Quantification of Subjective Information Assessments in C2 Decision Option Selection

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Abstract

Two of the more subjective processes in decision making involve forming an opinion about each decision-relevant information item (i.e., the impact and importance of that item to any decision option) and then selecting one option based upon some form of cognitive weighting of the entire information pool. The decision support package described here simplifies and quantifies these two processes by supplying an intuitive interface to capture: (1) location of the information item (2) content of the information item (3) quality of the information (4) timeliness of the information (5) decision option impacted (6) nature of that impact and (7) the importance of the item. Using a weighting matrix, the subjective assessments of impact and importance for each information item are converted into single score and then all the information item scores for a particular decision option are summed. The final total scores are used to quantitatively assess the ranking all the various decision options. An exchange module makes all assessments available to all participants, enabling the group to quickly focus on the key differing individual assessments causing any lack of group consensus.

Introduction:

Time availability, level of expertise and the complexity of the information often determine the decision making strategy that is employed in final option selection. In a crisis, time critical environment, experts often rely on naturalistic decision making, a concept developed by Klein and his associates (Zsambok and Klein, 1997), where the first option found to meet minimum essential requirements is selected. This "satisficing" (Simon, 1957) strategy does not compare and contrast all possible options but chooses the first that reaches a threshold of acceptance. As time, complexity, and the number of participants increase, it is more likely that the classical "analytical" decision making strategy will be employed. This involves comparing and contrasting the various options and selecting the one with the highest (subjective) utility. In a C2 environment, this strategy is particularly relevant to situation assessment and the generation of operational plans. Analytic decision making involves a logical sequence of actions which, in team decision making, include: (1) specifying the number of viable options and the various criteria that will be used to evaluate these options; (2) having participants collect decision-relevant information items for each option, (3) subjectively evaluating each of these items in terms of impact, importance, timeliness, etc. to (4) assess the resulting viability of each option and (5) make a final overall option selection (6) which is then exchanged with other team members to help in conflict resolution and the reaching of a group consensus recommendation.

The final four processes described above all involve highly subjective assessments. In a hostage rescue situation, for example, if one option is to use a SEAL team but they would arrive 12 hours later than any of the other options, how does one assess that information item? How negative is the impact? How important is this item compared to other information about the SEAL team? The subjective assessments about this individual item will vary from one team participant to another. Once the pool of SEAL information items has been completed, the team member then has to form an overall composite assessment of the SEAL option based on this grouped information. That involves the cognitive review and integration of information items that vary in impact, importance, quality, timeliness, etc., adding a further level of subjectivity to the decision process. Thus, the team of decision makers will vary both on how they evaluate each individual decision-relevant information item as well as how they group, weigh and assess the pool of items in the final recommendation. These differing assessments need to be exchanged and discussed by the team in order to reach a consensus opinion.

This report introduces a computer-based decision support tool that specifically addresses the issues of creating, displaying, evaluating and exchanging the subjective assessments that team members have attached to each item in their pool of decision-relevant information.

The Electronic Card Wall /Decision Constructs in a Distributed Environment (EWall/DCODE) Software Package

The Electronic Card Wall (EWall) is a software program designed by MIT. The objective of the EWall Project is to "investigate human sense-making activities with a focus on social interactions that improve the ways in which humans comprehend and share information. The objective of the EWall Application is the development of a flexible computational framework for the support of individual and collective human sense-making activities (Computer Supported Sense-Making). The EWall Application does not present a comprehensive solution for the support of all sense-making activities but offers a series of independent mechanisms for a variety of possible applications." One of those independent mechanisms is the Decision Making Constructs in the Distributed Environment (DCODE) program, which originated at SPAWAR, San Diego. The basic concept in EWall is the information card, shown in Figure 1. The information card can be either manually or automatically created within the EWall workspace, and displays a number of parameters about the information. As Figure 1 indicates, there is a high degree of flexibility in the configuration of an EWall card. The DCODE component is the small, three-horizontal-box, color-coded icon shown in each card.

