search route based on :

Target Capabilities

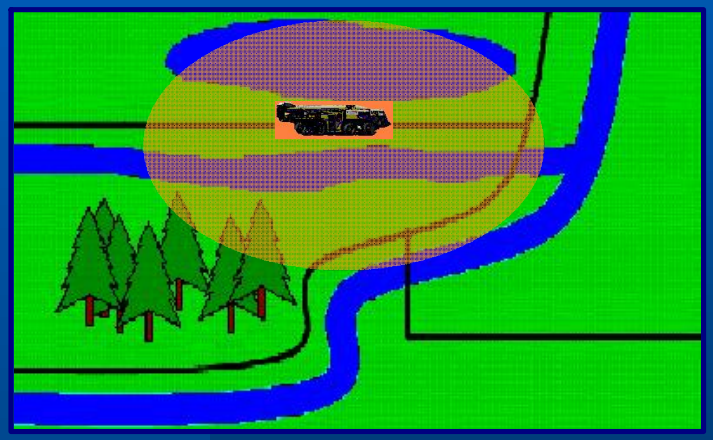
Reconnaissance Vehicle Capabilities

Operating Terrain

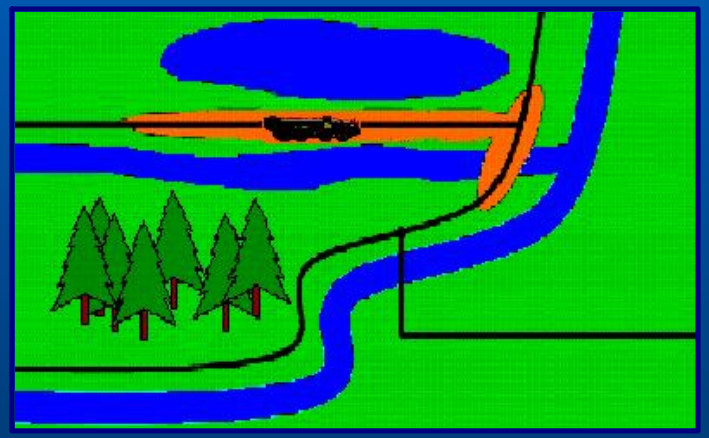
Weapon Capabilities

Approach (Continued)

Search Areas



vs.



Typical AOU

Optimized AOU

Scenario

Using LBTAOU against a mobile, time-critical target:

1. Transporter/Erector/Launcher (TEL) has been identified as a target by UAV
2. Tomahawk (or High Speed Weapon) is targeted
3. A later pass of the UAV indicates the target is no longer present
4. LBTAOU calculates an optimized search region, search route, and loiter area
5. UAV is routed to search the region
6. Tomahawk's current position and fuel status is queried
7. Tomahawk loiters while the target is reacquired
8. Once the target is located, the optimal strike area is selected
9. Weapon is retargeted

Goals

- Identify the AOU for land-based targets as a function of
  - Target Parameters
    - Dimensions, turn radius, max speed, terrain capability, etc.
  - Geographic Features
    - Roads, bridges, landmarks, elevation, terrain, rivers, etc.
- Provide optimized search routes
  - Reduce reacquisition times
- Provide optimal missile loiter position
  - Reduce missile loiter-to-strike time
- Identify target vulnerability windows in environment
- Identify optimal strike locations

Employed Technologies

- Combine mature algorithms, motion analysis techniques, and Geographic Information Systems (GIS)
  - Reduces development time
  - Increases reliability
  - Decreases risk
- Employ GIS Spatial Queries for terrain data access
  - Describes relationship between map locations and geographic features

