

## **Quantification of Subjective Information Assessments in C2 Decision Option Selection**

**Michael B. Cowen**

SPAWAR Systems Center

Code 246205

53560 Hull Street

San Diego, CA 92152

619.553.8004

[mike.cowen@navy.mil](mailto:mike.cowen@navy.mil)

**Robert A. Fleming**

Red-INC.

48015-2 Pine Hill Run Rd.

Lexington Park, MD 20653

619.429.7554

[bobfleming@gmail.com](mailto:bobfleming@gmail.com)

Primary POC: Michael Cowen

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## Quantification of Subjective Information Assessments in C2 Decision Option Selection

Michael B. Cowen  
Robert A. Fleming

### 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 (Zsombok 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.

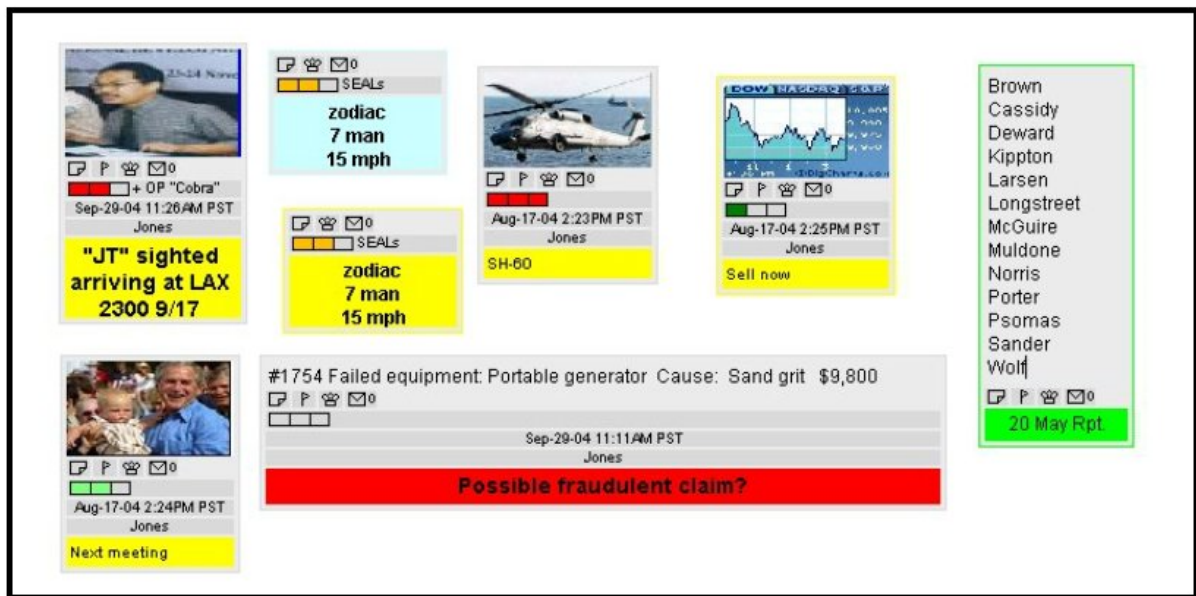


Figure 1. Sample configurations for EWall cards

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.

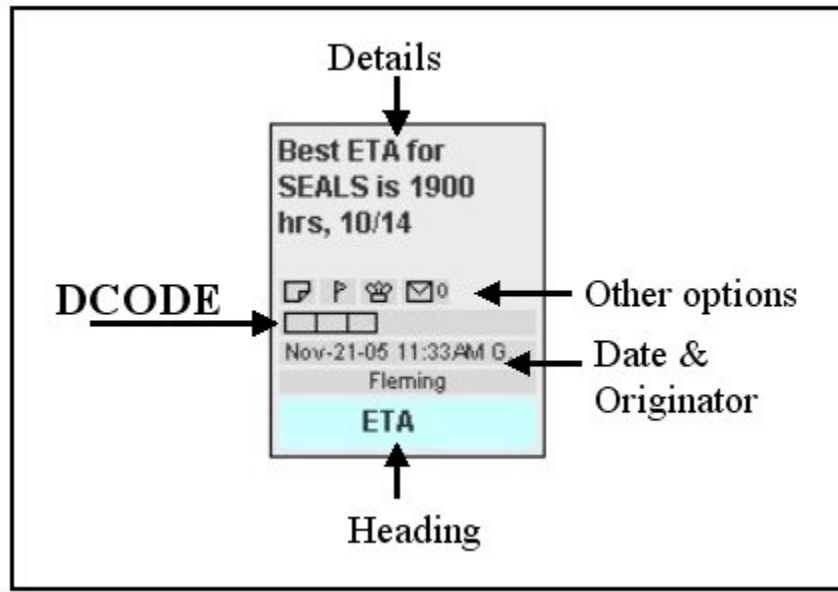


Figure 2. EWall information card

### 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.

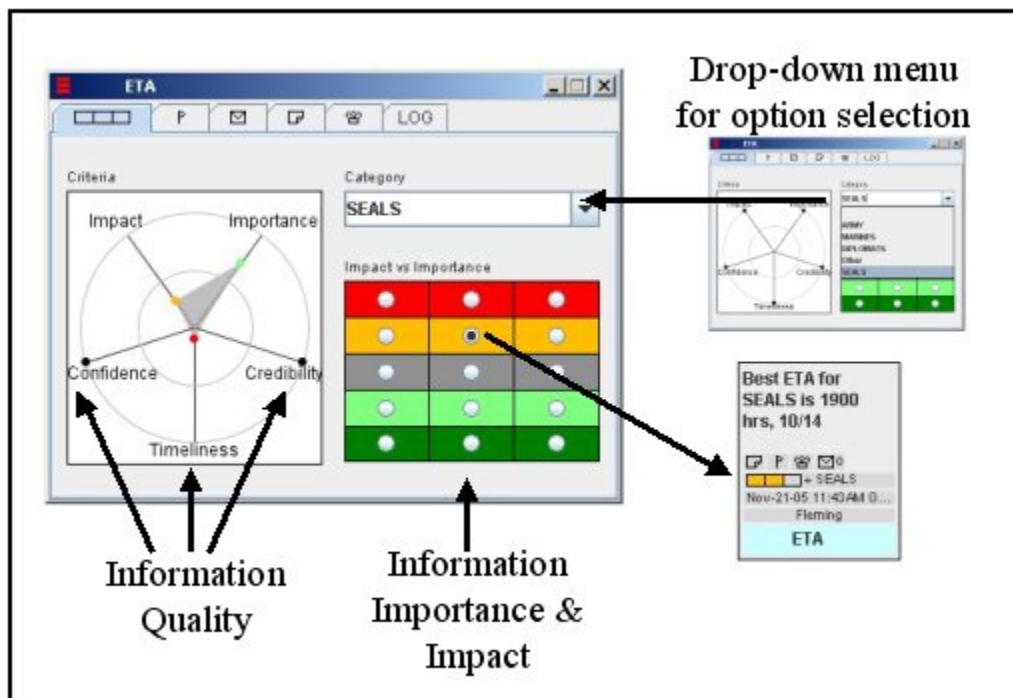


Figure 3. The DCODE Assessment Template

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).

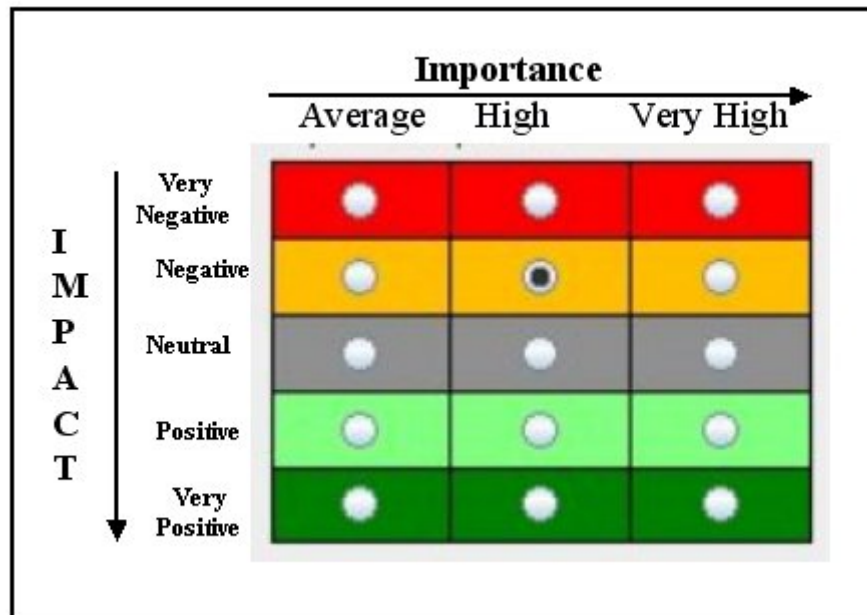


Figure 4. The DCODE Importance/Impact Assessment Display

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.

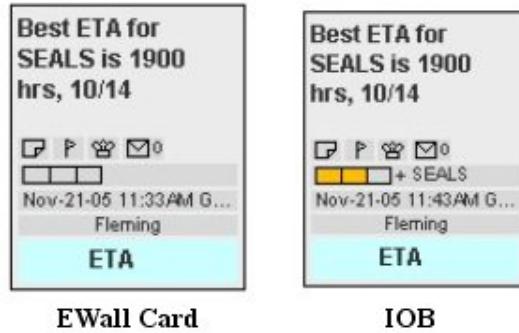


Figure 5. An EWall card, compared with an Information Object (IOB) showing Category, Impact, Importance and Quality

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.