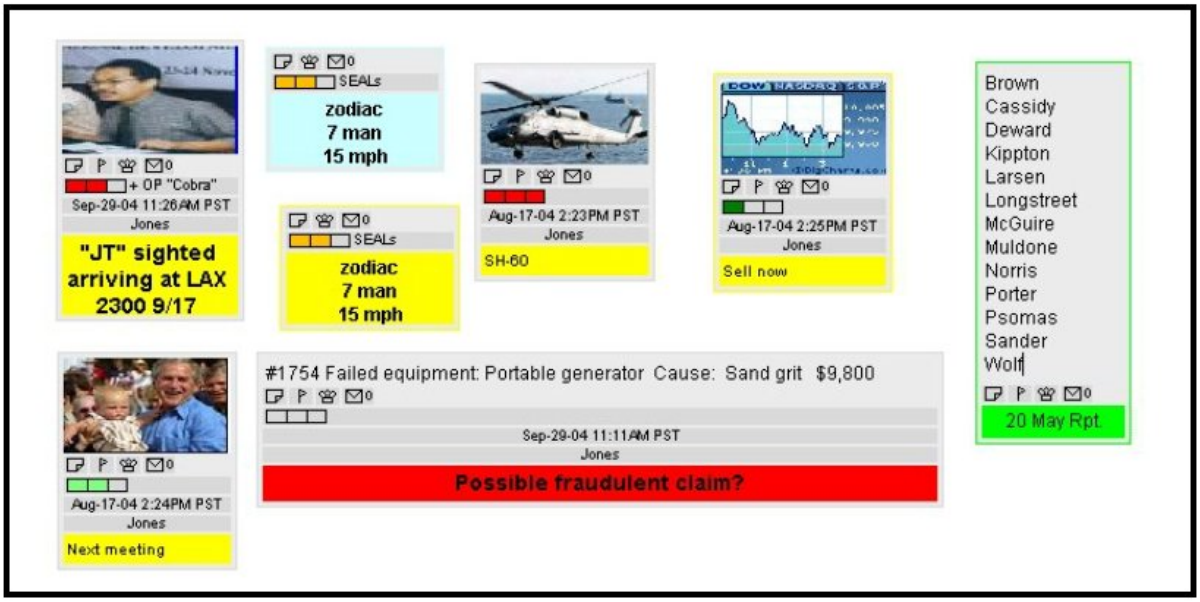

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Figure 1. Sample configurations for EWall cards

Figure 2 depicts an EWall information card that we might wish to use in selecting how to handle a hostage rescue situation, where one of the options is using a SEAL team. We can see that while the card has information about the use of SEALS, the information has not been subjectively *evaluated* by a decision maker. Is this information positive or negative regarding the SEAL option? How important is this information? What about the quality and timeliness of the information? The card has no information regarding its IMPACT on using the SEALS, which can only come from a subjective cognitive assessment by one (or more) of the decision makers.

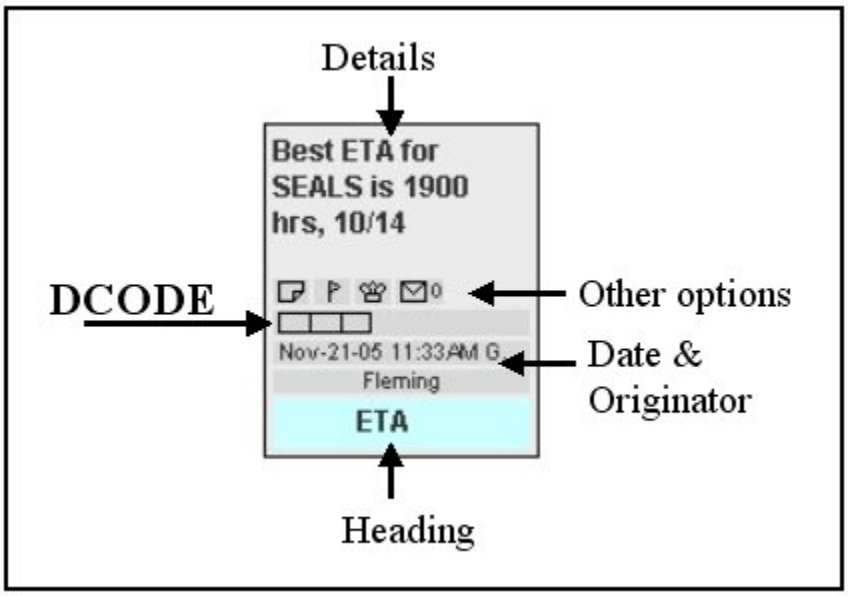

Figure 2. EWall information card

The DCODE Assessment Template

If a decision maker clicks on the 3-box DCODE icon, he would be given the display shown in left-hand area of Figure 3.