LBTAOU Terrain Data

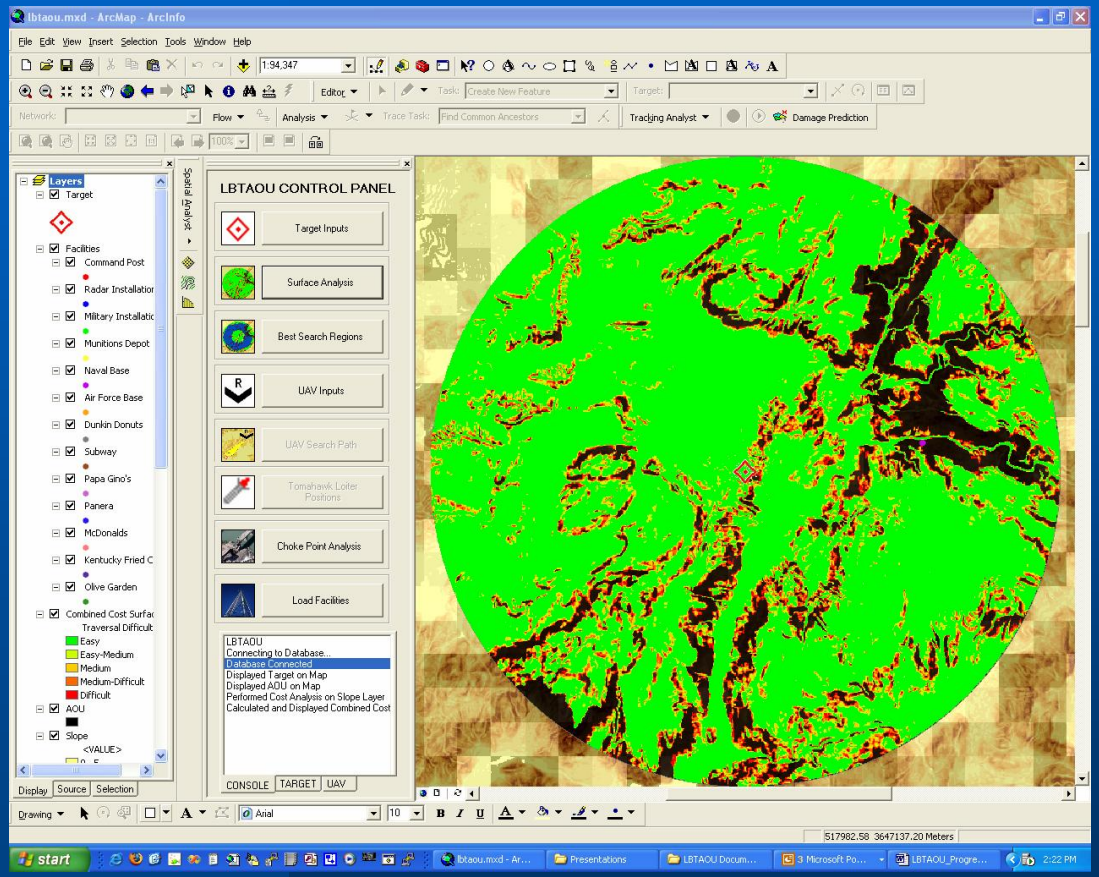
- The LBTAOU prototype currently uses four terrain layers which include:
  - Slope
    - Compared to the max gradient of the targeted vehicle
  - Water Depth
    - Compared to the maximum water depth that the targeted vehicle can traverse
  - Terrain
    - Compared to the ground clearance and terrain capability of the targeted vehicle
  - Forest Density
    - Compared to the width of the land-based target

Current LBTAOU Algorithm Suite

- Combined Cost Surface
- Search Region
- UAV Search Route
- Loiter Position
- Battle Damage Query

Combined Cost Surface

Cost Surface of AOU



The Cost Surface Algorithm will eliminate any region that is unreachable by the target, and rate the difficulty to traverse the land. This region will be given a non-traversable value.

