Computer Aided Long Range Planning of Real Property Investments

Janet H. Spoonamore, Richard L. Schneider and Prameela V. Reddy [1]

We develop a methodology for planners to use in preparing long range forecasts and address levels of uncertainty of these predictions to formulate facility investment plans. This proposed process includes two stages, one for identification and evaluation of implications of trends on Army facilities, and the second, the methodology for long term capital investment decisions.

Identification and Evaluation of the Implications of Potential Trends on Army Installations' Real Property Management

The U. S. Army Long Range Planning System

The U.S. Army has established a long range planning methodology which provides for the Total Army involvement in a long range planning process. This process defines linkages between long range goals, mid term objectives, and the programming process. The Army Long Range Planning System (ALRPS) or process is responsible for identification of significant long term military, political, social, economic, demographic, environmental, and technological world trends and their potential implications to the Army. It defines the methods by which senior Army leaders participate in plan generation and coordinate policy development. It further establishes the products/systems to be utilized to disseminate guidance and the means to govern plan implementation.

During the first phase of the ALRPS process, senior Army leaders develop their vision of the future and document it in part in the Army Long Range Planning Guidance (ALRPG). The ALRPG establishes goals for each Headquarters Department of the Army (HQDA) functional area and identifies the capabilities required by the Army to operate successfully in the future. It is developed with strategic guidance from the President, the Secretary of Defence and the Chairman, Joint Chiefs of Staff, through and iterative process involving the Secretary of the Army, the Chief of Staff, Army, Army Secretariat and Staff principals, Department of the Army Major Command Commanders, and Army Component Command commanders.

The second phase of the ALRPS process is the development of long range plans, for each of the Army functional or special areas reflecting the ALRPG. These plans forecast requirements 30 years into the future in consonance with the ALRPG, and as a minimum include: (1) definition of functional mission requirements for the long range period; (2) the goals and objectives for accomplishing mission requirements; (3) strategies or alternatives to achieve the specified goals and objectives; and (4).an explanation of how the plan correlates to Army warfighting concepts, doctrine, and other functional or special areas long range plans.

The proponent for the facilities functional area is the U. S. Army Office of the Assistant Chief of Engineers, Installations Planning Branch. They are responsible for the translation

---

[1]US Army Corps of Engineers, Construction Engineering Research Laboratories, P. O. Box 9005, April 1992 Champaign, Illinois 61826 9005

of ALRPG requirements into long range plans to guide the provision of quality Army installations real property support to the Total Army. They publish the Army Long Range Facilities Plan (ALRFP) which establishes the foundation for Department of the Army Major Command and Army Component Command installation and facilities plans. The ALRFP addresses facilities needs for a 30 year period in consonance with the ALRPG. It further establishes real property goals to be used by long range planners and the engineer community to guide military real property planning, programming, budgeting, execution and management activities.

Trend Identification & Analysis in the ALRPS Process/Facilities Planning

To be effective, the ALRPS process must successfully relate Army long range plans for all functional or special areas to the military, political, social, economic, demographic, environmental, and technological climate of the world as a whole. The Strategic Studies Institute of the U. S. Army War College provides key inputs in these areas into the ALRPS process. They are responsible for the review of strategic futures reports and other resources as necessary to identify significant long term world trends and their potential implications to the Army. Their successful identification and analysis of significant trends is critical to the effective development of the ALRPG and effective execution of the ALRPS process.

Trends affecting Army installation real property planning, programming, budgeting, execution and management are incorporated into the ALRPG. Guidance and trend documentation are broad in scope, however, relating primarily to the Army as a whole, and as such are insufficient to adequately develop the ALRFP or to apply to installations real property master plans. To assist the headquarters real property planners in the identification and analysis of trends that affect Army installation real property and in the synthesis of the many issues and trends involved in long range planning for installations, the U. S. Army Construction engineering Research Laboratory (CERL) developed a system called TRENDS. TRENDS is a prototype intelligent data management system designed to help Army planners at the headquarters level keep abreast of global trends that affect long range facilities plans. TRENDS models a dynamic process of locating information in, and incorporating new information into, a continuously updated database program. It is a microcomputer based system that uses a hyper text interface to reference global trends by title, category, or keywords. The system summarizes expert information on the implications of selected trends, lists titles of additional source information, suggests names of associated trends, and explains the relationships between global trends. TRENDS includes a telecommunications package allowing subject matter experts, and database users to network on facilities planning issues and to give feedback to system managers for database expansion with their experience, ideas, and expert knowledge.