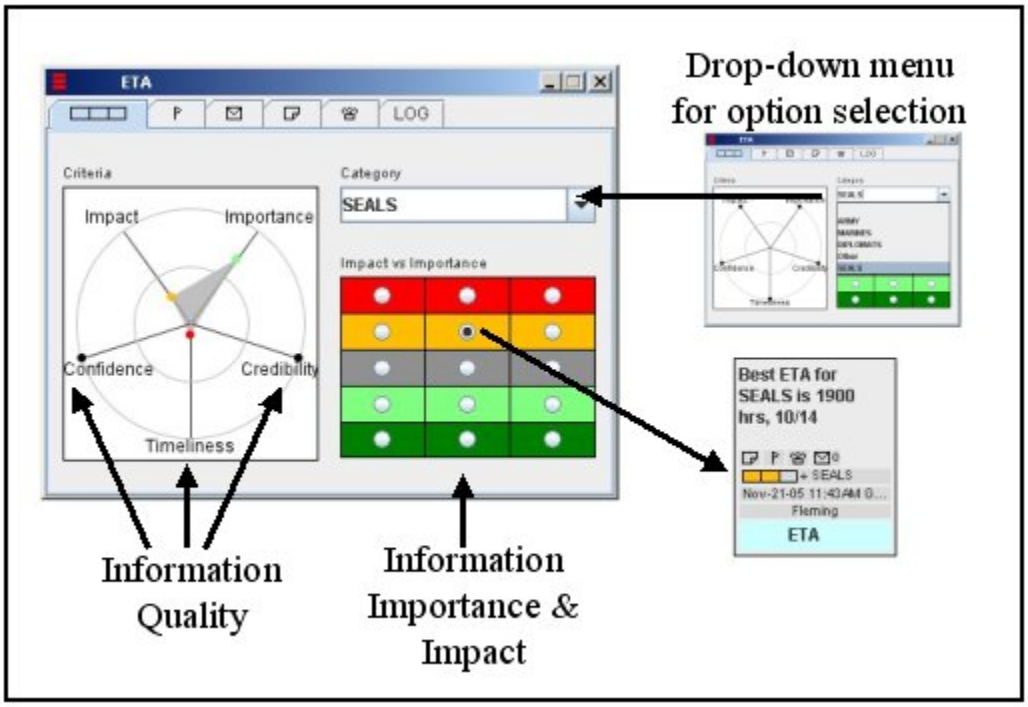

Figure 3. The DCODE Assessment Template

The display has a "Category" area where the user has a drop-down menu to select the decision option (category) to which this particular information item relates. In this instance, he has selected "SEALS" from the option list that includes "ARMY", "MARINES", "DIPLOMATS" and "OTHER". He also has three "slider-bars" on the left to indicate the Information Quality. These can be used to specify information about the Credibility, Timeliness and Confidence he has in the information. If any slider bar is moved off the outer rim, a "+" appears in the DCODE area of the card, next to the option name, and indicates that there is some more amplifying information that the user has specified about the quality of the information. If the DCODE 3-box icon is clicked on later it will display the Quality settings that have been selected. In this case the user has some question about the timeliness of this information.

Of primary importance is the information assessment area where the user can specify both the importance and impact (positive or negative) of this information on the selected option. An expansion of this area is shown in Figure 4. The horizontal axis is used to specify the importance of the item at one of three levels, "Average", "High" or "Very High" importance. The three levels relate to how many of the boxes in the DCODE 3-box icon are color-coded. One box filled indicates Average importance, all three boxes filled indicates Very High importance. The vertical color-coded axis specifies the impact that this item has on the viability of the selected option. There are four levels: Very Negative (Red); Negative (Yellow); Neutral (Gray); Positive (Light Green); and Very Positive (Dark Green). An impact example might be that if an item indicated that using Option A would deplete 10% of your resources it might be assessed as having a "Negative" impact on Option A, whereas if the indication was a 40% depletion it might be assessed as being "Very Negative". In the example shown in Figure 4, it can be seen that the user has assessed the information as being "Negative" and of "High" importance (i.e., two yellow boxes).

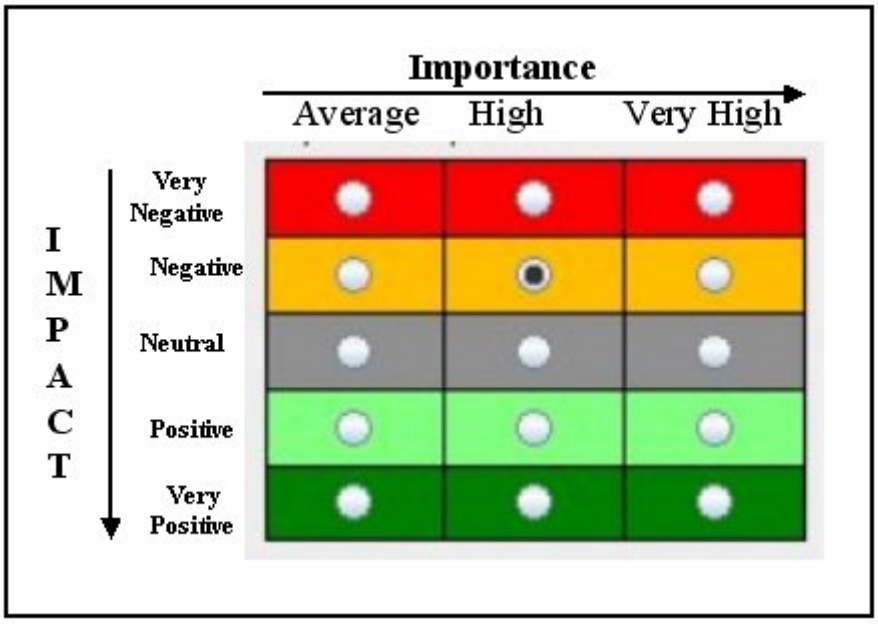

Figure 4. The DCODE Importance/Impact Assessment Display

If we look back at the EWall card in Figure 3, we can now interpret the card as indicating that the SEALS (option) will not arrive until 1900 hrs (details), and that information was assessed on Nov 21 (timeline) by Fleming (originator) as being of High importance and having a Negative impact on using the SEALS for this operation (two boxes color-coded yellow), although he has some question about the timeliness of this information (the "+"). When the DCODE assessment portion of an EWall card has been completed, the completed card is referred to as an Information Object (IOB). This comparison is shown in Figure 5.

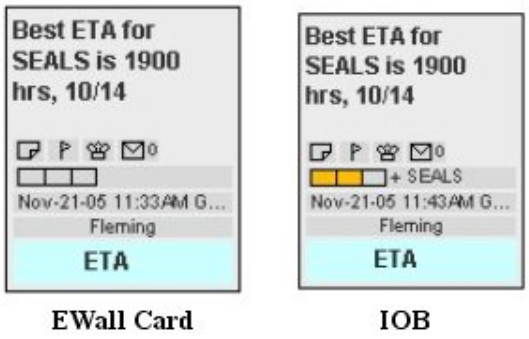

Figure 5. An EWall card, compared with an Information Object (IOB) showing Category, Impact, Importance and Quality

As the user continues to collect decision-relevant information, the number of IOBs will increase. Figure 6 shows a configuration of 24 IOBs, twelve of which are related to the use of the SEAL option, and twelve that relate to the Army option. Here, the format of the cards has been modified, to save space as well as to better highlight the DCODE function.