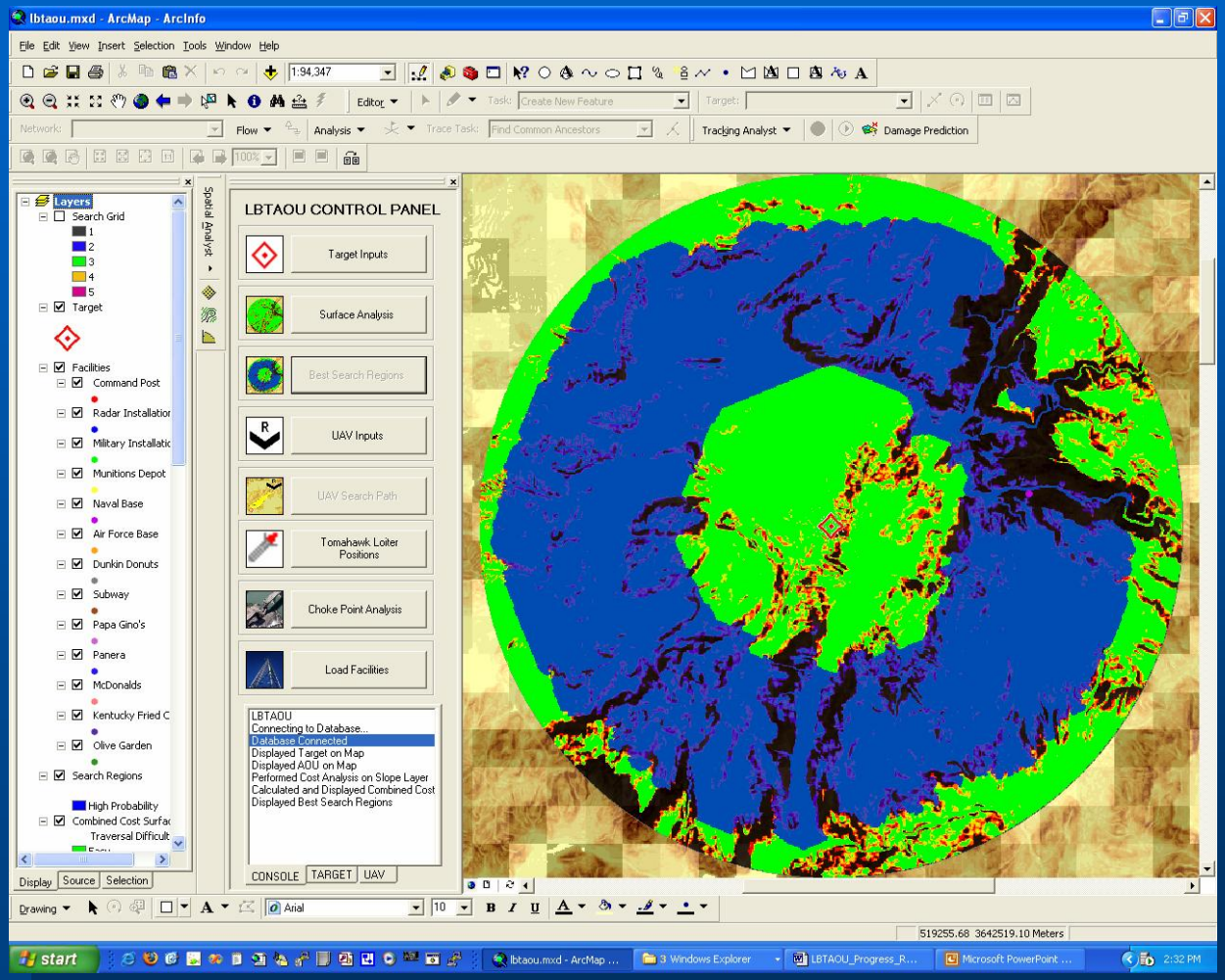
- **Non-traversable**
- **Easy**
- **Easy-Medium**
- **Medium**
- **Medium-Difficult**
- **Difficult**

