# Appendix II

# Case Studies

## AHP at the Inter-American Development Bank[1]

### INTRODUCTION

In addition to its use in face-to-face meeting environments, the Analytic Hierarchy Process (AHP) has also been successfully used in distributed group decision support (DGDS) environments. This section presents one of several applications of AHP in DGDS environments at the Inter-American Development Bank (IDB).[2] The Bank appointed project managers and organized both advisory committees and project teams to work on these important procurement decisions:

- selection of the best alternative for the automation of its investment activities
- selection of the best alternative for the automation of its bank account reconciliation function
- selection of the best alternative for the implementation of an electronic image management system
- selection of an external audit company
- selection of a provider of VSAT (satellite) communications
- selection of a provider of Employee Health Insurance

The advisory committees were made up primarily of managers of the organizational units that would be interested in the solution to be implemented. The initial role of an advisory committee was to provide

[1] Lauro Lage-Filho. Dr. Lage, an expert in decision support works as a consultant for the Inter-American Development Bank. The opinions expressed in this paper are the author's, and do not necessarily reflect the views of the Inter-American Development Bank.
[2] The Inter-American Development Bank, the oldest and largest regional multilateral development institution, was established in 1959 to help accelerate economic and social development in Latin America and the Caribbean. In carrying out its mission, the Bank has mobilized financing for projects that represent a total investment of $240 billion. Annual lending has grown dramatically from the $294 million in loans approved in 1961 to $10 billion in 1998.

guidance to the project team about the project goal, the decision-making process, and the schedule to be followed. The advisory committee members were also responsible for assessing the relative importance of the selection criteria.

The project teams were composed of staff and external consultants working in the units represented in the advisory committees. Project team members had in-depth knowledge of the problem to be solved and were responsible for evaluating the preference for the alternatives regarding the criteria previously established or approved by the advisory committees. Subsequently, the advisory committees would review and approve the technical evaluations performed by the project teams and prepare recommendations to support the selected alternative. The account reconciliation project is presented next.

**THE ACCOUNT RECONCILIATION PROJECT**

The IDB had been performing its account reconciliation function through a manual process requiring seven officers working ten days each month. The process was complex and tedious owing to the large and growing number of accounts (about 250), a majority of them dealing in U.S., Canadian, Japanese, or European currencies.

In 1993, the Accounting Division proposed the automation of the reconciliation process after identifying the following benefits for the project: (1) savings of over $100,000 a year in staff time; (2) ability to cope with the expected increase of transactions without hiring additional staff; (3) faster resolution of outstanding problems; (4) daily account balancing for critical bank accounts; and (5) more effective managerial controls.

The following schedule of activities was developed for the project:

| | |
|---|---|
| 10/14 | Introduce DGDS environment to participants |
| 10/15 | Implement computer conference |
| 10/18-10/27 | Attend vendors' demonstrations of the alternatives |
| 10/19-11/04 | Clarify Problem Statement and objectives |
| | Discuss alternatives' pros and cons |
| 10/28-11/05 | Structure AHP model |

| | |
|---|---|
| 11/08 | Approve AHP model<br>Establish relative importance of objectives (AC members, in-groups)<br>Establish preference for the alternatives (PT members, individually)<br>Consolidate evaluations (geometric means) |
| 11/12 | Discuss and approve results (PT)<br>Present recommendation to the AC |

**Decision Support Environment**

The main components of the DGDS environment[3] used by the Bank are: (1) the method for the decision-making process, which is centered on the AHP and implements Herbert Simon's classic Intelligence, Design, and Choice Phases providing overall orientation to the decision-makers (see Table 1); (2) the Expert Choice computer program that helps to structure and solve decision problems; (3) the Lotus Notes computer program that supports the implementation of a computer conference and enables decision-makers to participate in the decision process at the time and location of their convenience; and (4) network and communications software.

The DGDS environment was presented to members of the advisory committee and project team in a four-hour, "hands-on" seminar. AHP concepts were presented as well as techniques for making the computer conference effective. To illustrate the method, participants were asked to tackle a personal decision problem using the proposed approach. The participants worked on the purchase of a new home being considered by one of them. The exercise was very realistic and was a positive motivator.

[3] Lauro Lage-Filho, *A Group Decision Support Environment Facilitating Decision-making Distributed in Time and Space. Doctoral Dissertation.* (Washington: The George Washington University, 1994).

Table 1 – Method

| **Intelligence Phase** |
|---|
| • Discuss a preliminary problem statement to:<br>obtain an enriched and consensual view of the problem. |
| **Design Phase** |
| • Discuss an initial list of alternatives to:<br>obtain a revised list of alternatives;<br>obtain an initial set of objectives/criteria. |
| • Discuss an initial set of objectives/criteria to:<br>obtain a revised set of objectives/criteria. |
| **Choice Phase** |
| • Structure one or more AHP/Expert Choice models to:<br>obtain common (group) Expert Choice model(s). |
| • Elicit individual judgments. |
| • Incorporate the geometric mean of the individual judgments into the combined Expert Choice model and synthesize the priorities. |
| • Discuss and approve the results and analyses. |
| • Document the decision for justification and control. |

The intelligence, design and choice phases of the method are described next. The description, although focused on the account reconciliation project, also presents concepts applicable to generic decision problems.

