Report of Break-Out Group 3

Reliability and Uncertainty in Situational Awareness

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1 MOTIVATION

The motivation behind our discussion and analysis focused on understanding the realities of current political, strategic, operational and tactical environments. Current operations involve an increasingly rapid tempo, involving short decision cycles and high stress. There is an increased link between the units in which political considerations affect strategy, operations and tactics on a short term basis. While there are fewer tactical units, these units have increased fire power. Hence the activities of an individual tactical unit can have a greater impact at tactical, strategic and political arenas (in a negative and positive way). This is made possible due to increased communications capacity (both bandwidth and connectivity). Thus, network centricity is a double-edged sword.

2 GROUP PROCESS

The process that we used for this group involved first defining the operational needs from the viewpoint of a senior command officer versus an analyst. We wanted to understand key design considerations and basic visualization concepts that would work in this fast paced, high stress environment. We also discussed what reliability and uncertainty means from the viewpoint of the command officer. We then discussed what we viewed as technology gaps in achieving the necessary situational awareness specifically as it pertains to addressing the reliability of sources and uncertainty of the data. We concluded by identifying both short and long term recommendations for further investigation and experimentation.

3 CHALLENGES

The operational realities previously identified imply a number of challenges for visualization. First, we must recognize the need to support all levels: strategic, operational and tactical. One of the key challenges is to make a common operating picture (COP) that is consistent, repeatable (under identical query conditions), and customizable depending of the focus of attention. Another key challenge is how to represent uncertainty in a consistent "repeatable" manner such that it can be used to make decisions. The last key challenge we discussed is how to measure the reliability of a given source. Given that past performance may not be a good enough indicator for future performance, understanding (and thus, visualizing) reliability is a difficult challenge.

4 DESIGN IMPLICATIONS

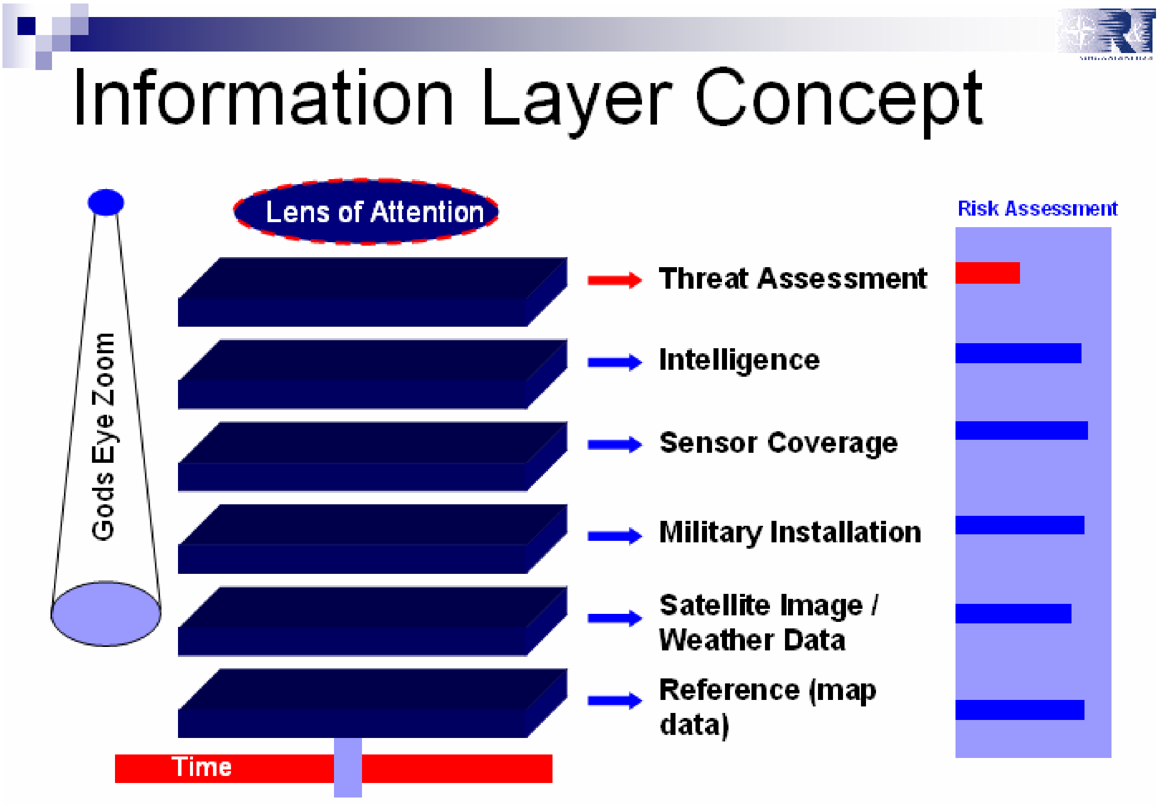
Some basic design considerations are to keep the information displays simple to avoid information overload. In general, analogue displays are preferred in lieu of digital displays (provides a "visual snapshot" of what is normal without having to "read" any data). It is also important that the user has adequate control to adjust the level of detail and the focus of attention. However, too many controls will allow too many options and complicate the process. While many attempts have already occurred, it is also important that symbology achieve a better level of consistency. Finally, it is critical that the design has full user feedback validation across a statistically significant cross section. Assuming new processes or procedures may result due to capabilities improvement, it is important to ensure that the change be handled in such a manner to permit a smooth transition (including “doing things the old way”).

