Visualizing Uncertainty in the Common Operating Picture – Proposed Research Program

IST-043/RWS-006 Working Group 4 Report

by

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PROBLEM

Data fusion has been identified as key to creating a common operating picture. Attempts to integrate data from various sources will invariably include underlying assumptions (i.e. built in by the system designers) and error inherent to the sources of data (e.g. sensor resolution and accuracy). There is danger in allowing the operator to believe that the data presented is "ground truth" as all data will have some level of associated uncertainty. Decision-makers need to know what is not known as much as what is known in order to take appropriate action. To help the operator visualise the most accurate operating picture, it is important to understand the role that uncertainty plays on task performance so as to provide design principles that should be followed for building displays to convey uncertainty in COP.

OBJECTIVE

Produce a COP that allows users to tailor their information needs on uncertainty to adapt to rapidly changing rules of engagement (ROE).

RECOMMENDED APPROACH

To meet the overall objective of making uncertainty of information explicit in the COP, the following steps are recommended:

1) Build a taxonomy of uncertainty related to COP
   a) Uncertainty inherent in display technology (e.g. spatial and temporal uncertainty in sampled data);
   b) Uncertainty in the data displayed (e.g. conflicting or missing attributes for track ID; spatial and temporal sensor uncertainties); and
   c) Uncertainty in perceptual response (e.g. due to viewing angle).

2) Design and evaluate display concepts to query and visualize uncertainty for decision-making
   a) Evaluate the effectiveness of existing uncertainty display techniques, alone or in combination, under varying conditions of decision-making (e.g. increasing time pressure). Uncertainty parameters for

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consideration include, but not limited to Track ID (e.g. icon-in-icon, disintegrated attribute representations); spatial uncertainty (e.g. spatial envelopes, blobology), and temporal uncertainty.

b) Develop and evaluate explicit visualisation concepts to 1) make uncertainty, underlying assumptions and display criteria explicit; 2) query uncertainty levels of tracks; 3) directly manipulate the consequences of choosing different uncertainty levels; and 4) support decision-making needs by tailoring uncertainty levels to extant ROEs. As a starting proposal, a potential design space for displaying uncertainty is presented in Figure 1.

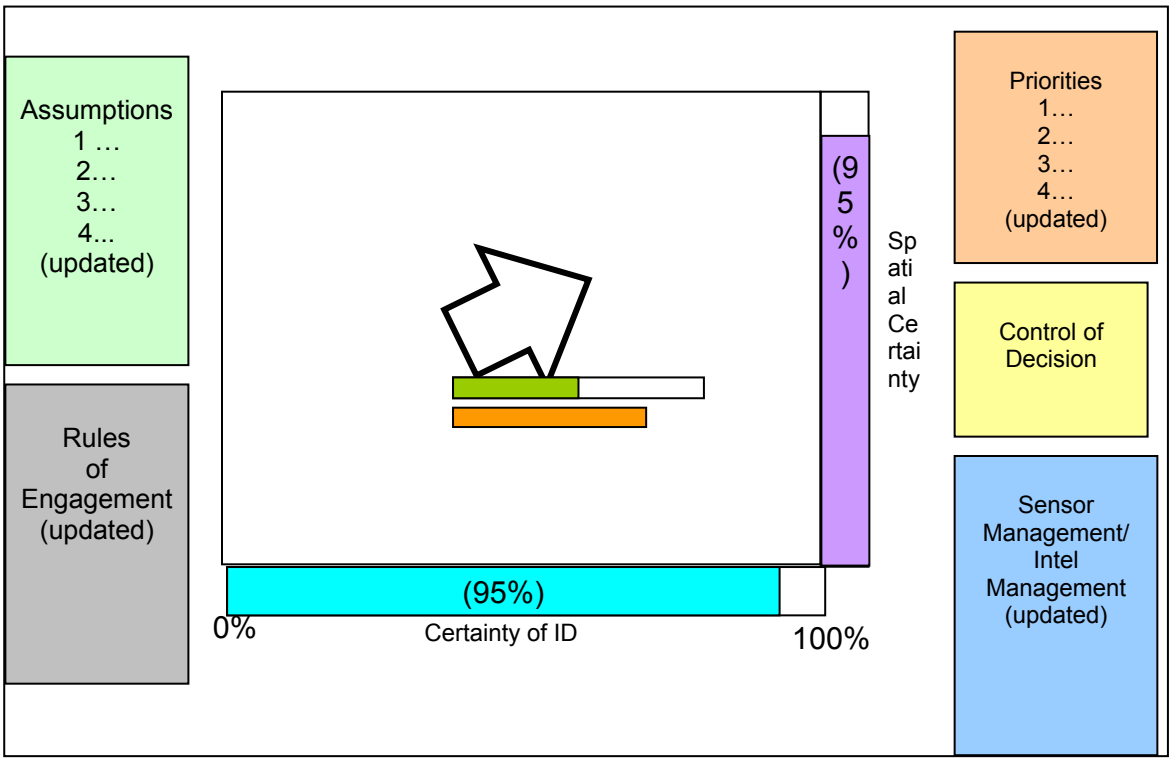

Figure 1: A Proposed Experimental Design Space for Evaluating Direct Manipulation of Uncertainty Within a Decision-Support System for COP.

DESIGN AND USABILITY ISSUES

Making uncertainty explicit in COP is not a trivial matter. Design guidelines should be established that address issues of design and control, interpretation, and relationships between decision-making variables. Questions raised include:

- What are appropriate designs for customizable displays for levels of uncertainty?
- How might querying of information be integrated with displays of target uncertainty?
- Should the customizable displays differ depending on the target and the type of query?
- How should temporal information related to information uncertainty be displayed?
- What are the trade-offs between displaying uncertainty and display clutter?

- How does user viewpoint contribute to the operator's assessment of uncertainty?
- What is the relationship between available time to decide and assessment of uncertainty as a useful decision-making variable in order to act?

SUMMARY

- Decision-makers need to know what is not known as much as what is known.
- Build a taxonomy of uncertainty related to COP.
- Design and evaluate display concepts to query and visualize uncertainty for COP decision-making.