**Intelligence Phase**

This phase, concerned with identifying the problem or opportunity, was conducted through a Lotus Notes computer conference. However, any mixture of face-to-face and computer conference sessions is possible. Regardless of the mode, it is important to give the group the opportunity to discuss, understand, and define the problem fully. During the intelligence phase, the group can reframe the problem or even define a new one. The problem statement resulting from the computer conference read:

> The team will evaluate and select an account reconciliation package to automate the reconciliation process conducted by the accounting section of the IDB. The system will match bank statement transactions received via SWIFT or manually entered from printed statements to cash transactions

recorded in the general ledger. This will help to identify discrepancies and assist in subsequent investigations. The system to be selected should also be able to handle other types of reconciliation but the initial scope of the project will be limited to the general ledger/bank statement reconciliation.

**Design Phase**

Here the group defined its objectives/criteria and alternatives. Some problems have a list of alternatives defined a priori as in this case, while other problems do not and will benefit from the definition of objectives before any alternative is even considered.

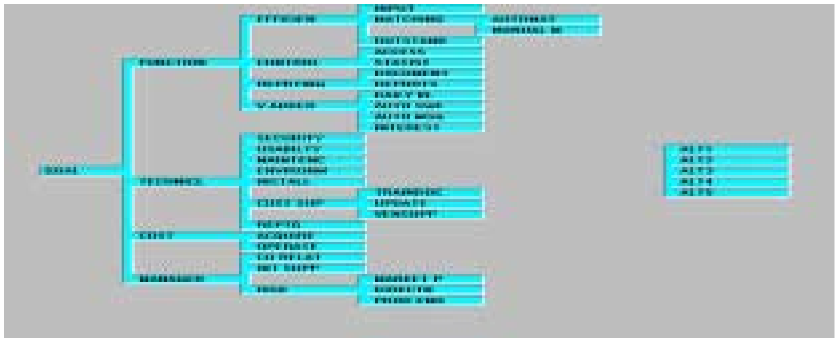
Five half-day vendor demonstrations of alternatives were made during a two-week period. Advisory committee and project team members attending these sessions used the computer conference to comment on the pros and cons of the demonstrated alternatives. They entered their comments as promptly as possible, preferably the same day of the session. A computer conference instruction advised participants to enter their own comments before reading the comments of others in order to better capture first impressions. An interactive exchange of ideas followed.

**Choice Phase**

The AHP served as the foundation of the choice phase. One of the strengths of the AHP is to provide a clear, organized, and logical view of the decision problem. However, there is no one 'right' view as a problem can be represented in several ways and the group members must exert some creativity[4].

The structuring of the AHP model started immediately after the demonstration period. There were four two-hour face-to-face meetings in addition to the highly active computer conferencing. Alternatives' pros and

[4] Thomas L. Saaty, "How to make a decision: The Analytic Hierarchy Process," *European Journal of Operational Research* 48, (1990): 9-26.



```
ACQUIRE  Acquisition Cost
CO RELAT Company Relations
CONTROL  To better control, analyze, and review transactions
COST     Cost
CUST SUP Customer Support
EFFICIEN To increase the efficiency of the recon process
ENVIRONM Environment
FUNCTION Functional Requirements
INSTALL  Installation
INT SUPP Internal Support
MAINTENC Maintenance
MANAGER  Managerial Considerations
OPERATE  Operational Cost
REPRTING To better document and report recon process
REPTG    Reporting Capability
RISK     Risk
SECURITY Security
TECHNICL Technical Requirements
USABILTY Usability
V ADDED  To a knowledge value-added features
```

Figure 1 – AHP Model

cons discussed during the design phase were used to identify objectives to build the model. Participants offered preliminary versions of decision models and the ensuing discussion regarding these proposed models led to an improved, well understood, and agreed upon group model. The objectives were clustered into a hierarchical representation shown in Figure 1.

The goal, or first level of the model, was to select the best alternative to automate the Bank's account reconciliation process. Below the goal are levels that include the objectives and sub-objectives (or criteria) used to evaluate the relative preference for the alternatives.

The major objectives were functional requirements, technical requirements, cost, and managerial considerations:

*Functional requirements* covered the users' business needs, including specific requirements in Matching Efficiency, Control and Reporting. Additionally, *functional requirements* considered "value-added" features of the alternatives, such as automation of internal and external message creation, availability of daily balance reports, and interest calculation. The majority of these sub-objectives were further broken down to allow a full, detailed analysis.

*Technical requirements* addressed important system features, such as security, usability, maintainability, computing environment, installation process, customer support, and reporting capabilities.

*Cost* encompassed acquisition and operational costs. Acquisition cost is the cost of hardware and software required by the alternative. Operational cost is the cost to operate and support the system over a five-year period.

*Managerial considerations* focused on company relations, internal support, and risk appraisal. The *risk appraisal* sub-objective was further broken down into *market penetration*, *direction*, and *product enhancements.*

The lowest level of the model contained the alternatives to be evaluated: ALT1, ALT2, ALT3, ALT4, and ALT5.

**Determination of the Importance of the Objectives**

The determination of the relative importance of the first-level objectives (*Functional Requirements*, *Technical Requirements*, *Cost*, and *Managerial Considerations*) and of the sub-objectives related to *Cost* and *Managerial Considerations* was made by members of the advisory committee, grouped according to the organizational unit they represented: Cashier's Division (CSH), Accounting Division (ACC), and Financial MIS Division (IRM).

Members of each group worked together and used Expert Choice to derive the priorities of the objectives/sub-objectives. The geometric means of these priorities were calculated to represent the position of the advisory committee. The ACC group members established the relative importance of the sub-objectives under *Functional Requirements* and the IRM group members established the relative importance of the sub-objectives under *Technical Requirements*. In order to avoid influencing those evaluating the alternatives, the final priorities of the combined model were not calculated until preference for the alternatives had been established.