5 RELIABILITY AND UNCERTAINTY

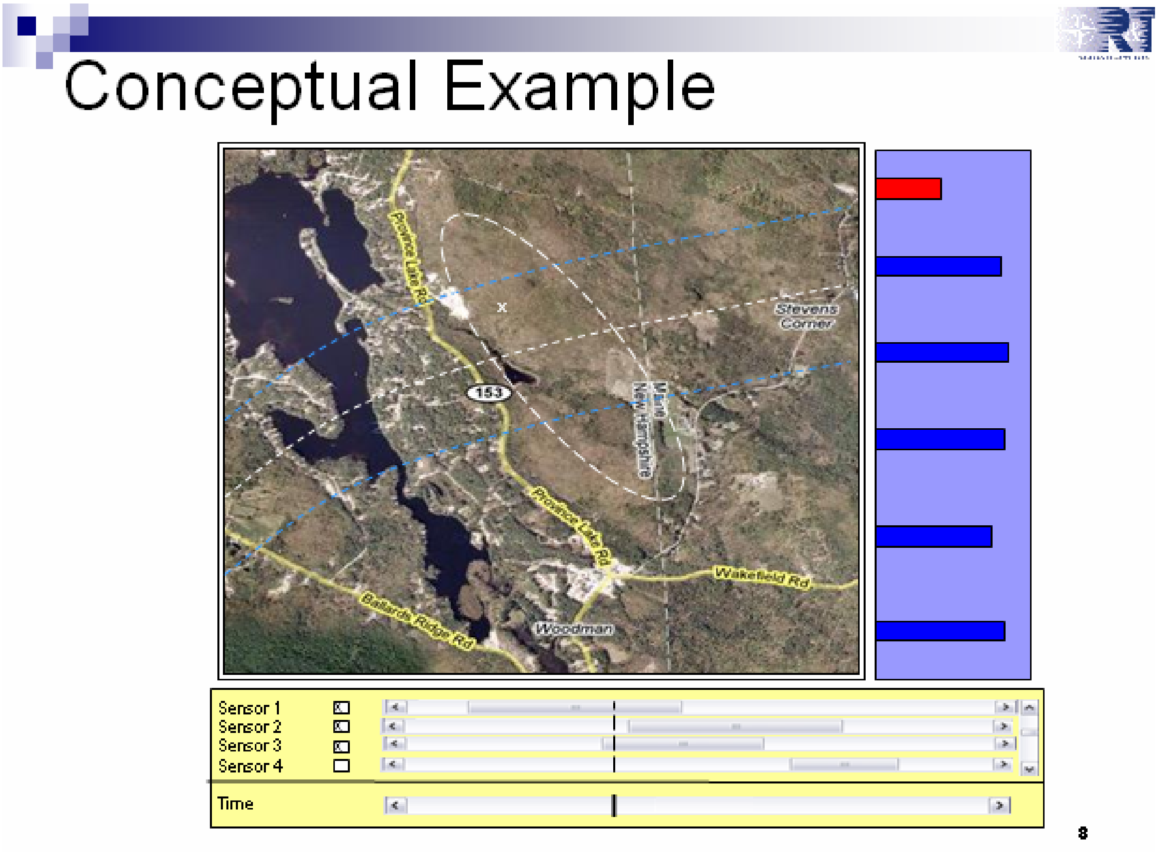
Before we can begin to visualize concepts such as reliability and uncertainty, we need to come to a firm understanding of what we mean when using these terms. One view is to think of reliability as a measure of the information source which may vary as a function of the task. It may be difficult to “quantify” or define metrics (or confidence ratings) in a consistent manner. To be meaningful, however, some degree of consistency and repeatable is critical. Uncertainty, on the other hand, is a measure of the information. It can vary as a function of time as in the case of a reported aircraft that is “lost” from radar. Every second that it is lost, the uncertainty of the aircraft location increases from a geospatial viewpoint. On the other hand, object identification can also undergo descriptions of uncertainty by using such terms as possible, probable, or confirmed. If these terms are defined using consistent (standardized) criteria such that the resulting uncertainty rating is repeatable, then visualization techniques are more readily conceptualized.