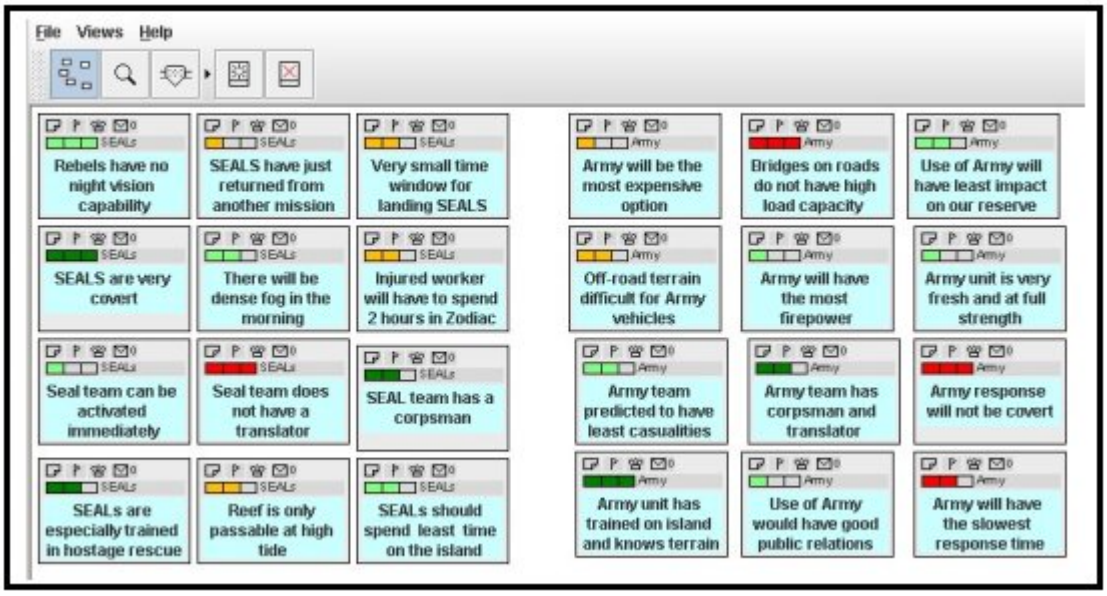

Figure 6. A completed set of IOBs, twelve related to the SEAL option and twelve related to the Army option.

Use and Display of the DCODE Sorting/Analysis Results

Examination of Figure 6 does not give any type of clear-cut indication as to which might be the preferred option. This is primarily due to fact that the IOBs are in an unsorted format (i.e., they are displayed in the manner in which the originator created them) without any prioritization of the Importance or Impact information.

DCODE does have the options of automatically sorting on a variety of parameters. These sorting options are displayed on the top of the DCODE workspace, and are shown in Figure 7.

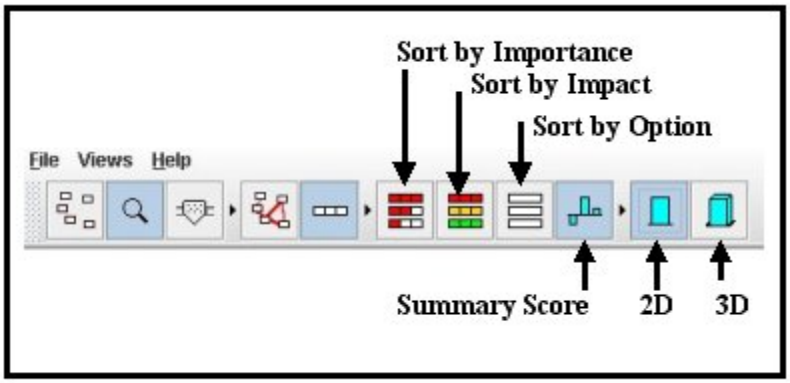

Figure 7. DCODE sorting option display

If the IOBs are intermixed, the user can click the "Sort by Option" button, which will group all the IOBs for one option into a 3-column configuration. He can then sort these grouped IOBs by clicking on either "Importance" or "Impact". If he selects "Importance", the algorithm will first display the "Very High" importance items (i.e. 3-boxes), followed by the "High" importance items (2-boxes) and finishing with the "Average" importance (1-box) items. If there are more that one IOB at any importance level, these IOBs with equal importance are then sorted by Impact, starting from "Very Positive" and going to "Very Negative". An example of this type of sort is shown in Figure 7.