**Evaluation of the Alternatives**

After the advisory committee approved the AHP model, evaluations were made about the relative preference for the alternatives with respect to each of the lowest level sub-objectives. The evaluators, project team members, were grouped according to their area of expertise: functional requirements, technical requirements, cost, and managerial considerations. Prior to the evaluation, the group members organized the computer conference messages about the alternatives' pros and cons according to the relevant sub-objective(s). Additional information was added when appropriate. Guidance for the evaluation was provided via the computer conference. Evaluators were advised to maintain their focus on the sub-objective being considered and to refer to the computer conference discussions related to that aspect of the AHP model being evaluated. The computer conference database had 47 discussion items with 484 responses – a printout of the conference generated 146 single-spaced pages.

Group members worked sometimes jointly and sometimes separately in establishing their preference for the alternatives. Although there are advantages to making judgments in a group atmosphere, there are also, advantages in having the group members make judgments separately. For example, when working individually, the evaluators will have an opportunity to do their analysis and thus contribute their knowledge at their most productive time and pace, while being protected from any disturbing behavior of other members, common in group settings.[5] Furthermore, they will be able to use resources generally not available to them at meetings. Finally, they will become fully prepared to discuss their evaluations in a later group session.

Comparisons of the alternatives with respect to sub-objectives under *Functional Requirements* and *Technical Requirements* were made in two steps. First, the evaluators worked separately. Next, the participant's evaluations were combined by the geometric means of individual judgments. This established a convenient starting point for the group discussion that followed. The preferences for the alternatives reflected in the combined model were analyzed by the group members and compared with those in their individual models. This was done for each sub-objective immediately above the alternatives' level in the AHP models. There were two interesting possibilities. First, there were those situations when a majority of the evaluators established their preference in the "same direction" (i.e., alternative A is preferable to alternative B to some degree). In this case, the group usually readily accepted the geometric mean results. Nevertheless, it was desirable to ask the dissenters to explain their reasoning. The discussion often led to a deeper understanding of the subject and to a higher degree of consensus. Second, those rare occasions when the evaluators were divided into two (or three) groups according to their preference for an alternative. This indicated an incomplete or superficial discussion of the subject at the computer conference (or face-to-face meeting).

The evaluators chose to work together when establishing the preference for the alternatives under the other objectives of the AHP model - *Cost* and *Managerial Considerations*.

## Validation of the Results

The project team held a two-hour meeting to synthesize, discuss, and validate the results. They reviewed the priorities of the main objectives derived by the advisory committee and discussed the results under each of

[5] Efraim Turban, *Decision Support and expert systems: Management support systems.* (New York: MacMillan, 1993).

these main objectives. The project team agreed that ALT5 should be selected. Figure 2 shows the results of the combined model. Later that day, in another two-hour meeting, the project team recommended ALT5 to the advisory committee. After thoroughly discussing the results under each of the main objectives in the model and making extensive use of the sensitivity analysis graphs, the advisory committee unanimously approved the recommendation.

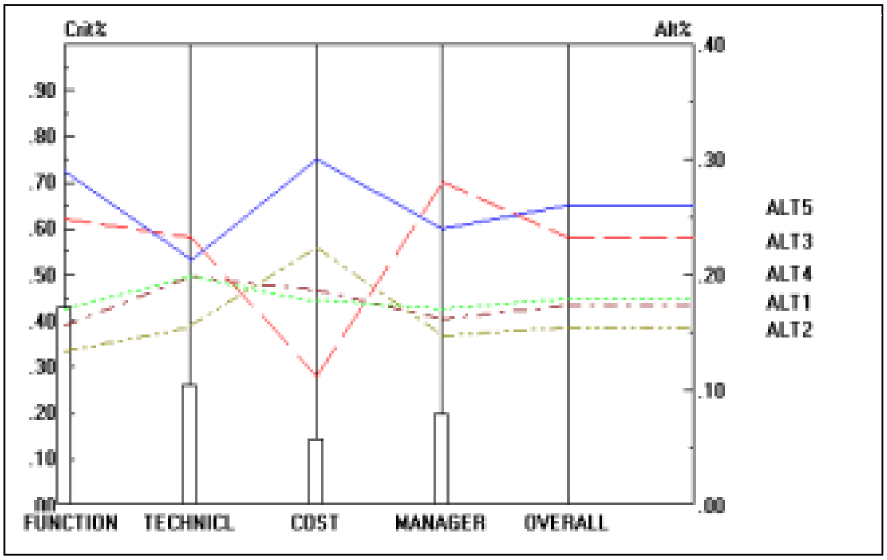



Figure 2 – Results of the AHP Model

**CONCLUSION**

Following the completion of the selection process, project participants compared the DGDS environment to the conventional, structured, face-to-face group decision-making process they had used before in similar projects. They perceived the DGDS approach as preferable to the face-to-face approach for group decision-making involving important and complex, real-world, decision problems. Specifically, the new approach contributed to[6]: (1) decreasing the time to reach a decision (a decision was made in little more than a month, whereas previously, project participants had been unable to make a similar decision in over a year); (2) increasing the depth of analysis; (3) increasing the degree of participation and consensus; (4) increasing task-oriented communication; and (5) decreasing the domination by a few members. The decision-makers perceived an increase in the quality of the decision and were more satisfied with the new group process.