6 INFORMATION LAYER CONCEPT

The illustration below is shows how information layers can be used to both convey what we know (information) and what we don’t know (lack of information). The information that we don’t know can then be used as a rough measure of the uncertainty associated with that information layer. The information in these layers, starting from the foundation terrain/map/image layers to the intelligence overlay, is used to create a series of assessment overlays such as a threat assessment or air capacity assessment. As an example, radar coverage from a surface-to-air missile (SAM) would “paint” a 3-D “red” (threat) dome that may be partially obscured by terrain elevation (nearby hill). Uncertainty at the fringe of the radar coverage could be colour shaded yellow or orange as a simple indicator that there is uncertainty in the potential danger area of these SAMs. These assessments can also be done within the context of an operational mission such as suppression of enemy air defence (SEAD) where we can (automatically) custom adjust the sensor coverage information to determine what we don’t know (i.e., scanning for indicators that can shoot down an aircraft) while ignoring other coverage shortfalls that are not pertinent to this assessment. In addition to the concept of information layers and the threat assessment overlays, it is also important to be able to adjust the field of view (FOV or God’s Eye Zoom) and customize the “decluttering” of information. The “zoom” adjusts the geo-spatial content while a time “slider” permits reviewing all available information (within this FOV). The next figure illustrates a further refinement in how one can declutter and customize the FOV.



Working from the previous guidelines, a recently taken image is used as a foundation map with map features overlaid (such as roads and borders). Within the "zoomed" FOV and a time period (set by the user and defaulted to "current time to X hours prior"), a list of available sensors that were available in that given spatial area and time frame is displayed. The user can "turn on" the display for the list of available sensors to overlay on the map/image. The sensor timeline also shows the time period that the sensor was active and operational. This collection of information can then be used to determine what we don't know and provide an indication of uncertainty (with regards to coverage) and also the reliability of the threat assessment. In other words, a threat assessment that might indicates "little or no threat" with a significant lack of coverage is not reliable and should not arrive at that conclusion.



Other examples of limited operational and prototype systems that work with information layers previously described are as follows:

- Common Operating Decision System (CODS) – video demonstration available
- Distributed Data Fusion Simulator (DDFS)
- Multi-sensor Integration and Intelligence Analysis (MSIIA)

7 TECHNOLOGY ASSESSMENTS/GAPS

Prior experimentation has shown that search related tasks on display devices can use nine (9) mega-pixels of display resolution (at the proper distance and pixel size) when the information display is viewed statically. As the visual task gets more complicated with multiple points of interest, there is strong indication that more pixel display area can benefit the users by shortening the decision process (due to not having to scroll or retrieve readily available information). Component technology to support this is available but further development may still be needed to determine how best to integrate the fusion of information within the visually rich display area. Another shortfall in better addressing uncertainty and reliability is the need for better representation of uncertainty and reliability. These representations need to be well understood and repeatable under the same conditions. Once these representations have been established, progress to creating better visualization techniques can be made.

8 RECOMMENDATIONS

The short term recommendations are as follows:

- Initiate operational studies and analyses of visualization needs from the analyst's and commander's viewpoints
- Develop visualization concepts and prototypes, defining what uncertainty and reliability conveys
- Conduct experiments with representations of uncertainty and reliability.

One "low hanging fruit" is to use higher resolution display technology or an appropriately matrixed array of high resolution displays oriented in such as manner as to maximize the information availability without "overloading" the user. Further research may improve how displays of this caliber can be organized to maximize the information output without creating an overload situation.

The long term recommendations are as follows:

- Development of consistent techniques for determining uncertainty and reliability
- Development of intuitive techniques for visualizing uncertainty and reliability
- Experimentation with 3-D visualization
- Deployment of real systems.