Some Human Factors Design Principles for Effective Visualization and Collaboration of Military Operations
## Some Human Factors Design principles for Effective Visualization and Collaboration of Military Operations

### Abstract


### Subject Terms

- Human Factors Design principles
- Effective Visualization
- Collaboration of Military Operations
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Collaboration in Military Command and Control

- Interactions are hierarchical and distributed
  - Need information sharing and plan coordination

- Interactions are asynchronous
  - Need intervening representations

- Plans are complex and many dimensional
  - Goals, tasks, assets, priorities, schedules…
  - Need information visualization and integration
Architecture Principle: Slice & Link

- Use multiple “2D” displays
  - Geoplot
    - Assets by location
  - Task Manager
    - Tasks by time
  - Resource Grid
    - Assets by attribute
  - Etc.

- Use Dynamic Visual Linking
  - “Content addressable memory”
“2D” Display Design

- **Task Manager**
  - Task by time
  - Schedules
  - Dependencies
  - Implications of delays
  - Etc.

- **Resource Grid**
  - Assets by attributes
  - Sort, filter, retrieve, compare assets and their attributes
PSYCLOPS
A Single Integrated “Eye” on the Situation

- Integrated Tools to Augment Command and Control
  - More effective situation and plan visualization tools with
  - Visually interlinked databases for content addressable memory and context tracking

- Linked components
  - Task Manager
    - Task components and schedule
  - Resource Grid
    - Asset data and availability
  - Asset List
    - Correlation of assets to tasks
  - Geoplot
    - Locations of assets
Example Scenario: NEO in East Timor

- Noncombatant Evacuation Operation
  - CH-53s, CH-46s, KC-130s, AC-130s, MC-130s, AV-8Bs, AH-1s, USMC RECON teams, Navy SEAL teams, Medical corps teams

- Evacuate approx. 50 Red Cross workers from rebel-held territory in East Timor

- Work with local embassy to develop an evacuation plan

- Insert advance forces to recon and secure staging areas

- Insert main body rescue force

- Extract Red Cross workers and the rescue force
NEO with Current Tools

- Are there Darwin-based tasks or resources?
- What would it mean if there were?
- Do I need to reassign anything?
- How will I find replacement resources?
- Which tasks need rescheduling?
- Are there Darwin-based tasks or resources?
- What would it mean if there were?
- Do I need to reassign anything?
- How will I find replacement resources?
- Which tasks need rescheduling?
METOC: “Bad weather in Darwin”
Sort RG by Base Location

Note Darwin-based asset
Select Darwin-based asset DVL to geoplot and TM
Expand “Advance Party” task
Refueling task is soon!

Expand "Advance Party" task
Refueling task is soon!
Sort by Mission Type to look for alternative tankers
Rabaul-based tanker is available
It is difficult to keep track of assets and their status
  - Distilled and organized from multiple sources

It is difficult to compare the attributes of assets

It can even be difficult to find assets

Where is the interceptor with the least fuel?
Basic GeoPlot
Search for strike aircraft, examine fuel level

Where is the Strike aircraft with the lowest fuel level?
Basic GeoPlot
Search for strike aircraft, examine fuel level

Where is the Strike aircraft with the lowest fuel level?
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Search for strike aircraft, examine fuel level

Where is the Strike aircraft with the lowest fuel level?
Basic GeoPlot
Return to strike aircraft with lowest fuel
RG: Method 1
Select a filter for all mission types

Where is the Strike aircraft with the lowest fuel level?
<table>
<thead>
<tr>
<th>Mission Type</th>
<th>Mission Num</th>
<th>Track Num</th>
<th>Call Sign</th>
<th>Platform</th>
<th>Controller</th>
<th>Station</th>
<th>Fuel Remaining (%)</th>
<th>Weapons</th>
<th>Schedule (C)</th>
<th>Assignment</th>
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Where is the Strike aircraft with the lowest fuel level?
RG: Method 1

Roll down looking for a strike aircraft

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Where is the Strike aircraft with the lowest fuel level?
RG: Method 1
Roll down looking for a strike aircraft
**RG: Method 1**

Select row

---

Where is the Strike aircraft with the lowest fuel level?
RG: Method 2
Select a filter for only strike aircraft
RG: Method 2
Roll down looking for lowest fuel

Where is the Strike aircraft with the lowest fuel level?
Enhanced GeoPlot
Find/Next search, examine fuel level

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Where is the Strike aircraft with the lowest fuel level?
Enhanced GeoPlot
Return to strike aircraft with lowest fuel

Where is the Strike aircraft with the lowest fuel level?
Design Alternatives for Showing Attributes

- **Resource Grid**
  - Tabular and spatial organizations
  - Dynamic visual linking
  - But two displays

- **Basic Geoplot plus pop-up list**
  - Spatial organization only
  - Single, integrated display
  - But search is difficult

- **Enhanced Geoplot**
  - Spatial organization only
  - Single, integrated display
  - Find/Next search
  - Still one-at-a-time display
Example Questions from the Experiment

- **Data-based search vs. map-based search**
  - Where is the aircraft that is closest to the carrier?
  - What is the platform of the aircraft with track number 7022?

- **Single attribute vs. comparison**
  - Where is the Strike aircraft with call sign Checkerboard 327?
  - What is the call sign of the aircraft with the lowest fuel level?

- **Single mission vs. all aircraft**
  - Where is the (DCA) aircraft with the fewest weapons?
Comparisons Among Assets
Where is the strike aircraft with the lowest fuel level?

- Comparisons were slower than Singles
  - E.g. Searching the geoplot and remembering previous values
- Except for RG
  - Sorting and comparing down a column
- For comparisons, RG was 42% faster than Basic
Conclusions

- Active tables for asset/attribute comparisons
  - Filter-able, sort-able, scan-able tabular display

- Architecture principle: “Slice and Link”
  - Multiple 2D displays, plus
  - Dynamic Visual Linking

- Military command and control is a rich domain for investigation of collaboration principles and innovative visualization concepts

- Many of these principles and concepts apply to multiple domains