Subsequent to this project, the approach described here has been used to support several other decisions by the Bank, including those related to the procurement of goods and services. Usually, the AHP model is included in the Request for a Proposal document and defines the structure of the proposal that the bidders will present. As a consequence, the proposals are homogeneous and comparable and the evaluation process is rational and transparent. The results have been well accepted internally as well as by the bidders -- no protests have been raised to the IDB. Also, as the approach became familiar to upper management, an increasing number of applications linked to the Bank's operations in its member countries is being made. In one such application, for example, Brazilian authorities used the approach to establish priorities for the preservation of Historic Cities and in another application the process was used by Venezuelan authorities to allocate resources for social projects.

[6] Lage-Filho, *Doctoral Dissertation.*

## AHP For Future Navy Sea-Based Platforms[7]

In March of 1996, the Undersecretary of Defense for Acquisition authorized the Navy to enter concept exploration for a new sea-basing platform designated as CVX. The general missions of sea-based platforms are to:

- Provide credible, sustainable, independent forward presence during peace time without access to land bases;
- Operate as the cornerstone of a joint and/or allied maritime expeditionary force in response to crises; and
- Carry the war to the enemy through joint multi-mission offensive operations by:
    - Being able to operate and support aircraft in attacks on enemy forces ashore, afloat, or submerged independent of forward-based land facilities;
    - Protecting friendly forces from enemy attack, through the establishment and maintenance of battlespace dominance independent of forward-based land facilities; and
    - Engaging in sustained operations in support of the United States and its Allies independent of forward-based land forces.

To develop this sea-based aviation platform the Navy has created a long-term program to assess alternative platforms and technologies that balances risk and affordability and actively solicits Fleet and industry participation.

In order to support CVX development with an affordable and timely solution, the CVX Strategy-to-Task-to-Technology Process was adopted. The goal of this process is to develop an investment strategy for research and development that will support acquisition of a new class of carriers and

---

[7] Earl Hacker, Whitney, Bradley & Brown, Inc.,Vienna, VA 22182

meet the needs of the Navy in the 21st Century. This process embraces the concepts of Quality Function Deployment (QFD) . QFD is a systematic approach used by teams to develop products and the supporting processes based on the demands of the customer and the competitive marketplace. In developing a complex system such as an aircraft carrier, one of the most difficult tasks is to capture the warfighting needs in a series of specifications. The customer's vision is often different than what the engineer perceives are the requirements and priorities.

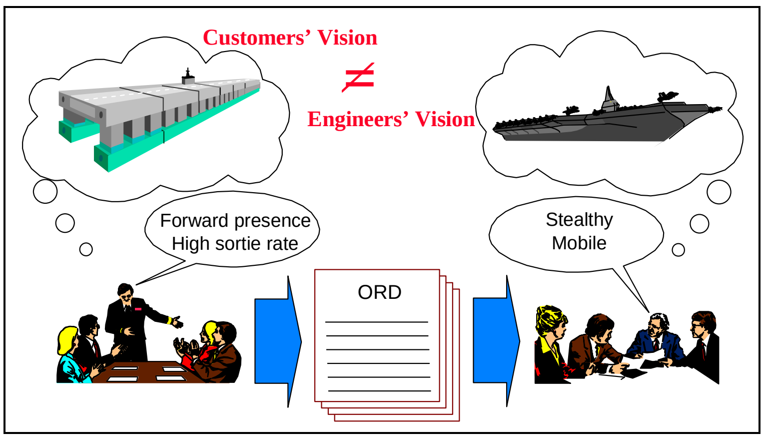



Figure 3 – Typical Problem

QFD is essentially a communication tool. If implemented properly, the engineer gains an in-depth understanding of the real needs and priorities of the "Fleet" (customer) and the problem is solved.

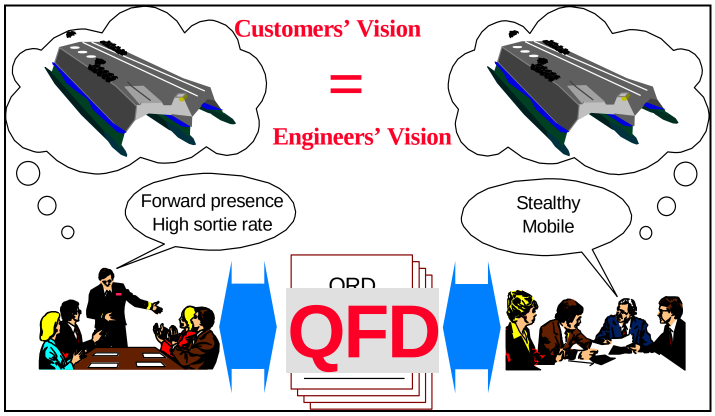



Figure 4 – Interfacing Customer and Engineering views with QFD

QFD is particularly useful for complex systems when there are multiple customers and users, conflicting user priorities, multiple feasible solutions, no quantified solutions in place, conflicting potential solutions, multiple disciplines involved, and no readily quantified user requirements. Such is the case with CVX. QFD is being used in the CVX process to document an objective definition of the users' need and priorities. As a result of early use of QFD in the investment strategy, the concurrent engineering process is strengthened through early definition of goals based on user needs, the visualization of complex system tradeoffs, highlighting of key issues, the gathering of "tribal" knowledge in a reusable database, early involvement of the Fleet and developers, and the early creation of teams and the facilitation of communications.

Figure 5 depicts the "house of quality" used in QFD.