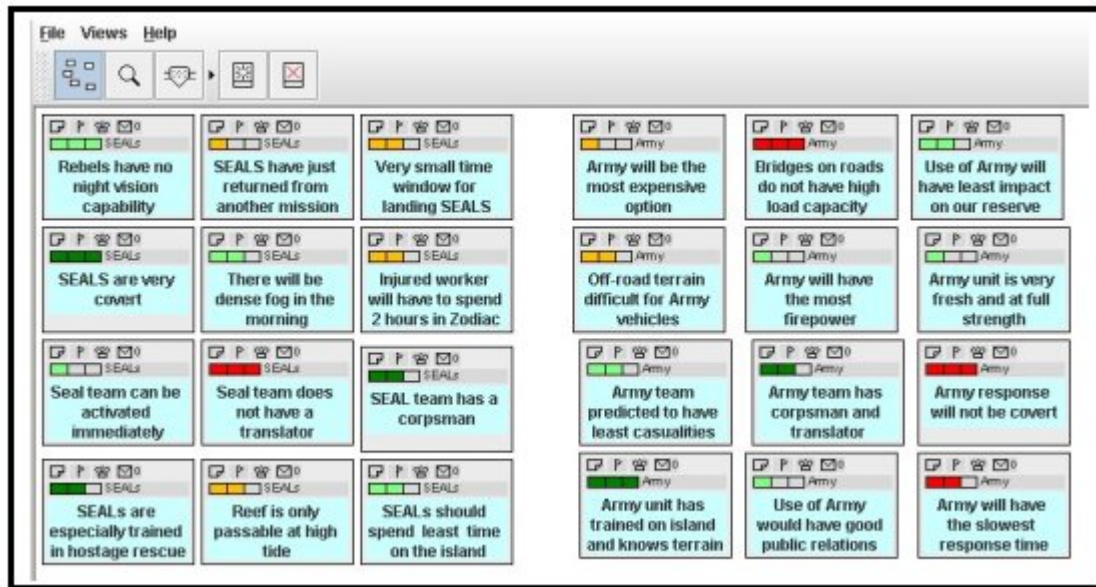


Figure 6. A completed set of IOBs, twelve related to the SEAL option and twelve related to the Army option.

### 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.



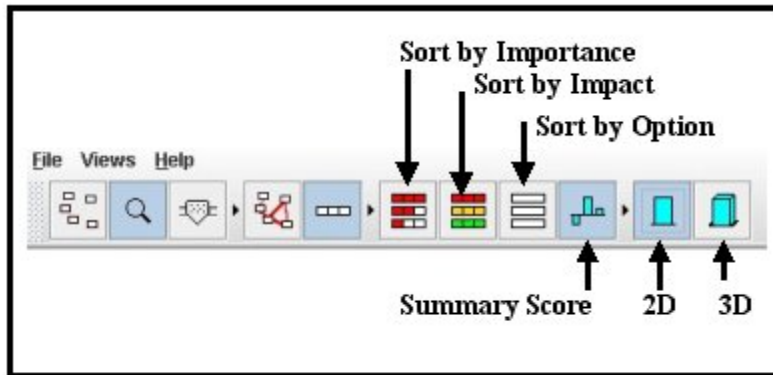


Figure 7. DCODE sorting option display

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 than 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.

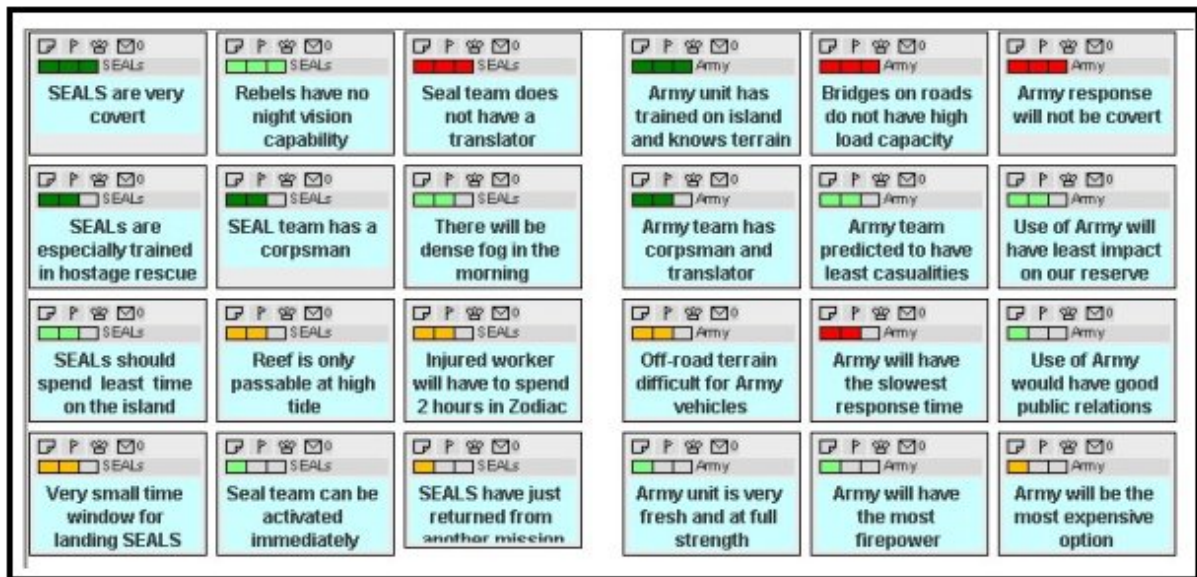


Figure 8. Sorting by Option and then Sorting by **Importance**.

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-by-item sorting comparisons but rather a “preponderance/scan” of assessed Impact and Importance. Item-by-item sorting is a future enhancement.



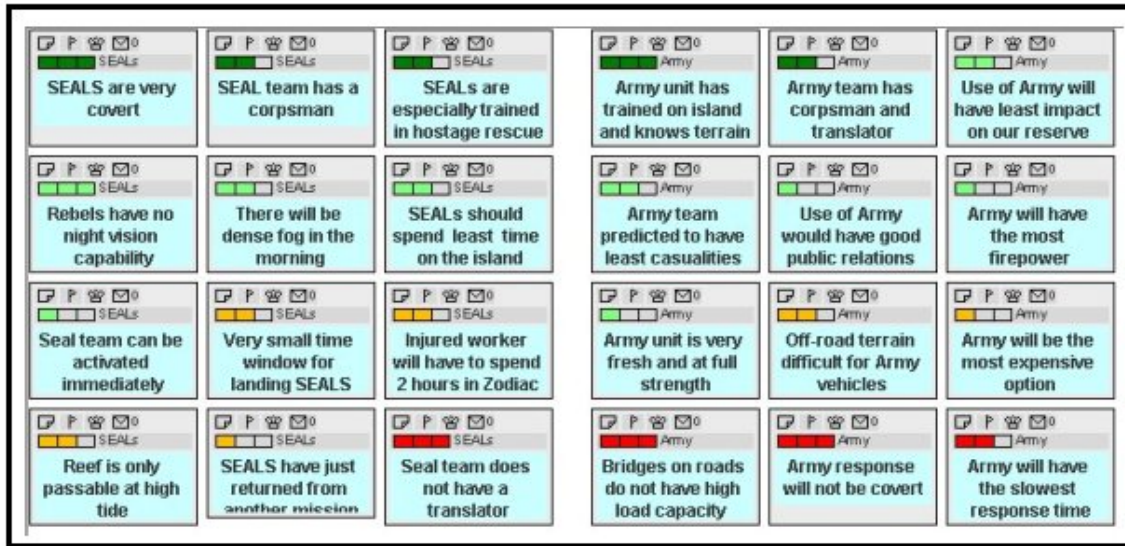


Figure 9. Sorting by Option and then Sorting by **Impact**.

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 every IOB has an assessment score that ranges from +6 to -6. An example of the weighting matrix is shown in Figure 10.

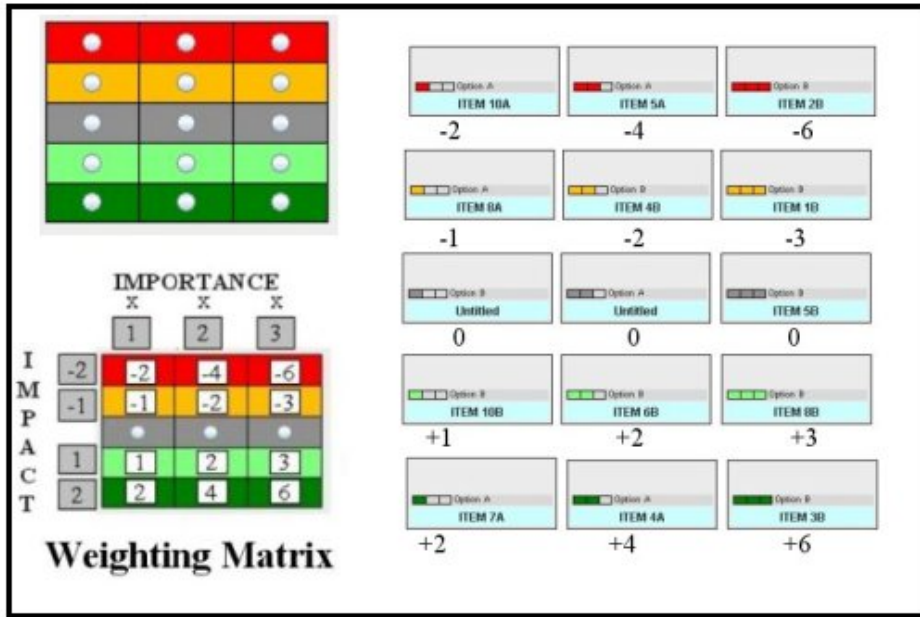


Figure 10. The DCODE weighting Matrix for Importance/Impact Assessment

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.

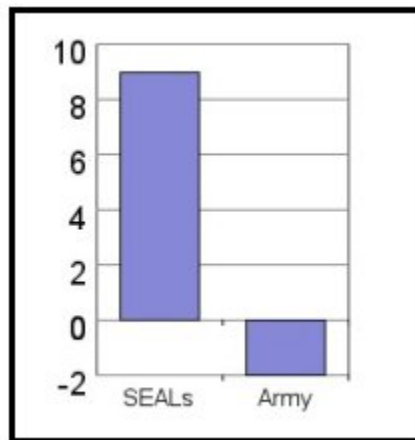


Figure 11. DCODE Summary Scores for SEALS and Army IOBs

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.