Real Property Trend Implication Development

Current procedures established in the ALRPS process are an acceptable means of identifying the important issues that will shape the Army for the next thirty years and disseminating the vision and guidance of the senior staff. CERL s TRENDS system provides an additional tool for accessing trends information, as well providing references to possible facility engineering and demand implications. The process and tools fall short, however, in their capability to generate guidance that can be easily translated into installation real property master plans and capital investment strategies to prioritize real property investments of the long range period. CERL proposes to develop a new model for long range planning which addresses the implications of long term trends so investment plans take into account possible changes in engineering specifications or other facility properties, such as costs or availability, as well as alternative predictions in future facility requirements.

The current long range facility planning process is somewhat flawed in that long range plans are sometimes developed without full consideration of the uncertainties of predicted facility assets information, as well as the uncertainties of predicted facility demand information. Oftentimes, the facility planner uses only one alternative future expected facility demand curve (of course, broken out by facility types). Capital investment plans as described in the next section of this report, are developed to meet these expected demands. The planner prepares a single "best" capital investment strategy in a least cost mode, e.g., facility life cycle costs, etc. This "best" capital investment strategy is based on today's engineering "wisdom", and does not take into account likelihoods of possible changes in future facility assets. This "best" capital investment strategy is based on the expected facility requirements and does not consider any likelihoods of alternative requirements. Complicating the matter, these capital investments must be scheduled into budget constrained time periods. Part of the critical information needed in priortizing these investments are the predictions of the other alternative scenarios of facility impacts and demands. In order for trend analysis to be useful to the real property master planner, some basic but important questions need to be answered:

1 What are the trends and which are the most important?
2 How do these trends affect Army installations real property?
3 Which Army facility types (or groupings of types) are affected by identified trends?
4 To what extent and when will identified trends affect Army facilities?

If trends can be identified with associated prediction of alternative outcomes (with likelihood estimates), if the facilities implications for these outcomes can be identified by facility type or grouping, eg. roads and pavement, maintenance, supply and storage, medical, administrative, housing, recreation, etc., and the impacts on facilities quantified (for example scope, cost, and when the impact might occur) then the planner has sufficient information to prioritize real property investments

Planners analyze trends information and develop alternative trend scenarios and predicted facility impacts over the long range planning horizon. From their expertise, they estimate the likelihoods and the timing of the impacts for selected alternative scenarios. By observing the historical increase in public sensitivity to environmental pollution, planners might predict that in a certain future time period, engineering specifications and codes for facility category groups or specific facility types will be strengthened, resulting in changes in the unit costs of construction for these facilities. Estimates can then be made of the likelihood of this change (scenario) occurring by assigning probabilities to each of the scenarios. Planners might be 70% certain of their prediction in an increase in unit costs of construction for certain facilities types in a future time period. On the other hand, they might be 30% certain that the prediction of an increase will not occur. These two alternatives represent two scenarios, each having associated probabilities of occurrence.

As an example, an historical trend, such as local community economic growth can be used to develop scenarios of possible future housing costs. The real estate expert, analyzing these trends, predicts, each with estimated likelihoods, several alternative trajectories of out year housing markets, including costs and availability.

Scenarios are also developed, by the user and/or planner, which predict alternative future curves of demands for facilities, categorized by facility type. These predictions are also subject to high levels of uncertainty. The user and/or planner, analyzing historical trends information, can assign probabilities to the alternative predicted facility requirement scenarios.