Search Region

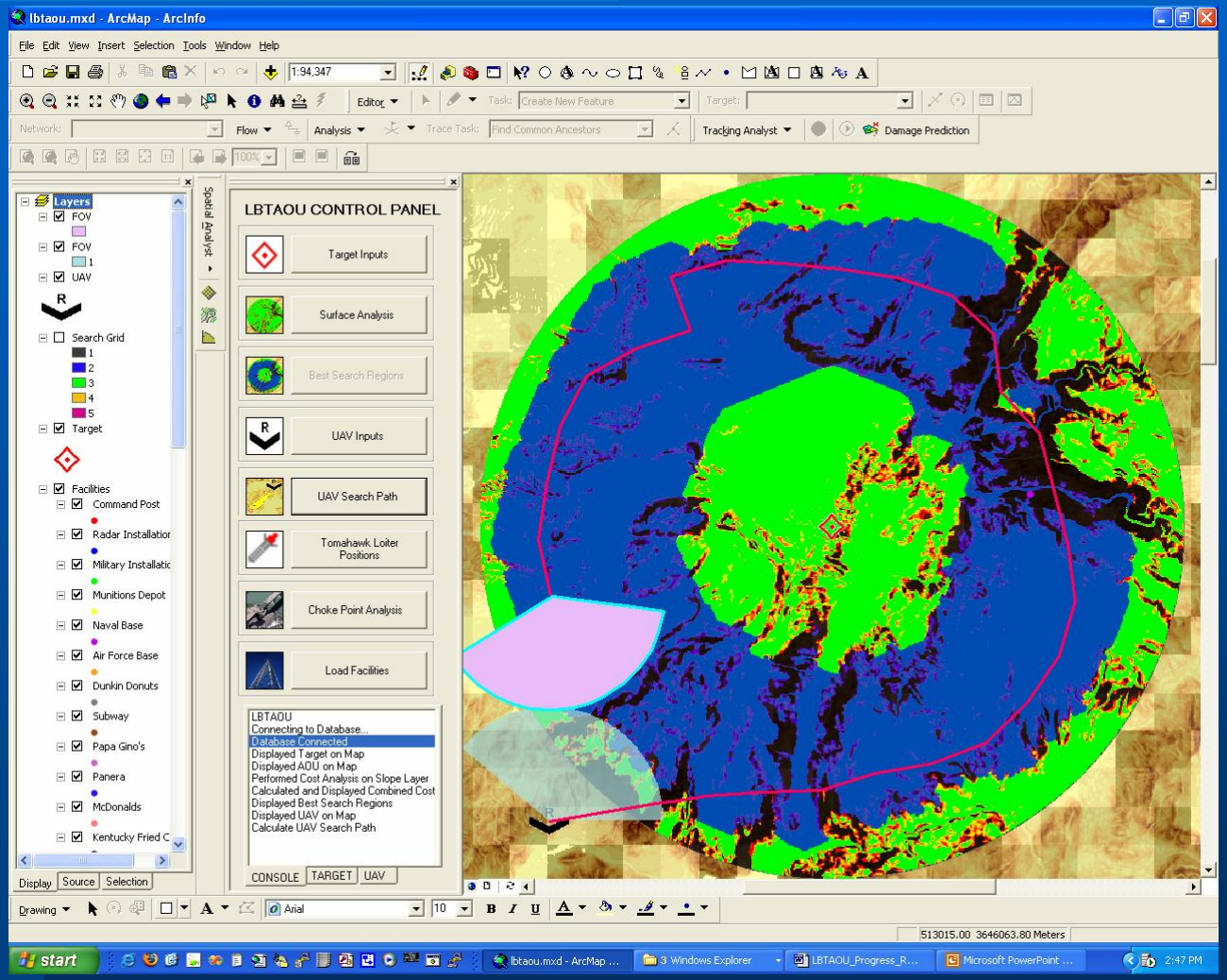
- **Determining the Search Region**
  - **Calculate Cost Distances for land-based target.**
    - Raster containing distance information extending from initial position
  - **Calculate Outer Extent of Search Region:**
    - Cost Distance (meters) <= Radius of AOU (straight line distance)
      - Radius of AOU = (MAX Speed) * (time elapsed)
    - Eliminates areas where target cannot possibly be in the elapsed time.
  - **Calculate Inner extent of Search Region:**
    - Inner extent = INITIAL speed * time elapsed