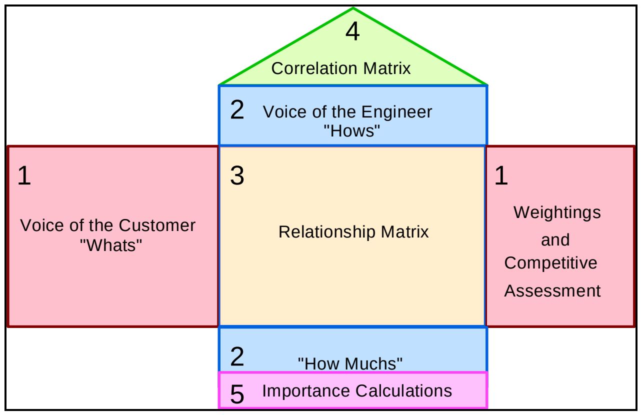



Figure 5 – House of Quality Methodology – AHP

The CVX process uses the Analytic Hierarchy Process (AHP) as a tool for capturing the voice of the "customer" -- the Fleet and integrating this with the voice of the design engineers and voice of the program management office. The methodology to accomplish this process consists of a thirteen-step process conducted in four phases as depicted in Figure 6.

The CVX Strategy-to-Task-to-Technology process (STT) establishes explicit linkage between "warfighter" needs and technology solutions by combining Strategy-to-Task methodology, functional attributes of CVX, and enabling research and development technologies in a prioritization process. Its output is used to help guide budget discussions and provide a framework for determining those technologies to apply to CVX research and development.

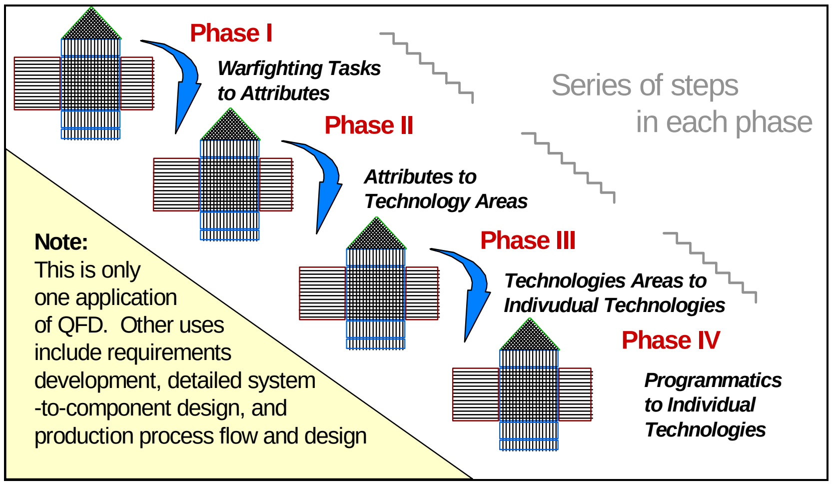



Figure 6 – Methodology Phases

To implement this process *Team Expert Choice* software was used to develop a linkage between and priorities of war fighting tasks and carrier attributes, technology areas, and technologies within each technology area. Once the individual technology priorities were developed, an investment strategy was adopted.

**Carrier Attribute Prioritization**

The STT methodology developed by RAND provides a linkage between our national goals and the tactical tasks that CVX must be capable of accomplishing in 2013. Figure 7 provides an overview of this STT linkage. The Rand STT was refined by the U.S. Army and then modified for the joint arena and adopted by the Joint Chiefs of Staff as the Universal Joint Task List(UJTL).

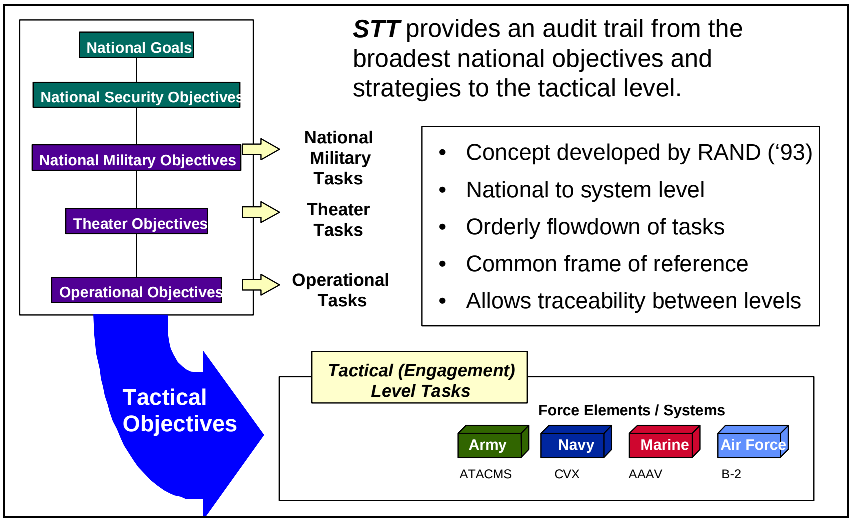



Figure 7 – Strategy-to-Task

### Step 1 –Determine Appropriate CVX Tasks

In **Step 1** of the process, the UJTL tactical tasks were arranged in a hierarchy model as described in the UJTL. The appropriate level of detail generally ran to the 3rd level of the UJTL hierarchy. The structure is depicted in Figure 8.

### Step 2 –Prioritize CVX Tasks

Two Fleet Process Teams (FPTs) were created to prioritize CVX tasks – one on the East Coast and one on the West Coast.