Given the various trends determined to impact facilities by category group, the magnitude of the projected impact, and the predicted time that the impact will occur, the planner can make programming comparisons with other facilities requirements to prioritize real property decisions/acquisitions. Trend analysis will result in a prioritized listing of facilities by category group for each predicted outcome. Each predicted outcome, having an associated likelihood estimate, along with the associated facilities requirement, form the basis for developing investment plans.

Figure 1 is an illustration of how such an analysis might occur. Each alternative projected outcome of a trend will be analyzed to determine if there is an impact by facility category group. The alternative outcomes and individual independent facility affecting trends for that alternative are listed horizontally in Figure 1 [**A**(lternatve)**1:T**(rend)**1**]. The facility category groups (FCG) to be prioritized are listed vertically in Figure 1 [**FCG** (roup)**1**]. For each alternative, there may be one or more independent trends that effect the facility category grouping. The effects of each independent trend are quantified and plotted over time. Additionally, the point in time at which the impact on the facility category group will be critical is identified [•]. The sum of the effects is then identified in the right hand column [**A1T**Σ]. The figure demonstrates that after analyzing the impacts of environmental, demographic, and military trends, the sum of the projected impacts for maintenance facilities is greater than that for the other category groups, and therefore maintenance facility projects are to be given priority. If evaluated in more detail, this may result from high and near term costs for environmental remediation projects in maintenance facilities, versus lower costs and a more long term requirements for family housing acquisition, results in a higher priority on environmental remediation projects in maintenance facilities.

Capital Investment Strategy (CIS) Decisions in the Planning Process

Following the development of long range forecasts for facilities requirements, the next step of the process is to prepare investment plans meeting these requirements. The capital investment methodology has been instituted as a component of the Army installation master planning process.

Issues in Capital Investment Decisions

The analysis of requirements, the comparison, and identification of the projects to provide the best value for the money is a complex issue. The understanding of any complex situation is derived from numerical measurements associated with that situation. In the productive sector of the economy a building or a facility is just a factor of the cost of production and has a precise monetary value. Its value depends on the income it generates to the company. Investment decisions in public buildings are not profit motivated. Most public buildings, specifically Army facilities are designed to meet specific needs, and those buildings have value as long as they are functional. So the investment decisions in public facilities or projects depend on the contribution of these facilities to the accomplishment of the mission.