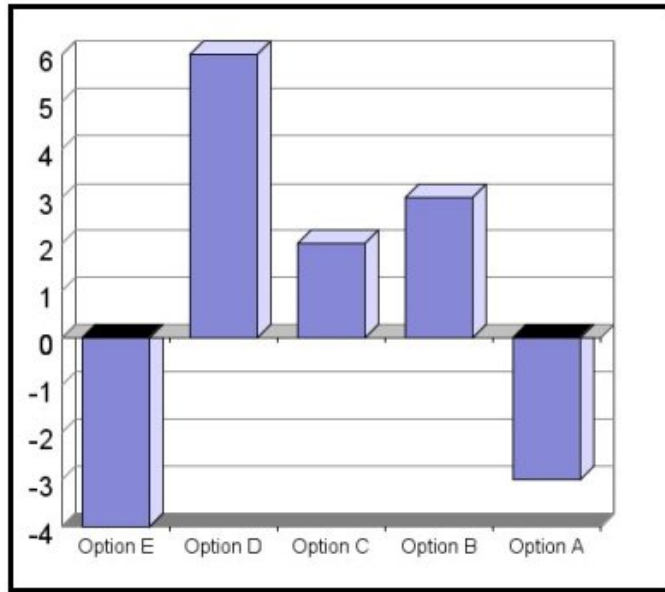


Figure 12. Sample DCODE Summary Score analysis for five decision options.

### 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.

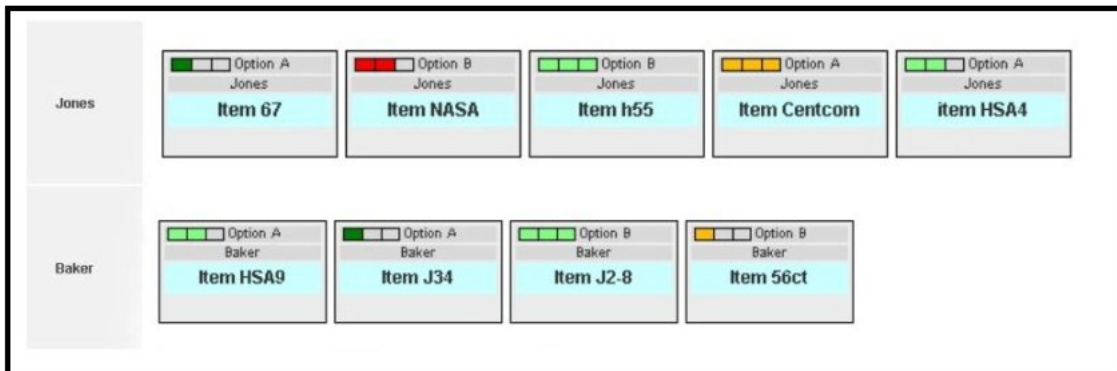


Figure 13. Exchange Server display window of IOBs from other team participants.

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.

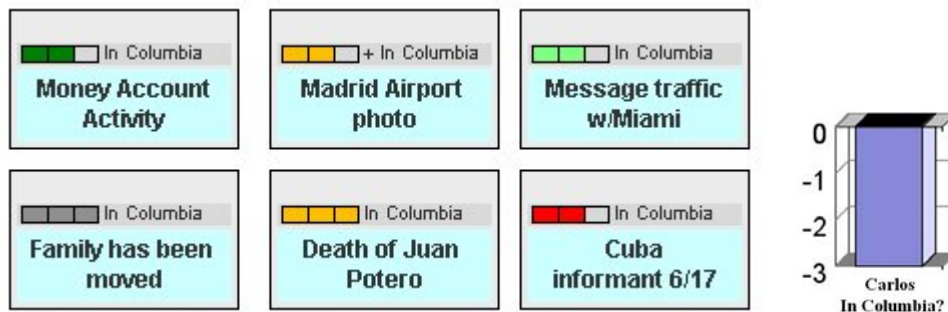


Figure 14. IOBs and Summary score for question “Is Carlos still in Columbia?”

## 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.

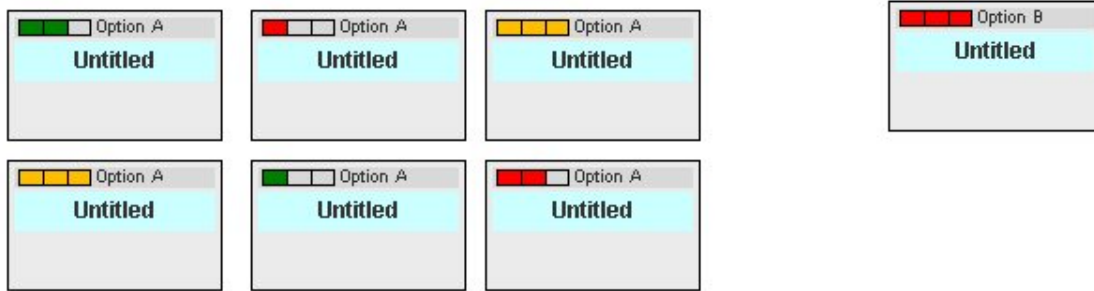


Figure 14. Two sets of IOBs which both have a Summary Score of -6.

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 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.

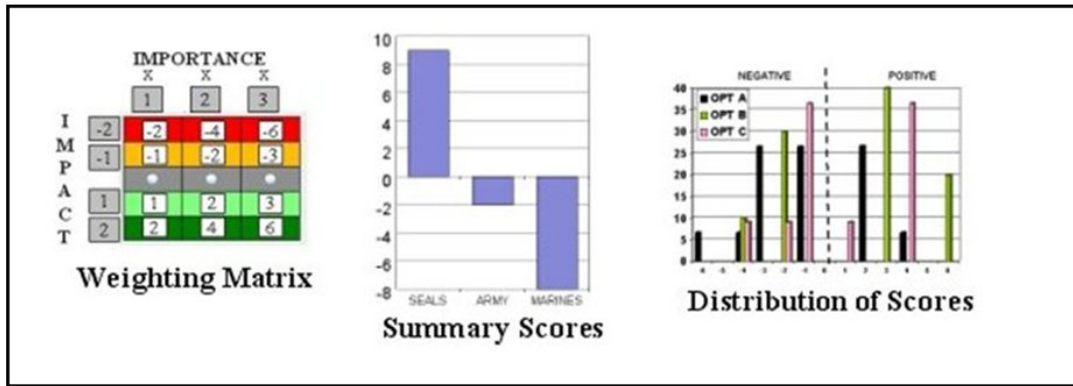


Figure 15. Proposed new Summary Score analysis display.

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# **Quantification of subjective information assessments in C2 decision option selection**

Dr. Mike Cowen  
SPAWAR Systems Center, San Diego  
619-553-8004  
[mike.cowen@navy.mil](mailto:mike.cowen@navy.mil)

Dr. Robert Fleming  
Red-INC.  
48015-2 Pine Hill Run Rd.  
Lexington Park, MD 20653  
[bobfleming@gmail.com](mailto:bobfleming@gmail.com)



# BACKGROUND

- **In the past...**
  - **a major cause for a lack of consensus in a group decision making task was that all participants did not have the same information.**
- **Today...**
  - **A major cause is differing subjective assessments (importance, impact) of the same information.**
    - **Particularly true in multicultural/coalition groups**
- **Decision Making Constructs in a Distributed Environment (DCODE) is a decision support system for the elicitation, display, sharing and comparison of individual subjective information assessments.**



# Decision Making Constructs in a Distributed Environment (DCODE)

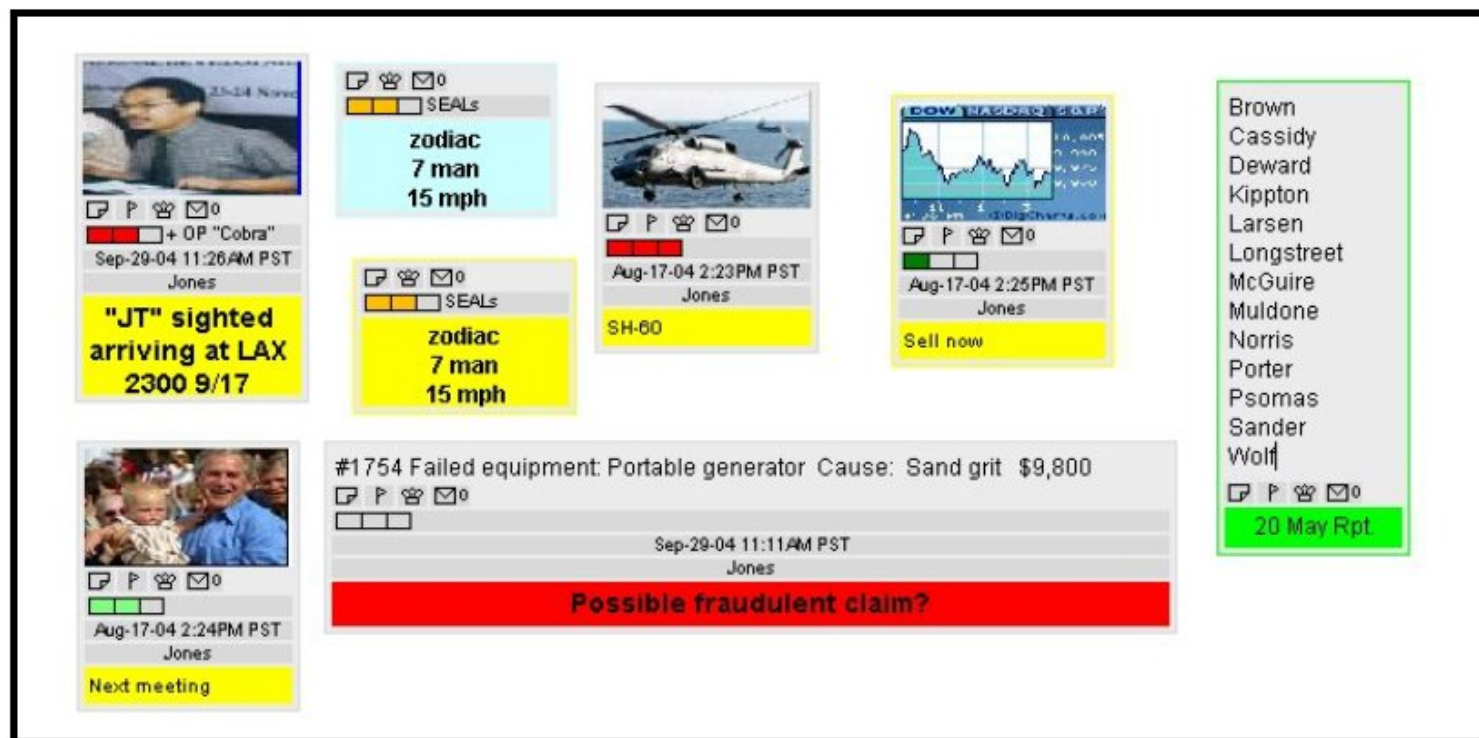
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**DCODE is a component of MIT's Electronic Card Wall (EWall) project, and has been developed by SPAWAR Systems Center in San Diego.**