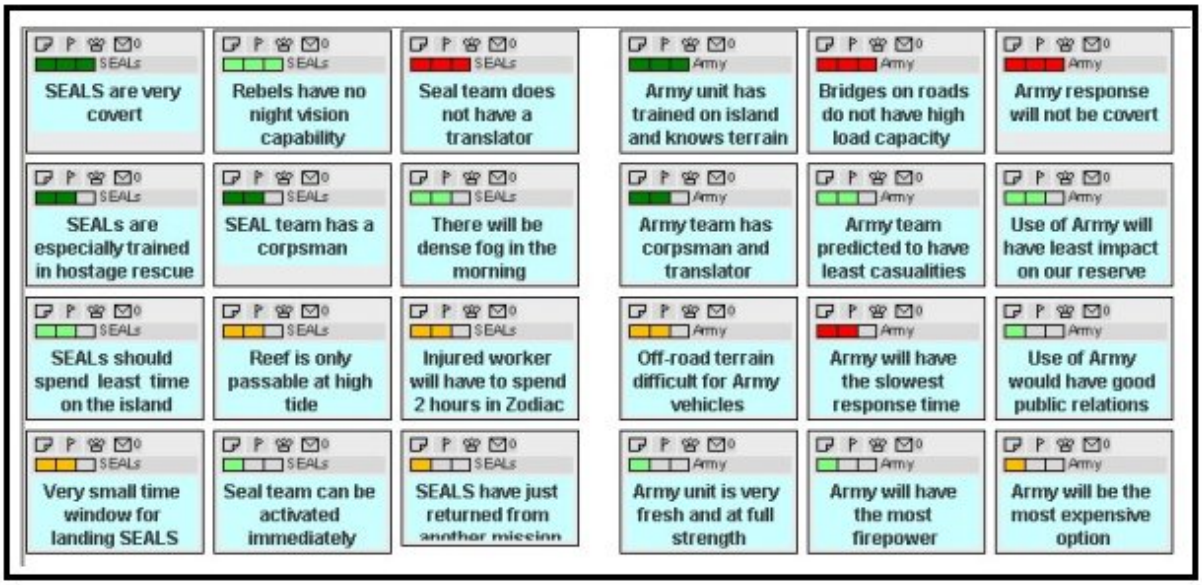

Figure 8. Sorting by Option and then Sorting by **Importance.**

Figure 8 shows the other alternative, i.e. sorting by Impact, where the "Very Positive" (dark green) IOBs are displayed first, followed by the "Positive" items (light green), then the "Negative" items (yellow), and finally by the "Very Negative" items. If there are more than one IOB at any Impact level, that group of IOBs are then further sorted from "Very High" importance to "High" importance and then by "Average" importance. Since participants may not use the exact same pool of information items, these are not item-be-item sorting comparisons but rather a "preponderance/scan" of assessed Impact and Importance. Item-by-item sorting is a future enhancement.

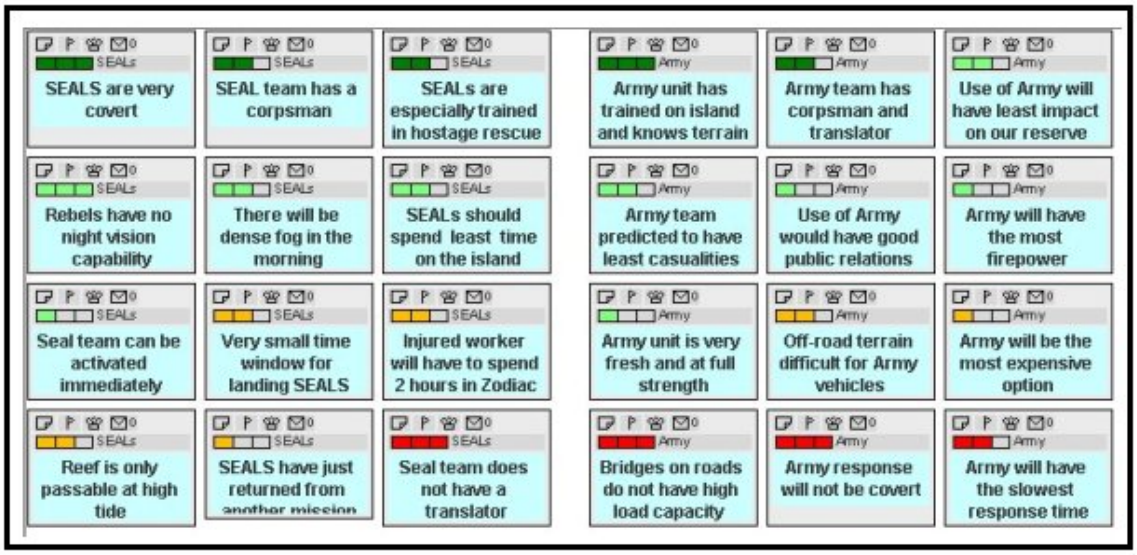

Figure 9. Sorting by Option and then Sorting by **Impact.**

Examination of Figures 7 and 8 gives a clearer perception of the overall viability of each option, as reflected in the assigned subjective assessments of Importance and Impact. There appears to be a preponderance of important, positive information for the SEAL option while the Army option has a number of important, and negative indicators. In order to better quantify the overall integration of this pool of IOB assessments, DCODE also offers a "Summary Score" option.