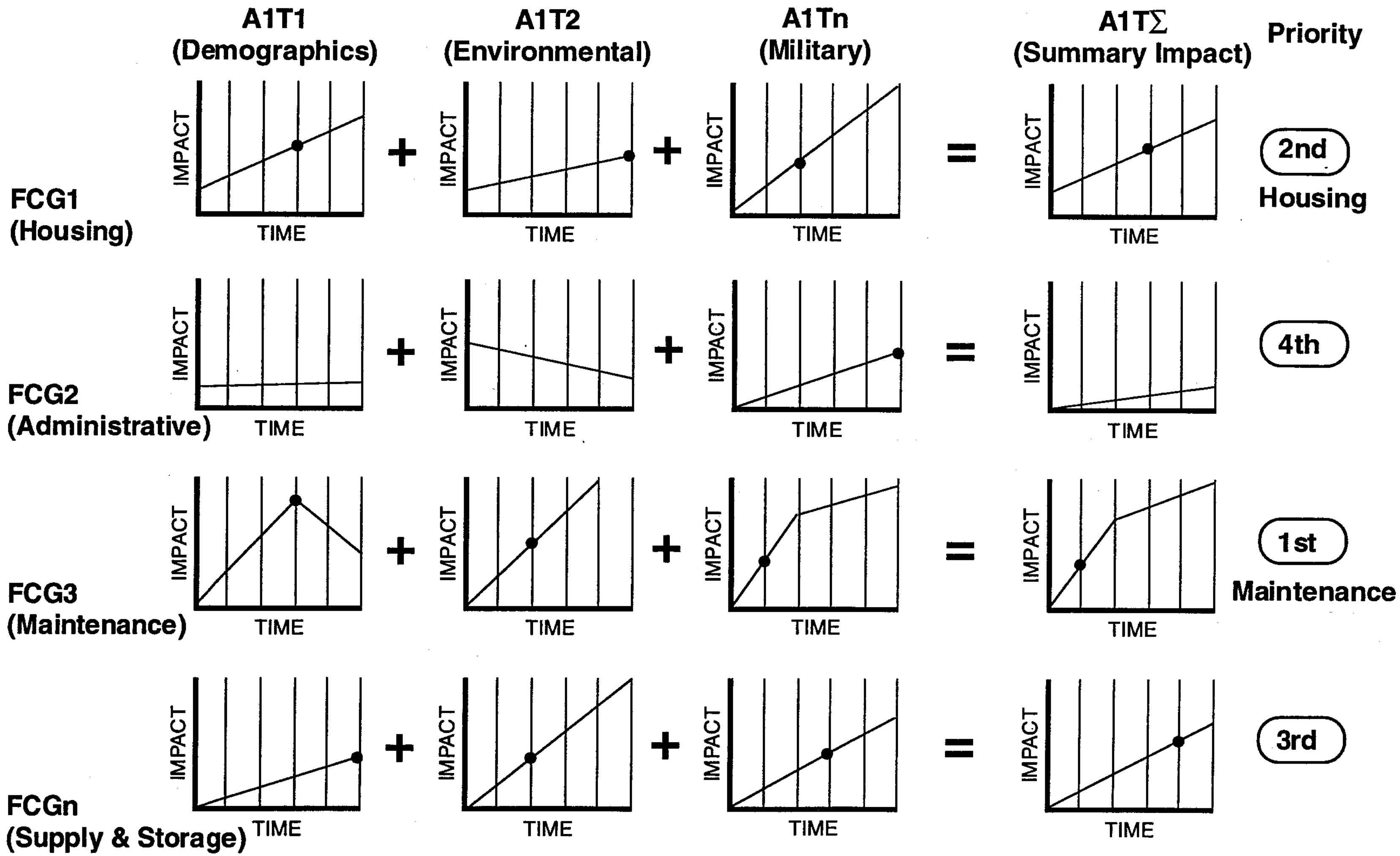

Figure 1 - Facilities Impact Assessment

Legend:
FCGn = Facility Category Group Number
AnTn = Alternate Number/Trend Number
● = Point Where Impact is Critical

Measurement of the contribution of the facilities to the accomplishment of the mission is part of the analysis of requirements. The quantitative data such as shortage of a certain type of space is available from the tabulation of existing and required facilities. Qualitative measures such as functional adequacy of existing facilities, the impact on safety, security, environment, aesthetics, productivity are difficult to measure quantitatively. Measurement of economic value of a building includes comprehensive evaluation of the attributes in relation to each other.

Planners at DOD Installations need to plan for facilities to satisfy occupancy needs. The facilities requirements are to be analyzed, and a plan to satisfy the total requirements is to be developed by the planner. The result of a sound master planning approach eliminates inefficiencies and maximizes return on investment.

In order to provide a methodology to assist the planners in making such decisions, CERL is developing a decision analysis tool. Decision analysis provides tools for quantitatively analyzing decisions with uncertainty and/or multiple conflicting objectives. Long range planning decisions are typical examples of complex problems involving numerous interacting factors and conflicting military, political, social, economic, demographic, environmental, and technological objectives. A decision analysis tool assists the decision makers to evaluate alternatives so that the decision maker can make an informed decision.

Multi Attribute Decision Analysis Approach (MADA) for CIS

Capital investment decisions in facilities and infrastructure planning are typical examples of complex problems involving numerous interacting factors, multiple conflicting objectives, and alternatives that differ from each other qualitatively as well as quantitatively. This section describes the Multi Attribute Decision Analysis (MADA) method to incorporate productivity and other benefits from alternative facilities into Life Cycle Cost analysis. This method permits more than one performance attribute or criterion to be considered in a decision, even if the criteria are not measured in comparable units [Zeleny 82]; [Keeney 76]. For example, MADA can account simultaneously for both traditional life cycle cost measures denominated in dollars, and nonmonetary measures of productivity impact.