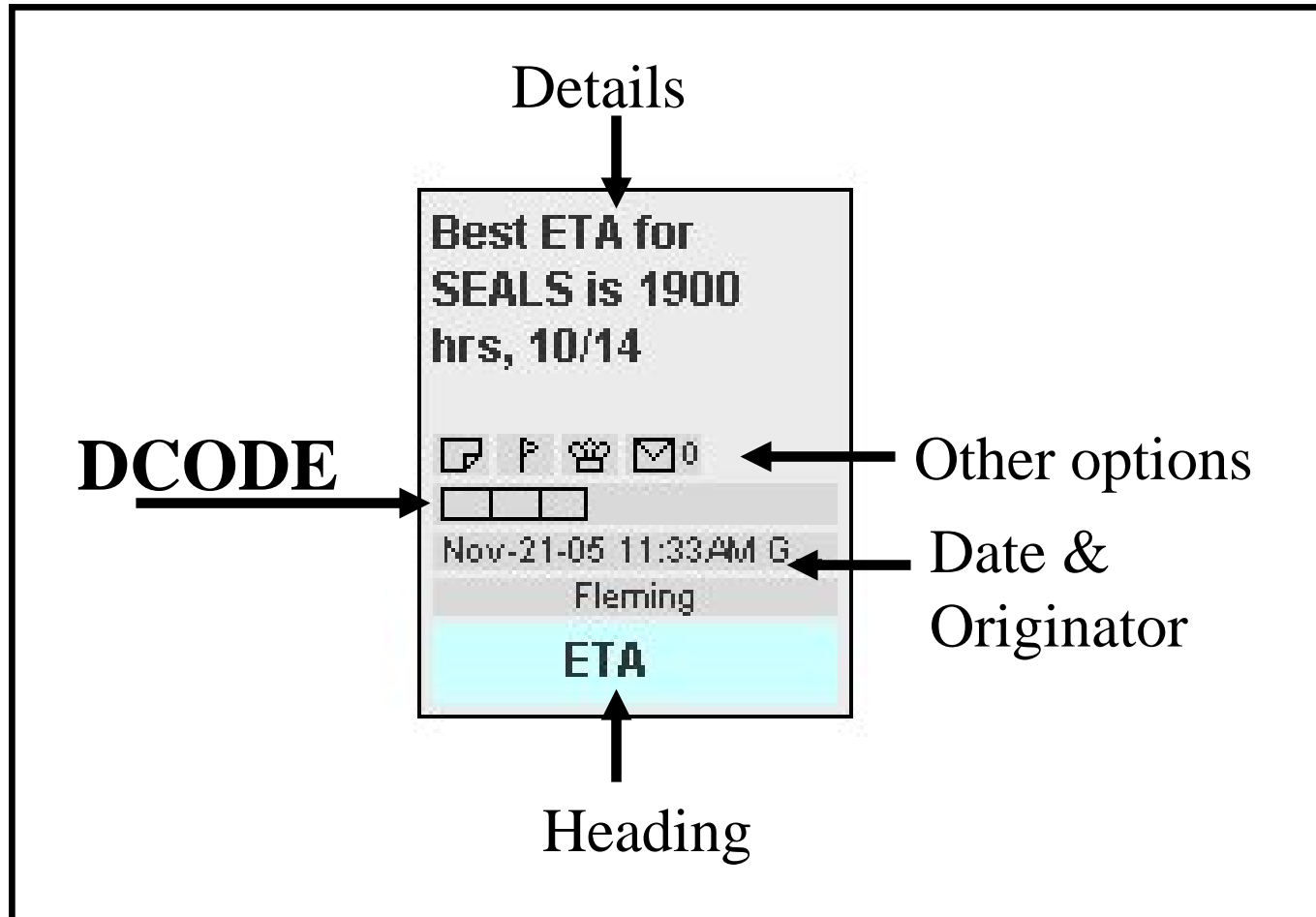
**DCODE Overall Objective: the development of a decision support tool for reducing the problems involved with the storing, sharing and integration of subjective information assessments.**

**The use of DCODE in the quantification and sharing of these subjective assessments can improve the quality of group decision making and significantly reduce the time devoted to conflict resolution and team consensus building.**

EWall cards are small iconic representations of relevant information items and include a series of information parameters. They can be configured in a variety of formats.

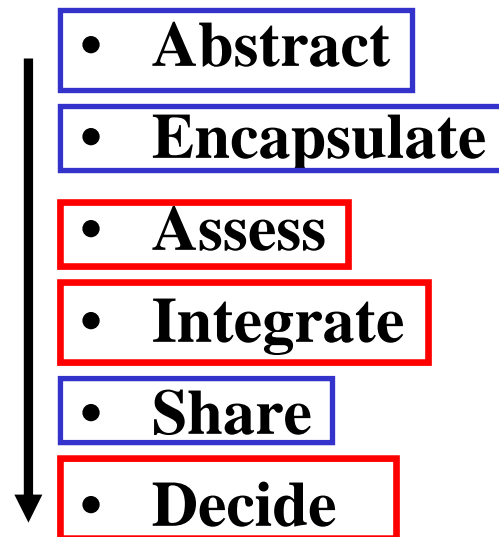


# EWall Card



# DCODE Process

**The use of DCODE as a decision support tool involves the following sequential process for each decision relevant information item:**



 EWall processes

 DCODE processes





# Information Abstraction and Encapsulation

**Mission:** Rescue hostages from Islandia  
**Decision Options:** Marines; SEALs; Army  
**Factors:** Speed (ETA), Covertness, Risk, etc

CINCPAC email

To: LTCJohnson@cincpac.mil  
From: steve.thomas@noaa.gov  
Subject: Islandia tides and currents

Hello LTC Johnson

I have been looking at detailed marine charts of Islandia's reef system. Based on this analysis I would say that only one small section of the reef (coordinate G17) is passable, and then **only at PEAK high tide**. This will next occur at 1700 10/14. The word of caution is that the soundings are over 25 years old and may have changed (either for the better or the worse) regarding ease of crossing.

V/R  
Steve Thomas

**Best ETA for  
SEALS is 1900  
hrs, 10/14**

☐ P ☐ ☐ ☐ 0

☐ ☐ ☐

Nov-21-05 11:33AM G...

Fleming

**ETA**

**Situation Assessment:  
Is Carlos still in Columbia?**

Homeland Security email

To: joseph.donovan@dea.gov  
From: william.kays@omb.gov  
Subject: Re: acct. activity

Mr. Donovan

Fred Barnes in Finance Tracking informs me within the last 10 days, \$27K was deposited in the referenced account (10/7) and \$25K was withdrawn on 10/9. This is unusual activity for this account

V/R  
Bill Kays

Information  
is abstracted,  
encapsulated  
but **NOT**  
Assessed!

**Unusual \$ activity  
in Carlos'  
checking  
account 10/7, 10/9**

☐ P ☐ ☐ ☐ 0

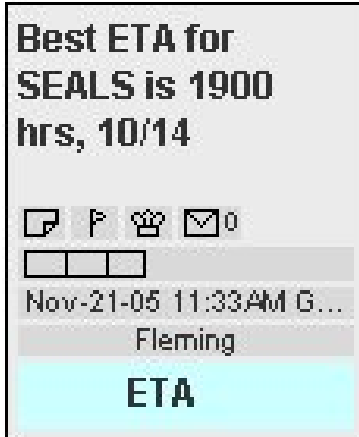
☐ ☐ ☐

Dec-19-05 9:03AM GM...

Fleming

**Money Activity**

# DCODE Information Assessment



**EWall Information Card**

Which option(s) is impacted?  
How is it impacted?  
How important is this item?  
Quality of the information?  
Timely?  
Credible source?  
Well documented?



**Information Object (IOB)**

This DCODE coding  
tells me that this  
information ...

- Negatively impacts the viability  
of the using the SEALS option.
- Is considered of high importance.
- There is some issue with the quality  
of this information.

## DCODE Information Assessment (cont.)

Unusual \$ activity  
in Carlos'  
checking account,  
10/7, 10/9

☐ ☐ ☐ ☐ ☐ 0

☐ ☐ ☐ in Columbia

Money Activity

Every time Carlos has  
left Columbia, there  
have been large deposits  
and withdrawals in his  
account

Unusual \$ activity  
in Carlos'  
checking  
account 10/7, 10/9

☐ ☐ ☐ ☐ ☐ 0

☒ ☐ in Columbia

Dec-19-03 9:05 AM 011...