Search Region

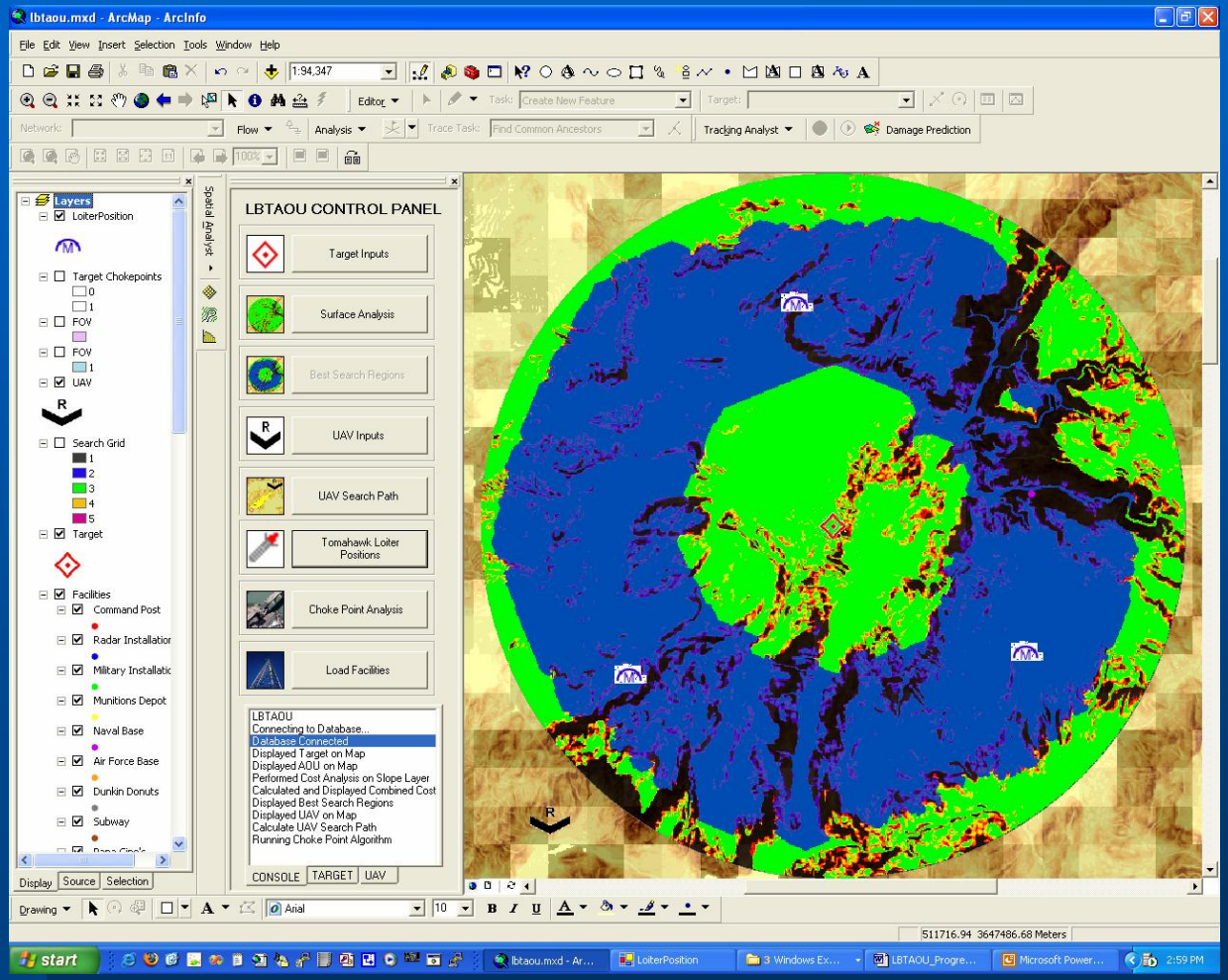
Search Regions Overlay of Combined Cost Surface