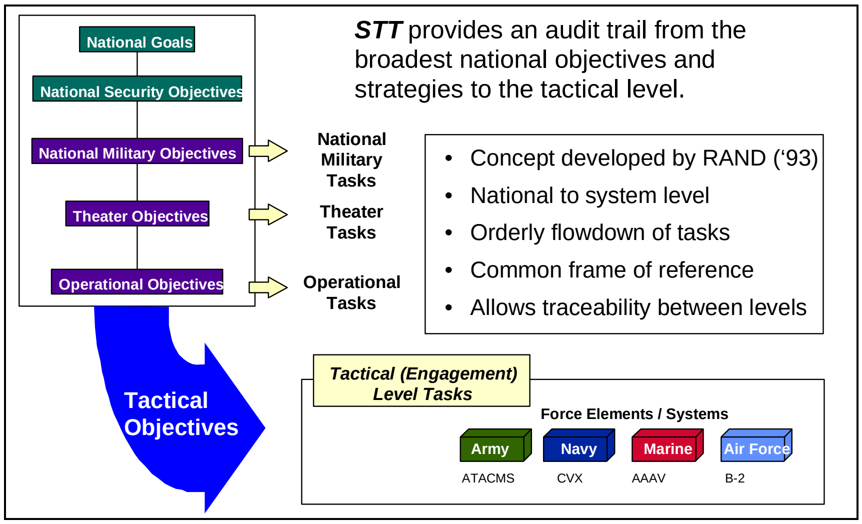



Figure 8 – CVX Tasks

Each FPT was made up of "war fighters" -- active duty officers experienced in a wide range of naval aviation and naval surface fields. Once the AHP hierarchy was established and the task definitions agreed upon and understood, the FPTs validated and prioritized the tasks.

| East Coast FPT | West Coast FPT |
|---|---|
| • COMCARGRU 8 | • COMNAVAIRPAC |
| • USS America | • COMHSWINGPAC |
| • USS Dwight D. Eisenhower | • COMSEACTLWINGPAC |
| • COMNAVAIRLANT | • COMAEWWINGPAC |
| • USS Enterprise | • COMCARGRU 7 |
| • PEO CLA/PMA-378 | • HQMC APP |
| • CINCLANTFLT | • USS Constellation |
| • PEO CLA/PMS-312 | • SWATSCOLPAC |
| • COMCARGRU 4 | • COMTHIRDFLT |
| • OPNAV N885 | • COMNAVSPECWARGRU 2 |
| • USS Theodore Roosevelt | • COMCRUDESGRU 1 |
| • COMOPTEVFOR | |
| • COMSECONDFLT | |
| • HQMC APW | |

Figure 9 – Fleet Process Team Participation

The Analytical Hierarchy Process (AHP), using Team Expert Choice with electronic scoring devices, supported the STT-to-Technology Process problem of prioritizing many tasks by arranging them into several levels and then guiding participants through a series of pairwise comparison judgments to express the relative priorities or importance of the CVX tasks and sub-tasks in the hierarchy. Each comparison began with discussion, led by a facilitator and keypads were used so that participants could enter their judgments simultaneously.

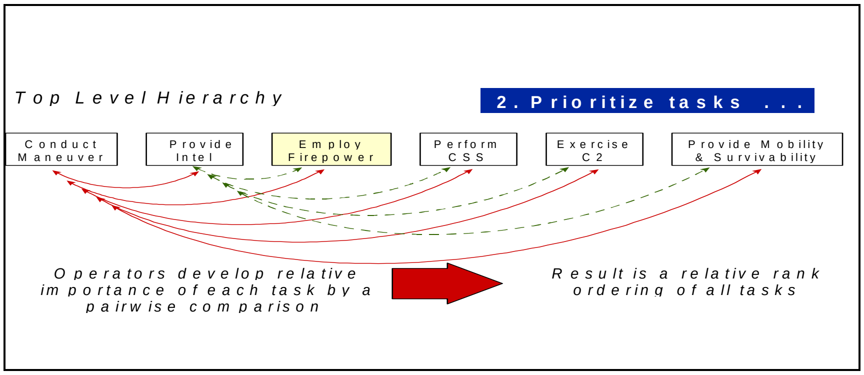



Figure 10 – Pairwise Comparison

The many judgments of FPT participants were synthesized to derive a single priority for each of the CVX tasks and sub-tasks. Metrics such as the geometric mean of each set of judgments, the geometric variance, the distribution of individual participant votes, and the consistency of the group as a whole were examined. These metrics were helpful in guiding discussion when large variations and wide distributions existed. An example screen is depicted in Figure 11. The number of participants and the discussions prior to voting kept the voting results very consistent throughout the entire voting process. Following any discussion, participants were allowed to revote. This was very beneficial by pointing out areas of concern and misconceptions and for providing "duty experts" an opportunity to voice their opinions if they differed from the initial voting results.