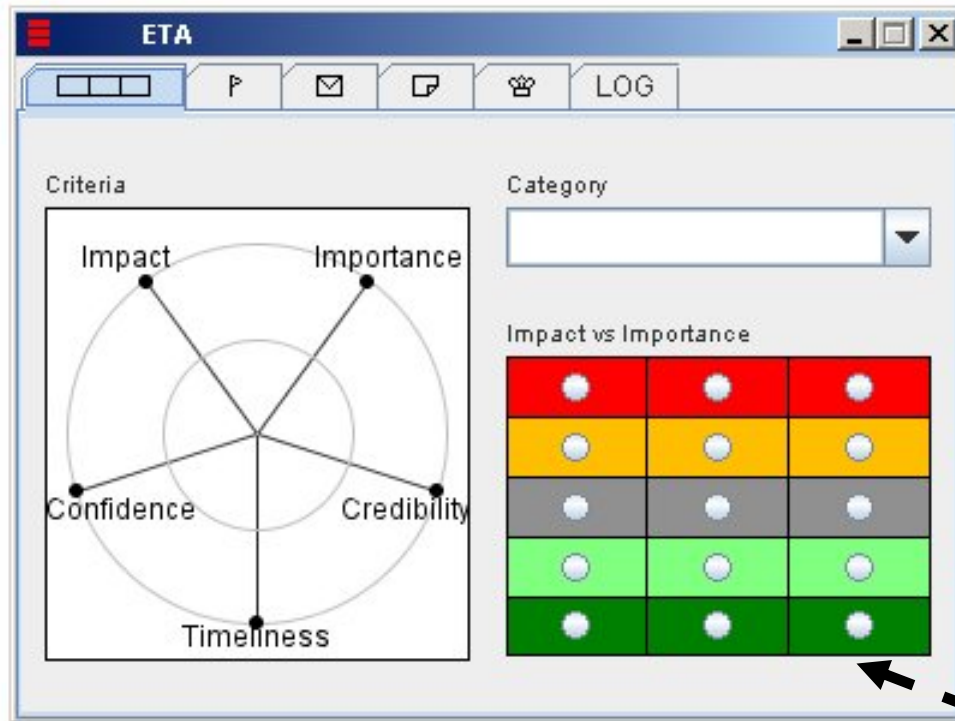
Fleming

Money Activity

This DCODE coding  
tells me that this  
information ...

- Very Negatively impacts the likelihood Carlos is in Columbia.
- Is considered of high importance.
- There is no question about the quality of the information.

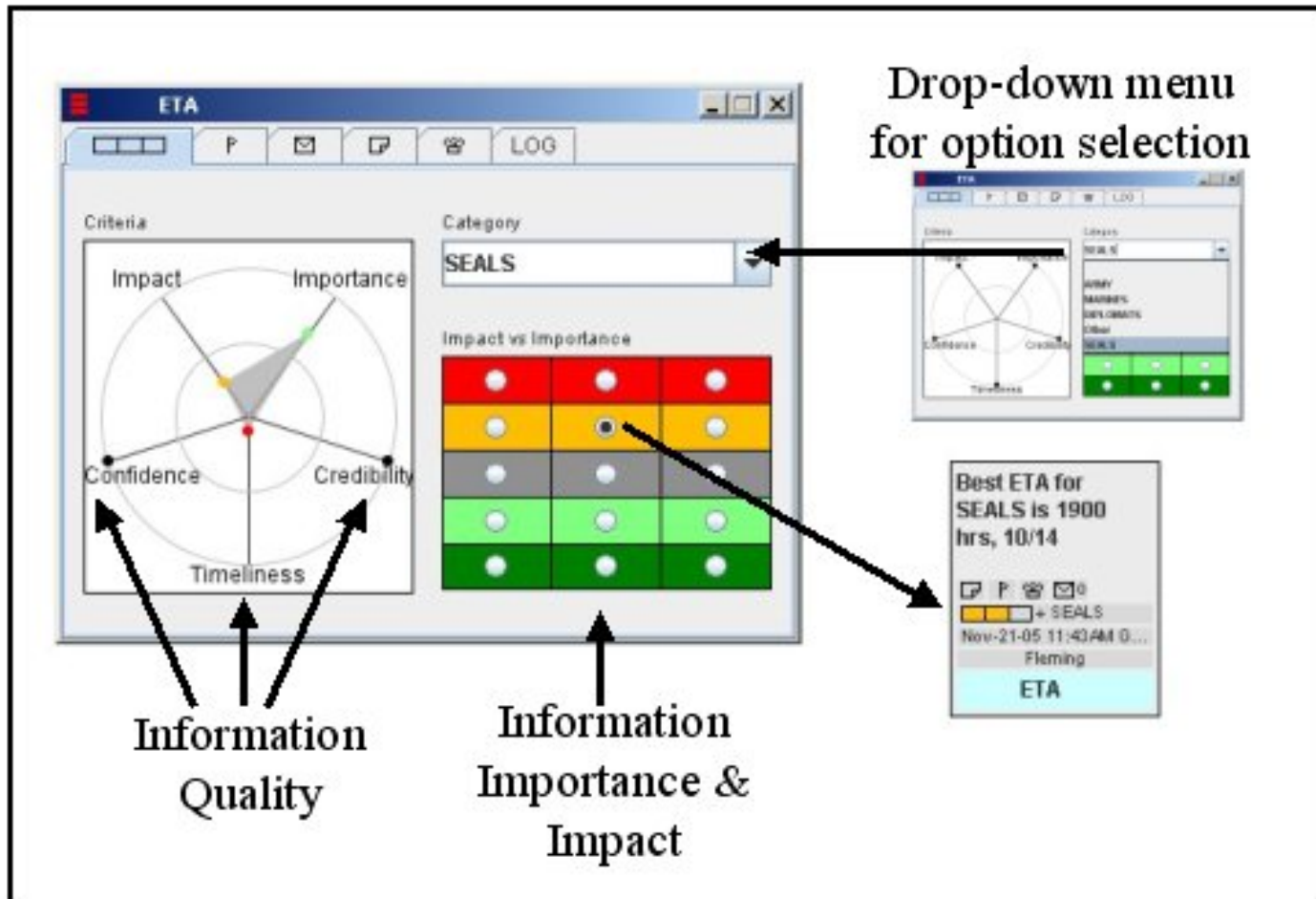
# Activating the DCODE Assessment Template






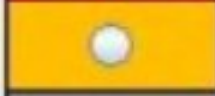

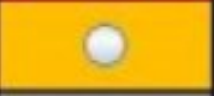
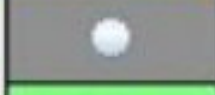
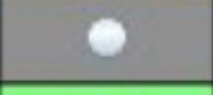
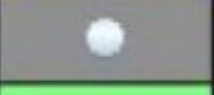
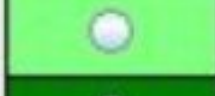

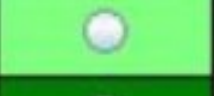



Best ETA for  
SEALS is 1900  
hrs, 10/14

Nov-28-05 10:45AM G...  
Fleming  
ETA

# The Assessment Template



# Scoring Impact and Importance

		Importance →		
		Average	High	Very High
I M P A C T ↓	Very Negative			
	Negative			
	Neutral			
	Positive			
	Very Positive			

Item is of “High” importance (2 boxes) and has a “Negative” impact (yellow) on this option.



## IMPORTANCE (# boxes filled):

AVERAGE (1)



HIGH (2)



VERY HIGH (3)



## IMPACT: (color)

Very  
Positive



Positive



Negative



Very  
Negative



Average Importance

Very Positive



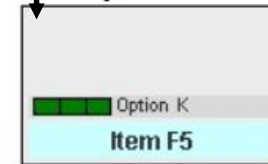
High Importance

Very Positive



Very High Importance

Very Positive



Average Importance

Positive



High Importance

Positive



Very High Importance

Positive



Average Importance

Negative



High Importance

Negative



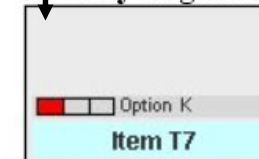
Very High Importance

Negative



Average Importance

Very Negative



High Importance

Very Negative



Very High Importance

Very Negative



# Sample DCODE Assessments

## Single Option: Buy stock "A"?

## Selecting a House

22 min.

☐ ☒ ☒ ☒ ☒ 0

☒ ☒ ☒ Concord Blvd

Nov-28-05 11:29AM G...

Fleming

**Commute time**

47 min.

☐ ☒ ☒ ☒ ☒ 0

☒ ☒ ☒ Adams St.

Nov-28-05 11:29AM G...

Fleming

**Commute Time**

Parking Lot

☐ ☒ ☒ ☒ ☒ 0

☒ ☒ ☒ Concord Blvd

Nov-28-05 11:32AM G...

Fleming

**View**

Shoreline

☐ ☒ ☒ ☒ ☒ 0

☒ ☒ ☒ Adams St.

Nov-28-05 11:32AM G...

Fleming

**View**

## Selecting a Car

9.7 mpg

☐ ☒ ☒ ☒ ☒ 0

☒ ☒ ☒ Hummer

Nov-28-05 11:24AM G...

Fleming

**Gas Mileage**

28.1 MPG

☐ ☒ ☒ ☒ ☒ 0

☒ ☒ ☒ Civic

Nov-28-05 11:27AM G...

Fleming

**Gas Mileage**

## Selecting a College

☐ ☒ ☒ ☒ ☒ 0

☒ ☒ ☒ Wisconsin

Nov-28-05 11:33AM G...

Fleming

**Parties**

☐ ☒ ☒ ☒ ☒ 0

☒ ☒ ☒ Utah

Nov-28-05 11:40AM G...

Fleming

**Parties**

87

☐ ☒ ☒ ☒ ☒ 0

☒ ☒ ☒ Dec-1-05 10:39AM GM...

Fleming

**P/E ratio**

7.9%

☐ ☒ ☒ ☒ ☒ 0

☒ ☒ ☒ Dec-1-05 10:39AM GM...

Fleming

**5-yr avg. return**

"Hold"

☐ ☒ ☒ ☒ ☒ 0

☒ ☒ ☒ Dec-1-05 10:39AM GM...