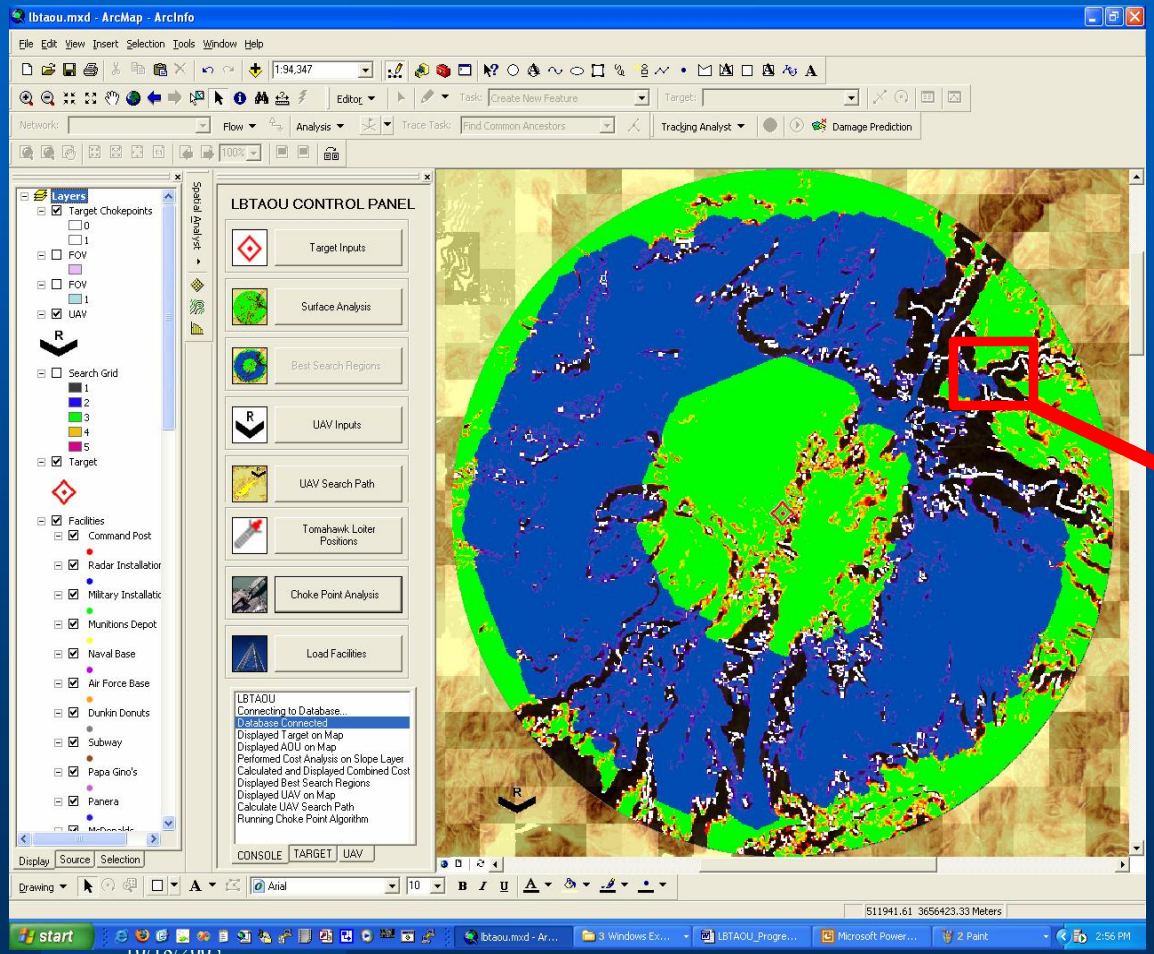
UAV Search Route Example



Tomahawk Loiter Position



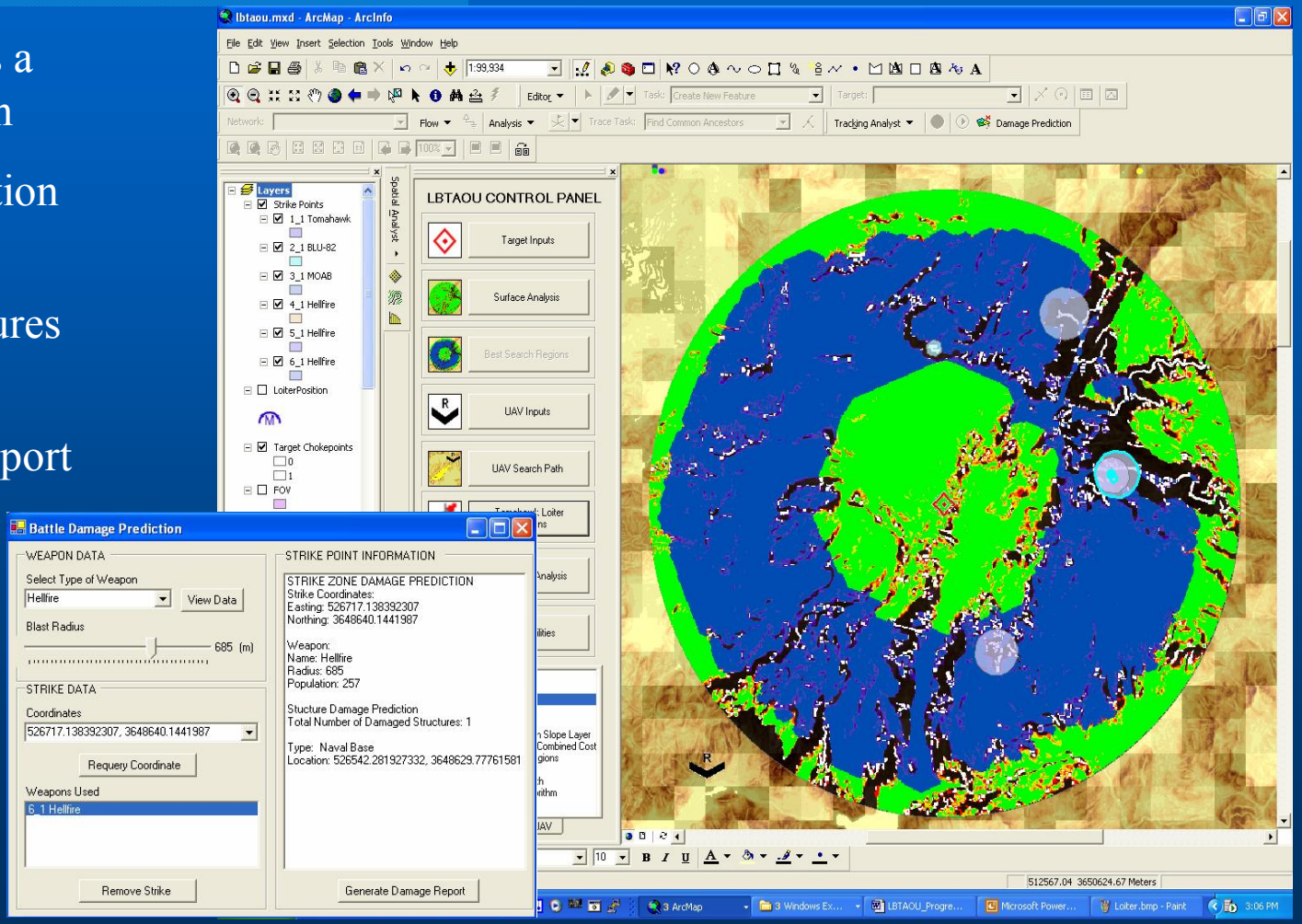
Choke Point Identification



- Determine areas that limited target's ability to evade
- These areas are represented in white

Battle Damage Query

- Graphically displays a strike from a weapon
- Displays the population in the area affected
- Describes the structures in the area affected.
- Generates a Web Report using XML



Future Work

- Investigate application of Fuzzy Logic to GIS spatial analysis
  - Spatial features often do not have clearly defined boundaries, and concepts such as "steep," "close," or "suitable" can better be expressed with degrees of membership to a fuzzy set than with a binary yes/no classification.
- Apply AI to target movement prediction
- Explore Multiple Objective Decision Support
  - Determine best strike coordinates as a function of population and religious sites, within weapon capability restraints
  - Provide target prioritization based on target threat/intent, loitering weapon status, rules of engagement, etc.
- Develop sensor visibility performance models
  - Examine effects of weather on sensor performance
- Develop Command & Control Information Exchange Data Model (C2IEDM) interfaces
  - Supports NATO multilateral data connectivity
  - Supports Sea Trials

Point of Contact

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