To calculate Summary Score, DCODE uses a weighting matrix to assign a score to each of the 12 Importance/Impact assessment pairs (all pairs for the "gray", middle color line are assigned a zero). The weightings currently used are arbitrary and function as the default condition. A future enhancement will enable participants to modify any of the weightings. An Impact assessment of "Very Negative" (Red) is assigned a score of –2, and assessment of "Negative" (yellow) is assigned –1, "Positive" (light green) is assigned +1 and "Very Positive" (dark green) is scored as +2. This score is then multiplied by the Importance assessment, with "Average" importance being a x1 multiplier, ""High" importance being a x2 multiplier and "Very High" importance being a x3 multiplier of the Impact score. Thus ever IOB has an assessment score that ranges from +6 to –6. An example of the weighting matrix is shown in Figure 10.

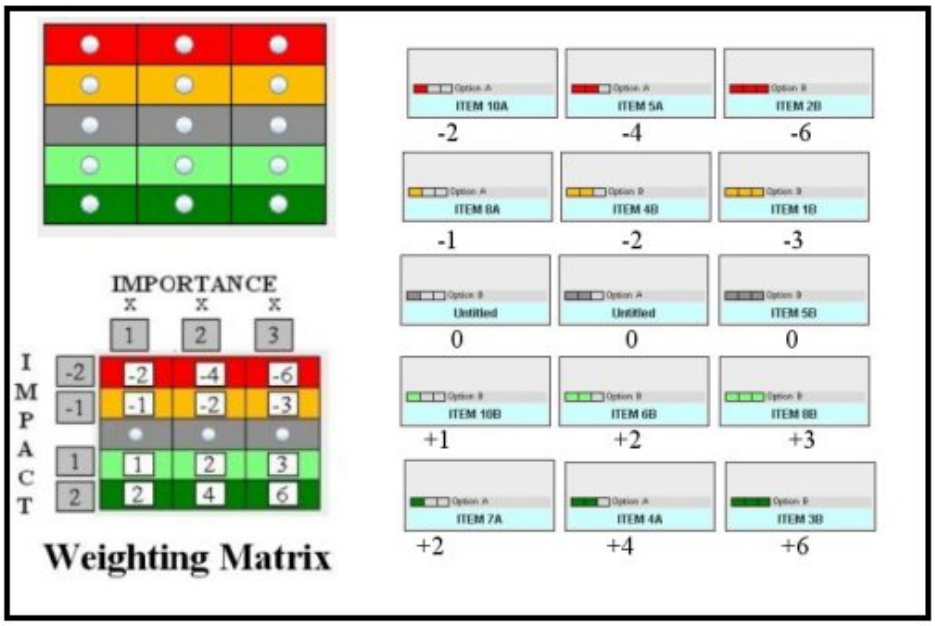

Figure 10. The DCODE weighting Matrix for Importance/Impact Assessment

When the "Summary Score" button is clicked, DCODE calculates the Importance/Impact score for each IOB, and algebraically sums all the scores for each option. The results are displayed as either a 2D or 3D bar chart. The Summary Scores for the IOBs used in Figures 8 and 9 are shown in Figure 11. Based on the DCODE weighting matrix parameters, it can be clearly seen that the SEALS are the superior option.

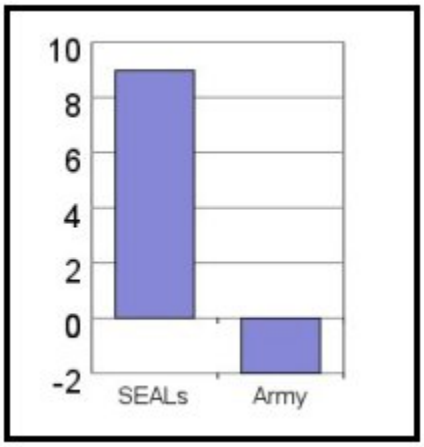

Figure 11. DCODE Summary Scores for SEALS and Army IOBs

Other than the limiting factor of display area considerations, there is no limit to the number of decision options that can be used in a DCODE analysis. Figure 12 shows a hypothetical Summary Score result (using the 3D bar graph) for a 5-option decision task.

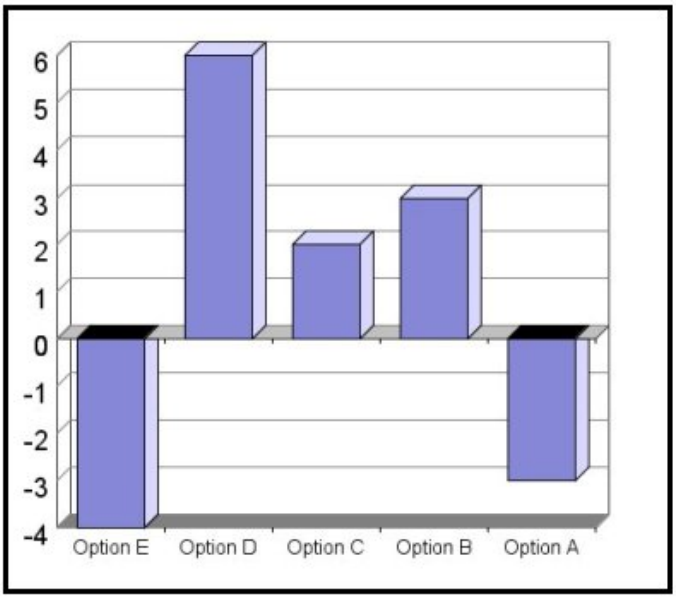

Figure 12. Sample DCODE Summary Score analysis for five decision options.