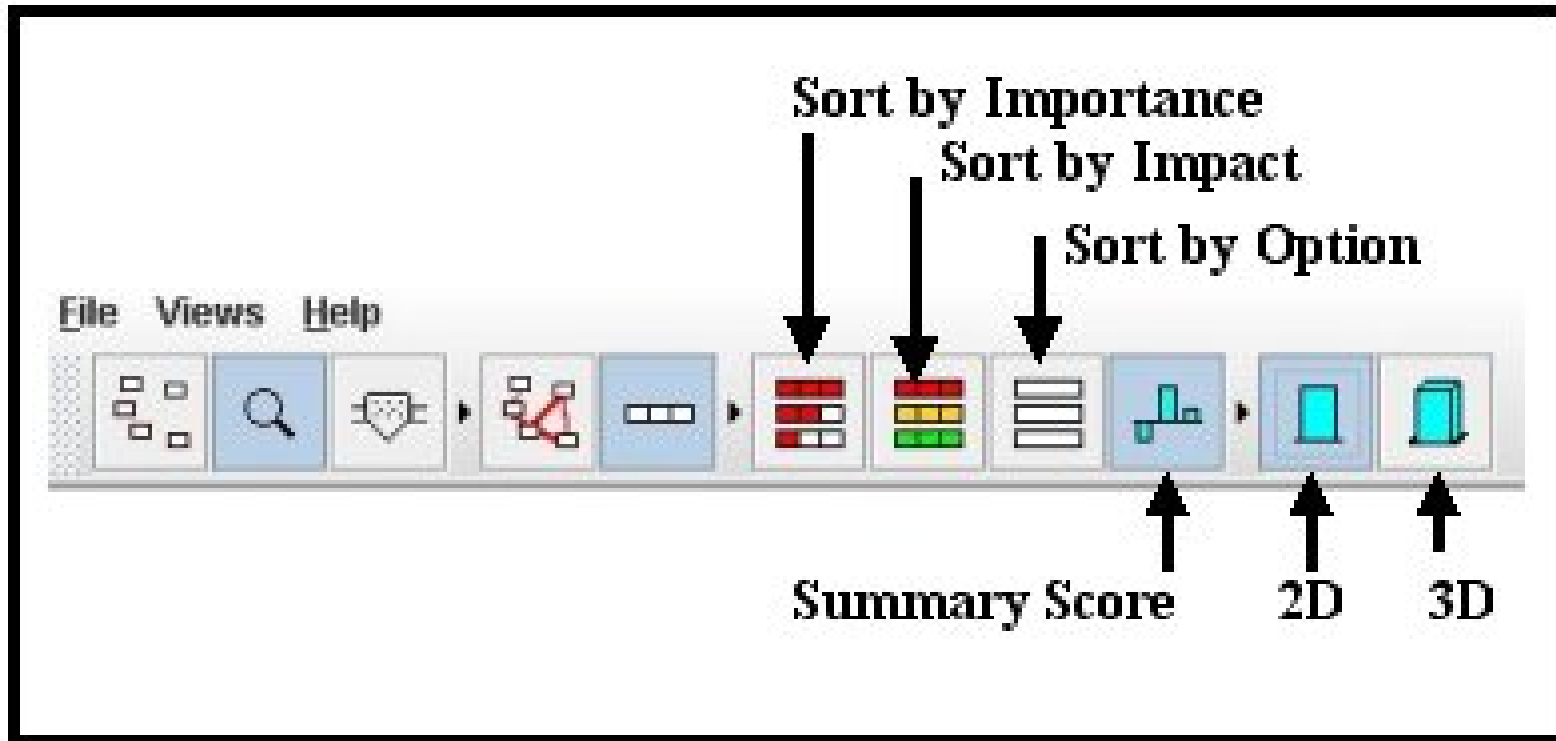
Fleming

**Broker rating**

# Which is the BEST option?

  SEALS <p>Rebels have no night vision capability</p>	  SEALS <p>SEALS have just returned from another mission</p>	  Army <p>Bridges on roads do not have high load capacity</p>	  Army <p>Army will be the most expensive option</p>
  SEALS <p>SEALS are very covert</p>	  SEALS <p>There will be dense fog in the morning</p>	  Army <p>Army will have the most firepower</p>	  Army <p>Off-road terrain difficult for Army vehicles</p>
  SEALS <p>Seal team can be activated immediately</p>	  SEALS <p>Very small time window for landing SEALS</p>	  Army <p>Use of Army will have least impact on our reserve</p>	  Army <p>Army team predicted to have least casualties</p>
  SEALS <p>Seal team does not have a translator</p>	  SEALS <p>Injured worker will have to spend 2 hours in Zodiac</p>	  Army <p>Army team has corpsman and translator</p>	  Army <p>Army unit has trained on island and knows terrain</p>
  SEALS <p>SEALS are especially trained in hostage rescue</p>	  SEALS <p>SEAL team has a corpsman</p>	  Army <p>Army unit is very fresh and at full strength</p>	  Army <p>Army response will not be covert</p>
  SEALS <p>SEALS should spend least time on the island</p>	  SEALS <p>Reef is only passable at high tide</p>	  Army <p>Army will have the slowest response time</p>	  Army <p>Use of Army would have good public relations</p>

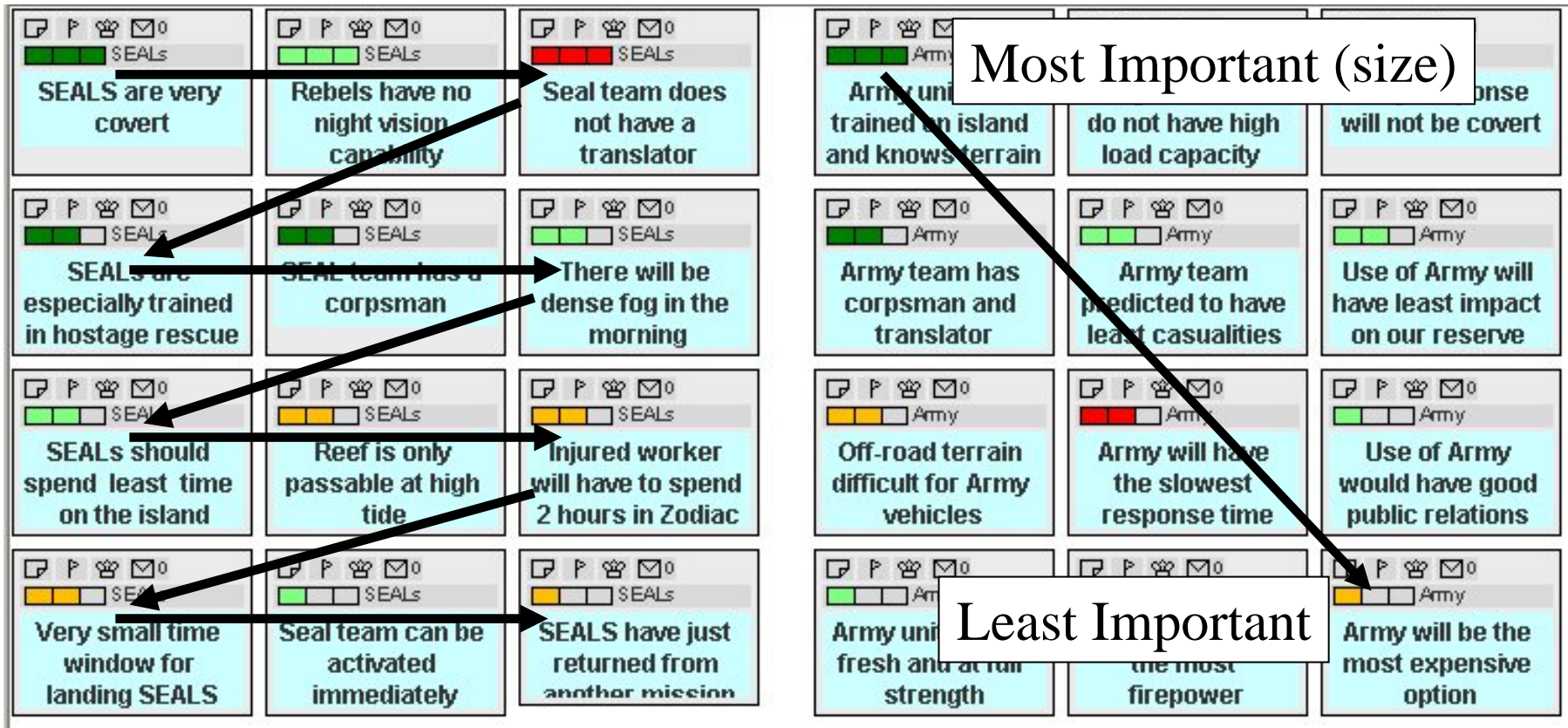
# Integration of IOBs





























# Sorted by Importance:

## Very High – High -- Average



# Sorted by Impact:

Very Positive, Positive, Negative, Very Negative

<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  SEALs <b>SEALs are very covert</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  SEALs <b>SEAL team has a corpsman</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  SEALs <b>SEALs are especially trained in hostage rescue</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  Army <b>Army unit trained on and knows terrain</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  <b>translator</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  <b>on our reserve</b>
<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  SEALs <b>Rebels have no night vision capability</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  SEALs <b>There will be dense fog in the morning</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  SEALs <b>SEALs should spend least time on the island</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  Army <b>Army team predicted to have least casualties</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  Army <b>Use of Army would have good public relations</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  Army <b>Army will have the most firepower</b>
<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  SEALs <b>Seal team can be activated immediately</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  SEALs <b>Very small time window for landing SEALs</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  SEALs <b>Injured worker will have to spend 2 hours in Zodiac</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  Army <b>Army unit is very fresh and at full strength</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  Army <b>Off-road terrain difficult for Army vehicles</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  Army <b>Army will be the most expensive option</b>
<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  SEALs <b>Reef is only passable at high tide</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  SEALs <b>SEALs have just returned from another mission</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  SEALs <b>Seal team does not have a translator</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  Army <b>Bridges do not have load capacity</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  Army <b>Most Negative</b>	<input type="checkbox"/> P <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0  Army <b>Army will have the slowest response time</b>

Most Positive (color)