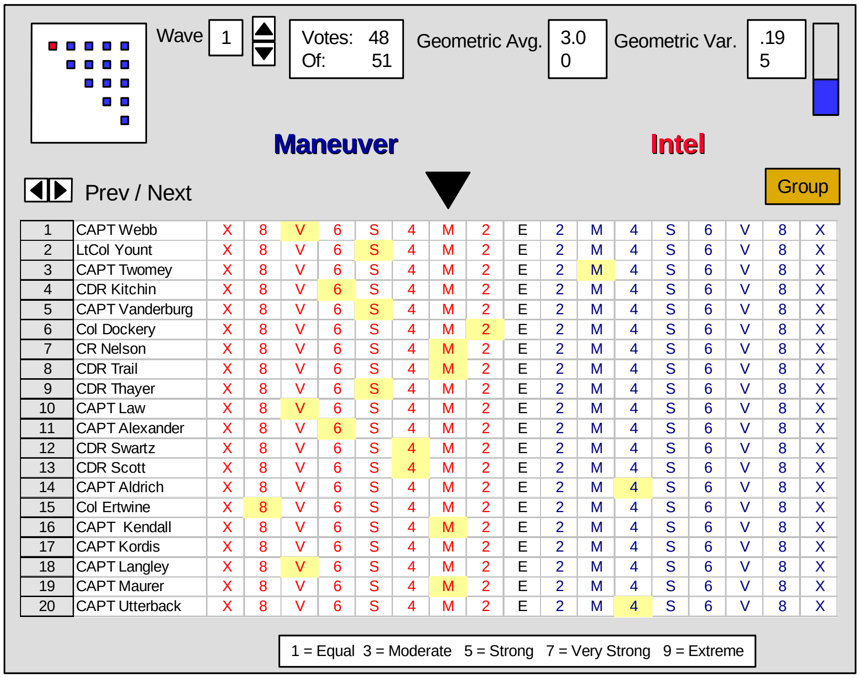



Figure 11 – Typical Voting Screen

The prioritization of the tasks conducted on both coasts was merged into one model with one set of priorities and normalized. The resultant priorities of all the identified CVX tasks are a ratio scale. Figure 12 depicts the top 15 of the 63 lowest level CVX tasks and their relative priorities. The priorities shown in Figure 12 have been multiplied by 1,000 for readability.

| Task | | Priority |
|---|---|---|
| TA 3.3 | Integrate Tactical Fires | 86 |
| TA 3.2.1.2 | Conduct Strike, Surface, Subsurface, Air Defense / Aintiair Attack | 74 |
| TA 3.2.1.1 | Conduct Fire Support / Close Air Support | 47 |
| TA 1.5 | Coordinate Maneuver and Integrate with Firepower | 44 |
| TA 6.1 | Maintain Mobility | 42 |
| TA 1.4.2 | Occupy Combat Area | 40 |
| TA 6.3.1 | Protect Against Combat Area Hazards | 40 |
| TA 4.3 | Fix / Maintain Equipment | 38 |
| TA 4.1 | Arm | 30 |
| TA 5.5 | Employ Tactical C2W | 30 |
| TA 1.2 | Negotiate Tactical Area of Operations | 22 |
| TA 5.1.1 | Communicate Information | 20 |
| TA 4.2 | Fuel | 19 |
| TA 3.1.2 | Select Fire Attack System | 18 |
| TA 5.4.6 | Synchronize Tactical Operations | 18 |

Figure 12 – Top 15 Prioritized CVX

**Step 3 –Develop CVX Attributes**

**Step 3** required developing a list of attributes for CVX. CVX attributes are the means to accomplishing the previously prioritized tasks and include design characteristics and capabilities that contribute to successful performance of the operational tasks. The attributes were arranged into three groupings:

- Functions: characteristics or activities necessary in the performance of a task;
- Parameters: physical property that determines the behavior or capability to perform a task; and
- Operational Flexibility / Constraints: characteristic that effects the likelihood or degree of performing a task.

An initial attribute list was provided at the second meeting of the FPTs. The initial focus of this effort revolved around limiting the list to a workable number of attributes (30-40) and ensuring that the focus was broad and at the same level of detail. The FPTs met on each coast validating, adding, and deleting attributes. Figure 13 lists the finalized attributes. To validate each attribute, participants were asked three questions:

- Is the prospective attribute a what or a how (means);

- Is the prospective attribute at the right level of detail; and
- Is the prospective attribute covered as part of another attribute?

### Step 4 –Prioritize CVX Attributes

In **Step 4** the FPTs evaluated the degree of correlation between the attributes and the prioritized tasks through individual inputs. This was accomplished by using the ratings module of *Team Expert Choice*. Unlike pairwise comparison which is a relative measurement, the ratings module uses absolute measurement. To determine the degree of correlation between the attributes and the tasks, a set of standards or intensities are first developed. These intensities are shown in Figure 14 Strong, Medium,

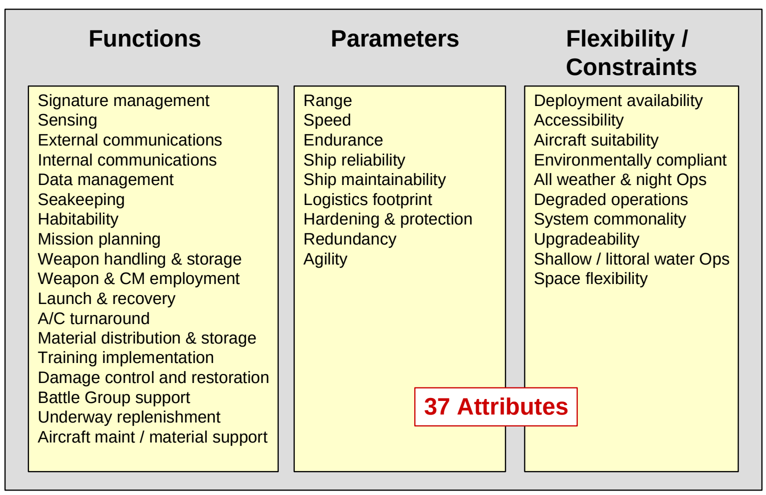



Figure 13 – Attribute Listing

Some, Tad, and None. The ratio scales below each intensity were developed through the normal pairwise comparison to establish their relative values. For example, a Strong (1.000) task-to-attribute correlation is approximately three times a Medium (.367) correlation. Participants then compared each attribute to each task by selecting one of the intensities. The selected intensity value is multiplied by weighting of the task and then summed for each task to arrive at a total value for each attribute. These values are shown in the TOTAL column. Figure 15 depicts the CVX war-fighting attributes and their relative priorities.