DCODE use in Distributed Group Decision Making

Much of military decision making has become a team effort, where participants may be distributed by both geography and time. To assist in this team decision making process, DCODE has a feature where each team member can see and interact with the IOBs created the other team members. Each team member activates and logs on to an EWall Exchange Server. The user then has the option of adding the Exchange Server display to his primary computer display area, which would then include his own DCODE workspace plus the Exchange view. An example of this exchange view is shown in Figure 13.

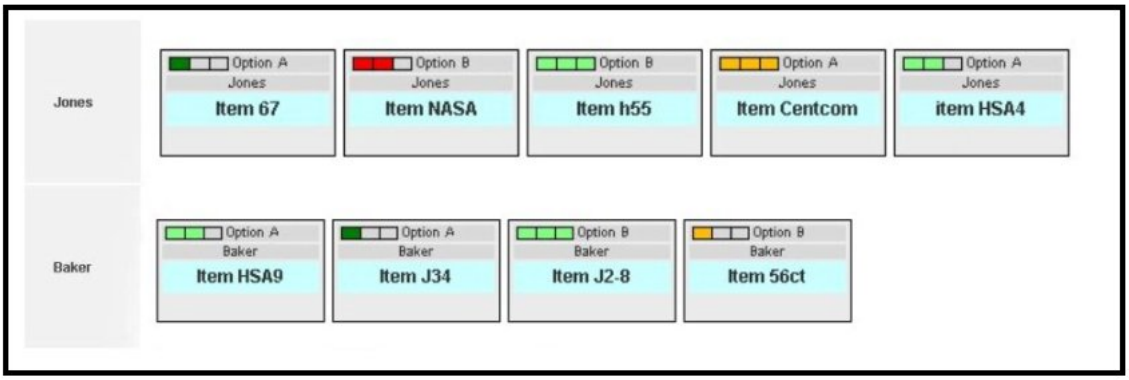

Figure 13. Exchange Server display window of IOBs from other team participants.

Here we have a 3-person decision making team, Smith, Jones and Baker. We are looking at the Exchange view created by Smith, which shows the IOBs created by the other two members of the team, Jones and Baker. Jones has created five IOBs, three for Option A, and two for Option B. Baker has created four IOBs, two for each option. If Smith wishes, he can "click and drag" any of these IOBs into his own DCODE workspace. At that point, he can either accept the IOB "as is" or take control of the IOB (i.e. become the "author") and modify any of the other user's assessments to better meet his own personal assessments about this specific item of information. He can also exchange comments with the originator of any of the IOBs. When he opens the comments box on an IOB he has dragged from the Exchange display,

he enters the comment and clicks "Enter". This causes a red flag illuminates on the IOB in the originator's DCODE workspace. The red flag tells the originator that one of the participants has either requested more information or has made a comment about his IOB. When he responds, his flag turns green and the requester gets a red flag on the IOB in his workspace indicating that he has an unread response to his comment.

This exchange of IOBs and comments is a very effective methodology for reducing the problems of unshared information in a group decision making task (see Stasser, 1999 or Fleming and Kaiwi, 2002, for a recent review) as well as enhancing conflict resolution and the building of a team consensus. The major DCODE advantages are that by comparing the varying assessments on the IOBs (1) each member is aware of all the available decision relevant information items and (2) the team can quickly locate and focus discussion on that small group of IOBs that represent the major areas of disagreement, i.e. have strong differing assessments of Importance and Impact. Combine this with the ability of each decision making to quantitatively assess his overall information pool using the Summary Score option, and we have a very effective decision support tool for both individual and group decision making tasks.

Previous research on earlier versions of the DCODE concept (Fleming 2003; Fleming and Cowen, 2004; Cowen and Fleming 2004) has indicated that the display of quantified subjective information assessments does improve the quality of the decisions and is rated as a strong preference by users. Further research is scheduled for later in 2006.

C2 and Intelligence Application Areas

The previous discussion has shown how the DCODE process can be used in the traditional C2 decision area of course of action (COA) selection. It is exceptionally well suited when multiple COAs are available, and the user is faced with the question of "Which one?" It is also highly useful in intelligence gathering and situation assessment, where the decision is more in the form of "Yes-NO" or "Respond-Don't Respond".

Consider an intelligence team that has been asked to determine "Is Carlos still in Columbia?" Figure 14 shows some IOBs that they might have collected during their task. They assumed that if Carlos had left Columbia, there would be some unusual activity in his money accounts. Since they have not seen any unusual activity, they interpret this as being of High Importance and a Very Positive (2 dark green boxes) indicator that Carlos is still in Columbia. Conversely, there is a photo from surveillance at Madrid airport that appears to be Carlos so this is scored as a negative indicator that Carlos is in Columbia. However, since the picture is not that clear, they have a question about the quality of the information, and have activated the "+" on the DCODE line to indicate this concern. The gray color on the "Family" card indicates that they think this is useful information, but have not yet determined whether it is a positive or negative indicator. They will return and complete this item later when they have better assessed the information. The Summary Score (-3) analysis, to the right of the IOBs, indicates that an integration of this current, and conflicting, pool of information (6 items) shows that there is an overall negative assessment to the question of whether Carlos is still in Columbia.