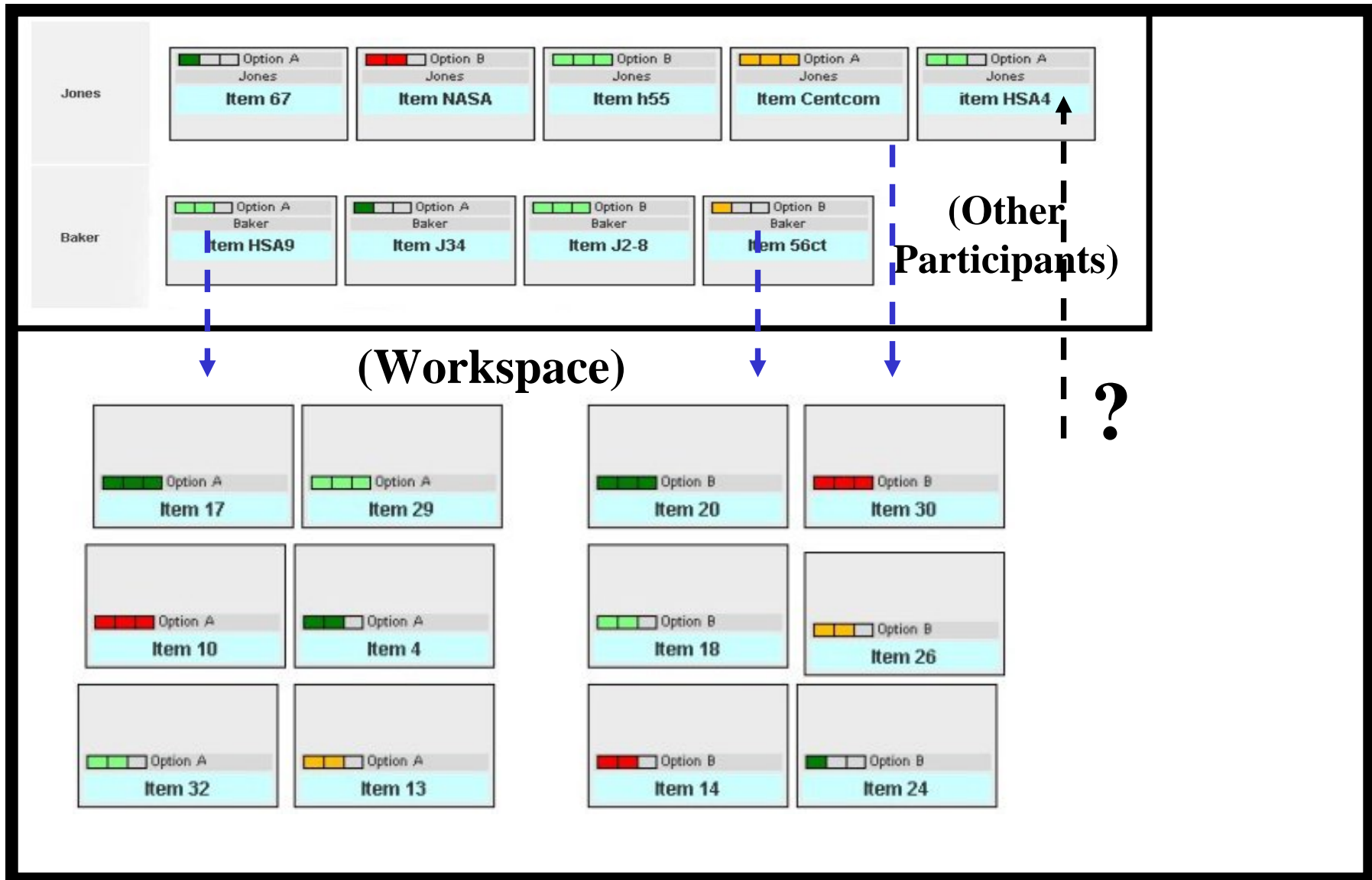
Most Negative





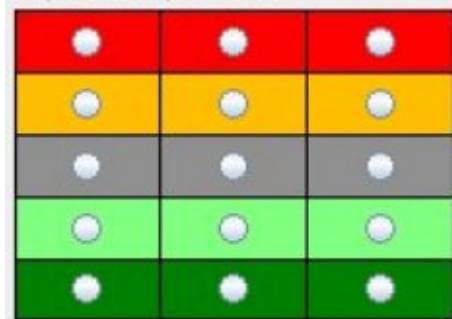
# DCODE Sharing

Research & Engineering  
Development, Inc. (RED-Inc)



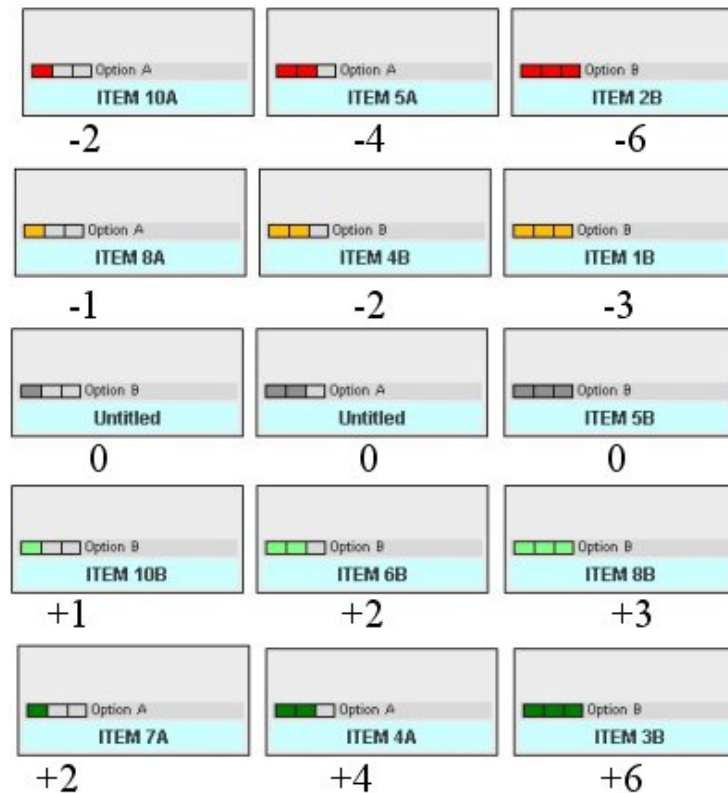
Smith's Display (EWall workspace + Exchange view)

# Making Decisions with DCODE (the weighting matrix)

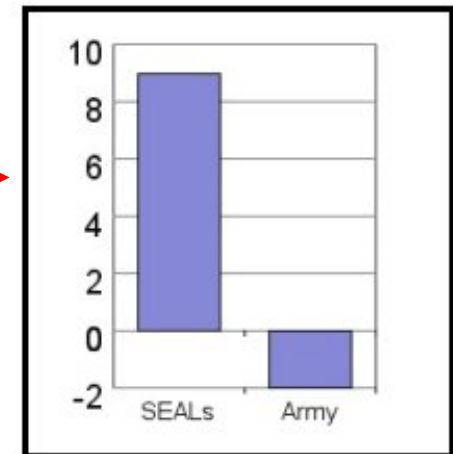
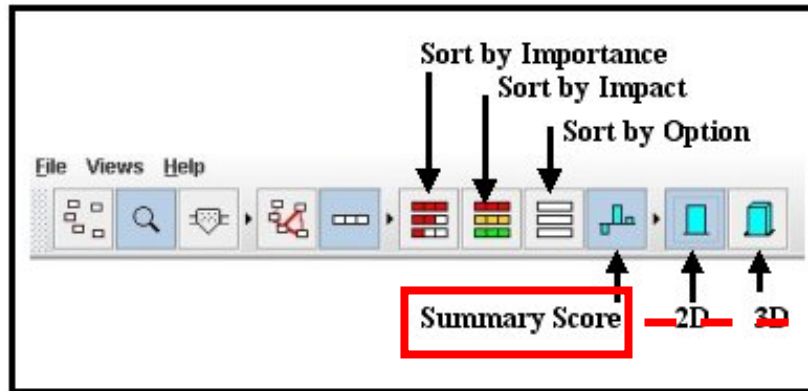


		IMPORTANCE		
		X	X	X
		1	2	3
IMPACT	-2	-2	-4	-6
	-1	-1	-2	-3
	1	1	2	3
	2	2	4	6

**Weighting Matrix**



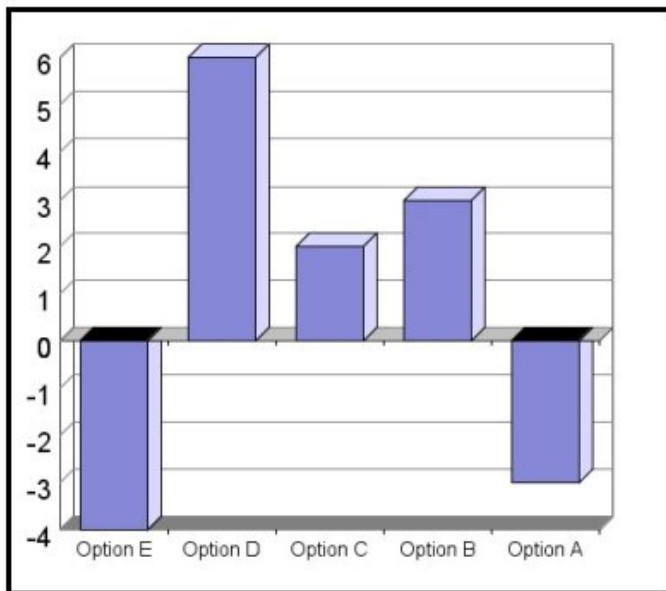
# Summary Score Bar Chart



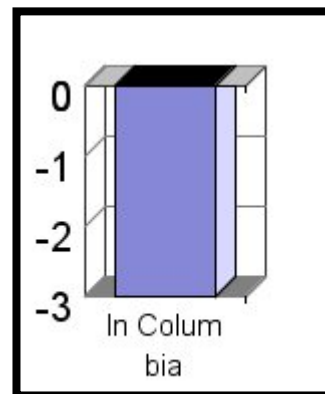
Algebraic sum  
of all IOBs for  
each option.