Maneuver | Position | MovePrep

Strong 1 (1.000) | Medium 2 (.367) | Some 3 (.150) | Tad 4 (.062) | None 5 (.000)

| | ATTRIBUTES | TOTAL | MANEUVER POSITION MOVEPREP | --------- --------- MOVE | --------- --------- TACPOSIT | --------- NEGOTIATE --------- | --------- NAVIGATE --------- | --------- DOMINATE CTRFIRES |
|---|---|---|---|---|---|---|---|---|
| 1 | Aircraft Turnaround | 0.605 | 0.251 | 0.441 | 0.441 | 0.340 | 0.144 | STRONG |
| 2 | Data Management | 0.737 | 0.388 | 0.332 | 0.332 | 0.396 | 0.616 | 0.680 |
| 3 | Internal Communications | 0.793 | 0.474 | 0.443 | 0.443 | 0.583 | 0.764 | 0.729 |
| 4 | External Communications | 0.825 | 0.565 | 0.587 | 0.587 | 0.560 | 0.704 | 0.879 |
| 5 | Habitability | 0.255 | 0.243 | 0.180 | 0.180 | 0.260 | 0.173 | 0.147 |
| 6 | Launch and Recovery | 0.640 | 0.357 | 0.644 | 0.644 | 0.756 | 0.238 | STRONG |
| 7 | Material Distribution | 0.339 | 0.574 | 0.277 | 0.277 | 0.141 | 0.106 | 0.391 |
| 8 | Mission Planning | 0.700 | 0.355 | 0.454 | 0.454 | 0.455 | 0.557 | 0.910 |
| 9 | Seakeeping | 0.438 | 0.489 | 0.928 | 0.928 | 0.813 | 0.683 | 0.873 |
| 10 | Sensing | 0.630 | 0.365 | 0.650 | 0.650 | 0.910 | 0.789 | 0.976 |
| 11 | Signature Management | 0.482 | 0.271 | 0.511 | 0.511 | 0.668 | 0.332 | 0.855 |
| 12 | Training Implementation | 0.319 | 0.285 | 0.283 | 0.283 | 0.264 | 0.326 | 0.456 |
| 13 | Wpns & CM Employment | 0.563 | 0.205 | 0.645 | 0.645 | 0.668 | 0.125 | 0.976 |
| 14 | Wpns Handling & Storage | 0.480 | 0.533 | 0.338 | 0.338 | 0.298 | 0.056 | 0.867 |
| 15 | Endurance | 0.470 | 0.528 | 0.827 | 0.827 | 0.729 | 0.411 | 0.964 |

Figure 14 – Task / Attribute Correlation Example

Following a synthesis of the results, discussion developed concerning the accuracy of the results. It was noted that the top six attributes were cross-functional. As discussions continued the participants understood that these top attributes correlated to many of the CVX tasks; whereas launch and recovery was more specific to firepower and underway replenishment. The point taken was not that launch and recovery was unimportant, but that attributes like external communications cut across most of the tasks the carrier must be capable of accomplishing.

| No. | CVX Attribute | Warfighting Priority | No. | CVX Attribute | Warfighting Priority |
|---|---|---|---|---|---|
| 1 | Reliability | 0.837 | 20 | Aircraft Suitability | 0.478 |
| 2 | External Communications | 0.825 | 21 | Aircraft Maint/Material Spt | 0.472 |
| 3 | Internal Communications | 0.793 | 22 | Endurance | 0.470 |
| 4 | All Weather/Night Capability | 0.762 | 23 | Logistics Support Footprint | 0.442 |
| 5 | Data Management | 0.737 | 24 | Seakeeping | 0.438 |
| 6 | Mission Planning | 0.700 | 25 | Shallow/Littoral Ops | 0.436 |
| 7 | Launch and Recovery | 0.640 | 26 | UNREP | 0.433 |
| 8 | Sensing | 0.630 | 27 | Hardening & Protection | 0.414 |
| 9 | Degraded Operations | 0.625 | 28 | Agility | 0.374 |
| 10 | Aircraft Turnaround | 0.605 | 29 | Range | 0.366 |
| 11 | Wpns & CM Employment | 0.563 | 30 | Speed | 0.364 |
| 12 | Ctl / Restore Damage | 0.559 | 31 | Material Distribution | 0.339 |
| 13 | System Commonality | 0.545 | 32 | Training Implementation | 0.319 |
| 14 | Maintainability | 0.537 | 33 | Habitability | 0.255 |
| 15 | Battle Group Support | 0.533 | 34 | Space Flexibility | 0.239 |
| 16 | Redundancy | 0.510 | 35 | Accessibility | 0.217 |
| 17 | Upgradeability | 0.492 | 36 | Deployment Availability | 0.082 |
| 18 | Signature Management | 0.482 | 37 | Environmental Compliance | 0.056 |
| 19 | Wpns Handling & Storage | 0.480 | | | |

Figure 15 – Prioritized CVX Attributes

NAVSEA engineers will use previously cataloged potential technology investments to determine those technologies, which if pursued, could provide major increases in carrier effectiveness or efficiency. This will be accomplished by correlating the degree to which potential technology investments contribute to the prioritized CVX attributes. This list of relative technology priorities will aid in determining which potential enabling technologies can provide the best value for design of the CVX. Subsequently, AHP will be again applied to develop a strategy for funding technology investments within the constraints of CVX research and development.

**Index**