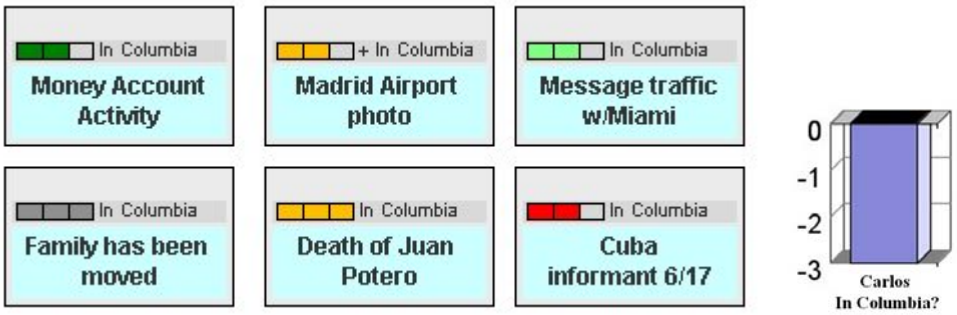

Figure 14. IOBs and Summary score for question "Is Carlos still in Columbia?"

Future Enhancements

There are a number of display/color/size modifications that we are considering, however the two major enhancements we propose relate to the use of the Summary Score analysis.

Figure 14 shows a set of IOBs for two options. The summary score for both is the exact same (-6), but it is clear there is a far different distribution of scores that contribute to each total, indeed Option B has only one score while Option A has six separate IOBs contributing to the total. We propose that the Summary Score bar chart also include a frequency distribution of the scores contributing to each Option total. This would enable the user to quickly determine if a large score is the product of many "average" information items or if it is the result of just a few "High" importance items.

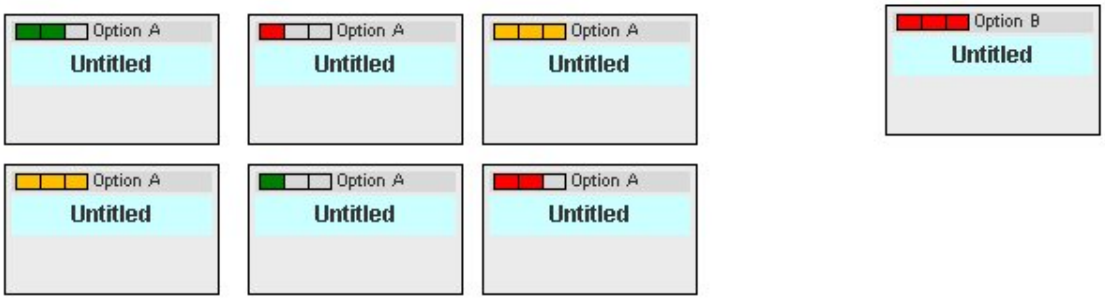

Figure 14. Two sets of IOBs which both have a Summary Score of –6.

As noted earlier, we also feel that the user(s) should have the option of changing the weighting values in the assessment matrix. There is no real "right or wrong" in terms of assigned weighting values, as long as each participant uses the same metrics. The team could agree, at the start, that a "Very Negative" assessment should be assigned a value of –3 or –4 instead of the current default value of –2. Similarly, they may decide that any item assessed as of "Very High Importance" should have a x4 or x5 multiplier instead of the default x3 multiplier. This gives the user/team much greater flexibility in dictating how the various IOBs should be integrated into a summary score. Additionally, user feedback has questioned the independence of the Impact and Importance parameters. For example, a number of users have indicated that the combination of Average Importance and a Very Negative impact simply did not make sense and would not be used. Future research will address the this issue and the granularity needed for each type of assessment.

A sample of how this modified Summary Score analysis might be displayed is shown in Figure 15. On the left, the current settings for the weighting matrix are displayed and can be modified by the user. In the middle are the requested Summary Analysis results and on the right side is the distribution of scores that contributed to the summary.

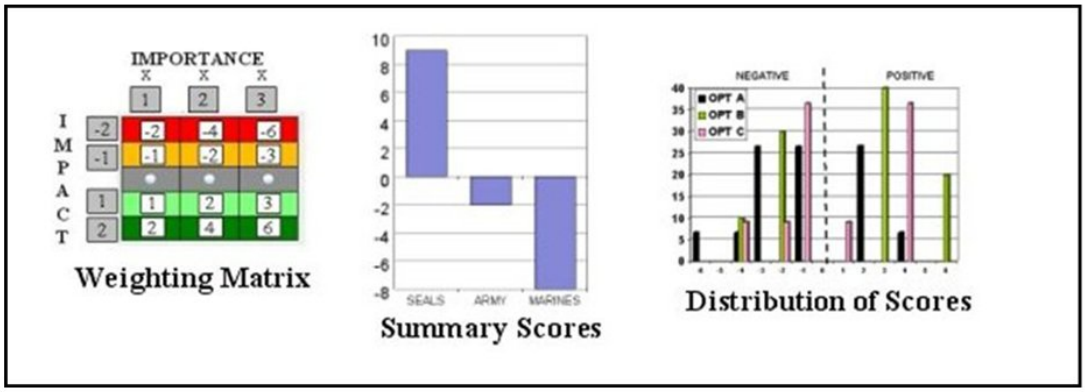

Figure 15. Proposed new Summary Score analysis display.

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