<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> SEALS SEALS are very covert	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> SEALS SEAL team has a corpsman	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> SEALS SEALS are especially trained in hostage rescue	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> Army Army unit has trained on island and knows terrain	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> Army Army team has corpsman and translator	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> Army Use of Army will have least impact on our reserve
<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> SEALS Rebels have no night vision capability	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> SEALS There will be dense fog in the morning	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> SEALS SEALS should spend least time on the island	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> Army Army team predicted to have least casualties	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> Army Use of Army would have good public relations	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> Army Army will have the most firepower
<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> SEALS Seal team can be activated immediately	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> SEALS Very small time window for landing SEALS	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> SEALS Injured worker will have to spend 2 hours in Zodiac	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> Army Army unit is very fresh and at full strength	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> Army Off-road terrain difficult for Army vehicles	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> Army Army will be the most expensive option
<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> SEALS Reef is only passable at high tide	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> SEALS SEALS have just returned from another mission	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> SEALS Seal team does not have a translator	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> Army Bridges on roads do not have high load capacity	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> Army Army response will not be covert	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> Army Army will have the slowest response time

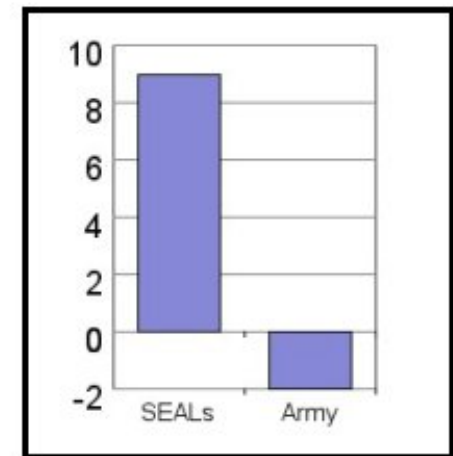
# Sample DCODE Summary Results



Multiple Options



Single Option  
(Yes-NO, Act-Don't Act)



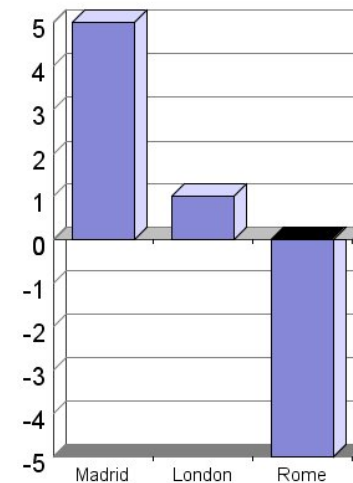
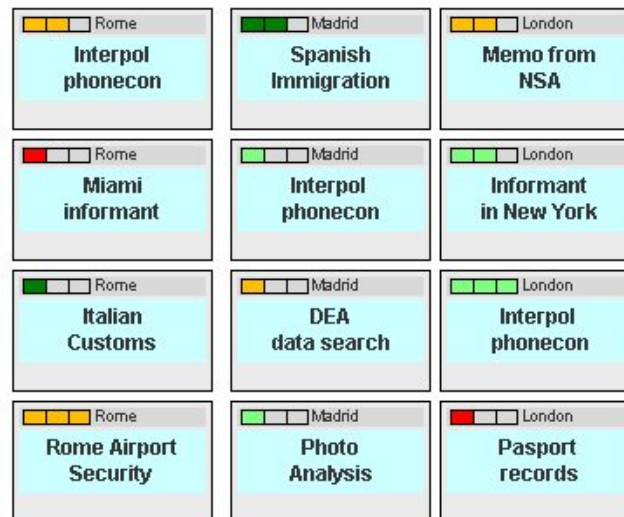
Two Options

# Use of DCODE in the Intelligence Community

“Is Carlos still in Columbia?”



“Where is Carlos?”





# DCODE Process



- Abstract
- Encapsulate



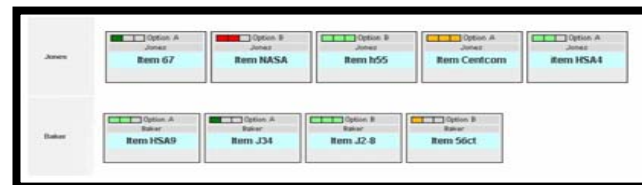
- Assess
- Option
- Importance
- Impact
- Quality

- Option
- Importance
- Impact

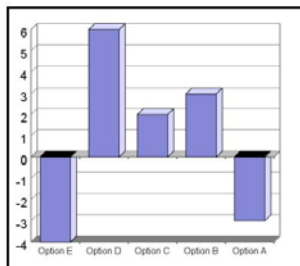


- Integrate/Sort

- Share



- Decide





# Recent DCODE Developments



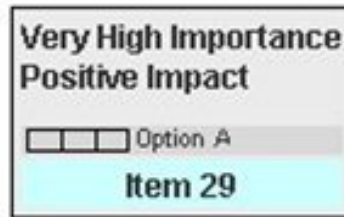
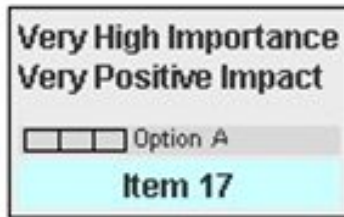
# Does DCODE Work?

## DCODE Experiment

- 123 College Students
- Task: Rank order three cities (A, B and C) in terms of expansion sites for a new plant
- 12 items of information about each city
- Items had been rated on importance (three levels) and impact (4 levels)
- Given 30 min. for task (most took 10-15 min.)
- Text vs DCODE COLOR coding
- Male vs Female



# Text versus Color Condition



Two Text Item Examples



Color Equivalent

OPTION A		OPTION B		OPTION C	
Very High Importance Very Positive Impact Option A Item 17	Very High Importance Positive Impact Option A Item 29	Very High Importance Very Positive Impact Option B Item 28	Very High Importance Positive Impact Option B Item 19	Very High Importance Very Positive Impact Option C Item 20	Very High Importance Very Negative Impact Option C Item 30
Very High Importance Very Negative Impact Option A Item 10	High Importance Very Positive Impact Option A Item 4	Very High Importance Positive Impact Option B Item 15	High Importance Very Positive Impact Option B Item 27	High Importance Positive Impact Option C Item 18	High Importance Negative Impact Option C Item 26
High Importance Positive Impact Option A Item 32	High Importance Negative Impact Option A Item 13	High Importance Negative Impact Option B Item 12	High Importance Very Negative Impact Option B Item 23	High Importance Very Negative Impact Option C Item 14	Average Importance Very Positive Impact Option C Item 24
High Importance Negative Impact Option A Item 9	High Importance Negative Impact Option A Item 16	Average Importance Negative Impact Option B Item 8	Average Importance Negative Impact Option B Item 22	Average Importance Positive Impact Option C Item 3	Average Importance Positive Impact Option C Item 36
Average Importance Very Positive Impact Option A Item 25	Average Importance Positive Impact Option A Item 1	Average Importance Negative Impact Option B Item 5	Average Importance Negative Impact Option B Item 21	Average Importance Positive Impact Option C Item 6	Average Importance Positive Impact Option C Item 34
Average Importance Positive Impact Option A Item 7	Average Importance Negative Impact Option A Item 11	Average Importance Negative Impact Option B Item 31	Average Importance Negative Impact Option B Item 33	Average Importance Negative Impact Option C Item 2	Average Importance Very Negative Impact Option C Item 35

36 Item Display  
Text Condition

OPTION A		OPTION B		OPTION C	
Option A Item 20	Option A Item 30	Option B Item 17	Option B Item 29	Option C Item 28	Option C Item 19
Option A Item 18	Option A Item 26	Option B Item 10	Option B Item 4	Option C Item 15	Option C Item 27
Option A Item 14	Option A Item 24	Option B Item 32	Option B Item 13	Option C Item 12	Option C Item 23
Option A Item 3	Option A Item 36	Option B Item 9	Option B Item 16	Option C Item 8	Option C Item 22
Option A Item 6	Option A Item 34	Option B Item 25	Option B Item 1	Option C Item 5	Option C Item 21
Option A Item 2	Option A Item 35	Option B Item 7	Option B Item 11	Option C Item 31	Option C Item 33

36 Item Display  
Color Condition



# Response Sheet

- Write your choice as Best option on the “100” line.
- Write your choice as Worst option on the “0” line.
- Circle the number that best represents where you would assign the remaining option.

100	<u>Option C</u>
90	
80	
70	Option A
60	
50	
40	
30	
20	
10	
0	<u>Option B</u>

# Results

- Color condition had significantly fewer errors
- Color condition had significantly more people get all 3 rankings correct
- Color condition was significantly better at assigning position to the Middle rank
- Text condition had more people select the Best option—but then performed significantly worse than chance on the last two rankings
- Males had significantly more confidence in their rankings



# DCODE **S**mall business **T**echnology **T**ransfer Program (**STTR**) Awarded

- N06-T025 Decision Making Constructs for a Distributed Environment (DCODE)
- OBJECTIVE: Enable quick-response knowledge interoperability in coalition operations decision making.
- PHASE I: Develop a cognitive processing-based concept, tool or methodology to
  - improve the ability of both individual and distributed group decision makers to evaluate, share, and integrate decision-relevant information items and
  - to improve decision time by reducing the time and effort devoted to conflict resolution and consensus building in reaching an overall group decision.

**Three Phase I proposals accepted by ONR 6/06**



# More Information

- DCODE contacts:
  - [bobfleming@gmail.com](mailto:bobfleming@gmail.com)
  - [Mike.cowen@navy.mil](mailto:Mike.cowen@navy.mil)
- DCODE documentation, updates:
  - <http://www.dcode-onr.net/>
- EWall information:
  - Paul Keel, [keel@mit.edu](mailto:keel@mit.edu)
- ONR Sponsor
  - Mike Letsky [letskym@onr.navy.mil](mailto:letskym@onr.navy.mil)



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