In MADA process, the decision maker establishes multiple objectives and evaluation measures, or attributes to measure the desirability of the various alternatives with regard to each of the objectives. The objectives and attributes comprise the value structure. The desirable properties for a value structure include completeness, operability, decomposability, lack of redundancy, and size (Keeney and Raiffa, 1976). The objectives, attributes, and values are identified, and are used to assess the value of alternatives. The alternative with highest value is the preferred choice.

The broad overall objective for facility investment analysis is to make economically effective decisions. The detailed objectives are specified in more operational terms. The detailed objectives in planning process are: meet mission requirements (user requirements), safety, security, good physical condition, maximum productivity, convenience, environmentally safe, good appearance, good location, and minimum life cycle costs. The sub objectives might further be broken into lower level objectives. Each of these lowest level objectives is associated with attributes which CERL is developing. These attributes will indicate the degree of fulfillment of these objectives for each alternative. CERL is also developing the weights and value structure for this complete set of attributes using Army regulations, literature searches, and brainstorming with planners and decision makers. This value structure forms the basis for Army facility planning decisions.

Before using MADA facility investment analysis, planners analyze and generate the total long range facilities requirements to identify the needs and shortcomings by facility type (Figure 2). Planners then generate alternative strategies to satisfy each requirement. An inspector with technical area expertise, eg. fire safety, structural, environmental, etc., evaluates each alternative facility for its performance against the attributes and scales of measurement developed by CERL.

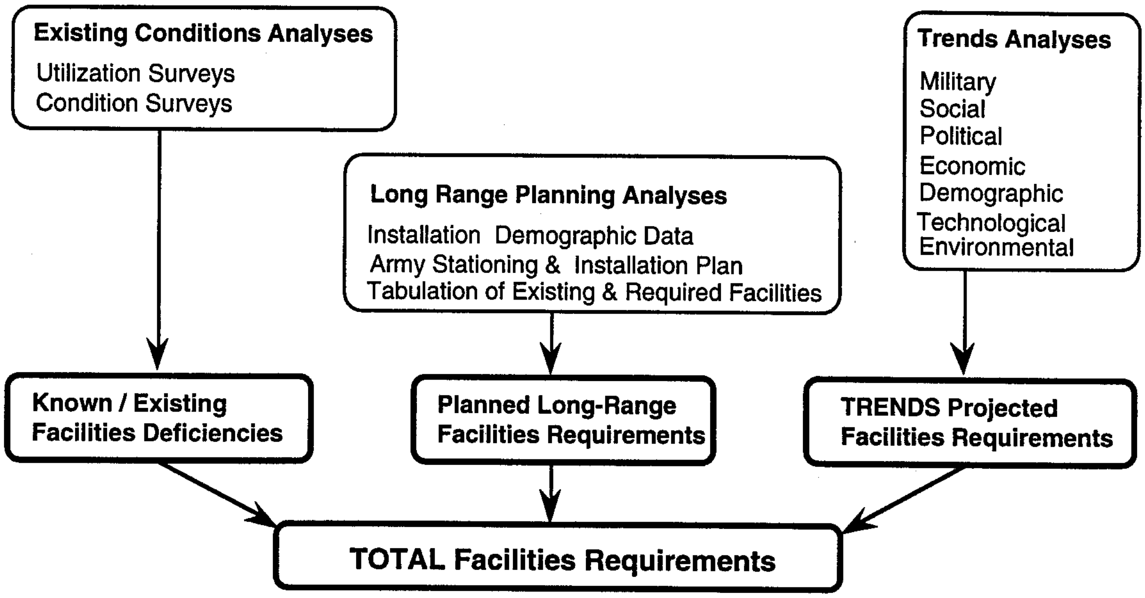

Figure 2 - Hierarchy for Requirements Identification

The planner enters the scores of the attributes into the model for each alternative. The performance of each alternative X is derived by the technical area expert for each attribute A yielding attribute ratings V (X). Weight W , developed through CERL research, is applied to each attribute by the model, reflecting its 'relative importance' of value differences in the attributes. Finally, weights and single attribute ratings are combined into an overall evaluation of each alternative by an additive model:

$$V(X) = \sum_{i=1}^{n} W_i V_i(X)$$

Figure 3 is a simple illustration to show how CERL, working with planners, technical experts, and decision makers, will develop the value structure for an office building requirement. The sub objective under the broad overall objective is 'meet user functional requirements'. The subdivisions and attributes are shown in this figure. Weights are attached to these sub objectives, and attributes to indicate the relative importance of these factors. Normalized weights and values are used in the determination of the overall value for this sub objective. This process continues with each objective to ensure that it is included in the combined objectives hierarchy. Most of the attributes in planning decisions are subjective, and as a result, a subjective index is being constructed to measure the performance of specific facilities against these attributes. As an example the inspector might subjectively rate the facility using five possible scores, eg. excellent, good, moderate, poor, and failed. CERL is developing such scales and inspection methods for each one of these attributes. Using the value structure the planner develops overall scores of each one of the major objectives for all selected alternatives. The planner estimates life cycle costs of each alternative using ECONPACK (Economic Analysis Package for Army facilities).

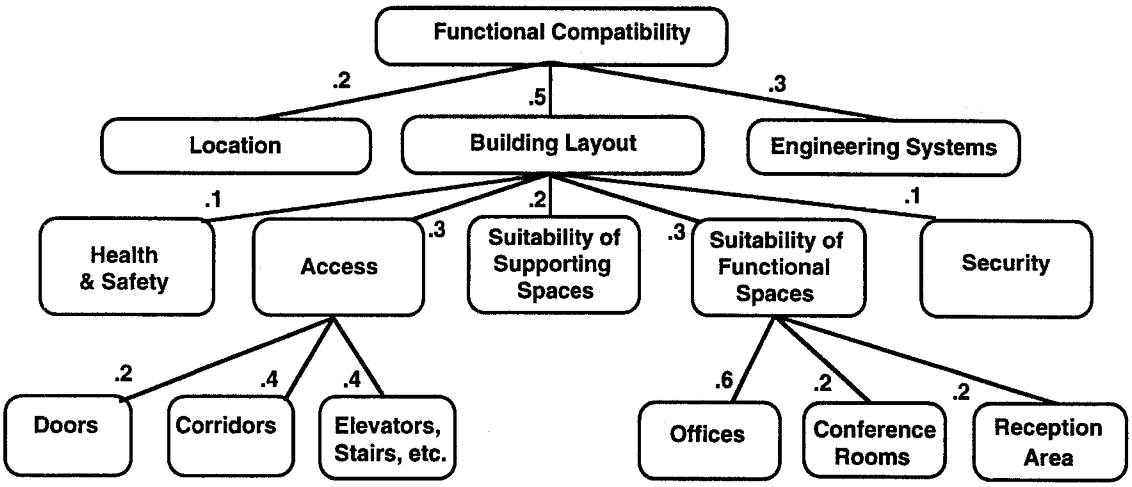

Figure 3 -Sub - objective: Meet User Functional Requirements

The planner presents the alternatives, life cycle costs, and performance scores of the objectives to the decision making group. This group may use this higher level part of the model to analyze tradeoffs, and the preferred alternative. The group may wish to vary the weights of these top level objectives to perform sensitivity analysis.

Figure 4 is a simple illustration of how a planner can use this process to help the decision making group to determine capital investments. This illustration focuses on one particular type of MADA, the Analytic Hierarchy Process (AHP) [Saaty 88]. The AHP structures a complex decision into a hierarchy with the decision criteria at the top and the alternatives to be evaluated at the bottom. The sub objectives we have discussed earlier can be used as decision criteria with their weights. The decision depends on all these criteria with their corresponding weights. The relative weights are combined with the performance scores to derive a single overall rating for each decision alternative. The alternative with the highest overall rating should be selected. The use of this decision aid helps clarify issues for individual decision makers and provides a deeper understanding of the alternatives.

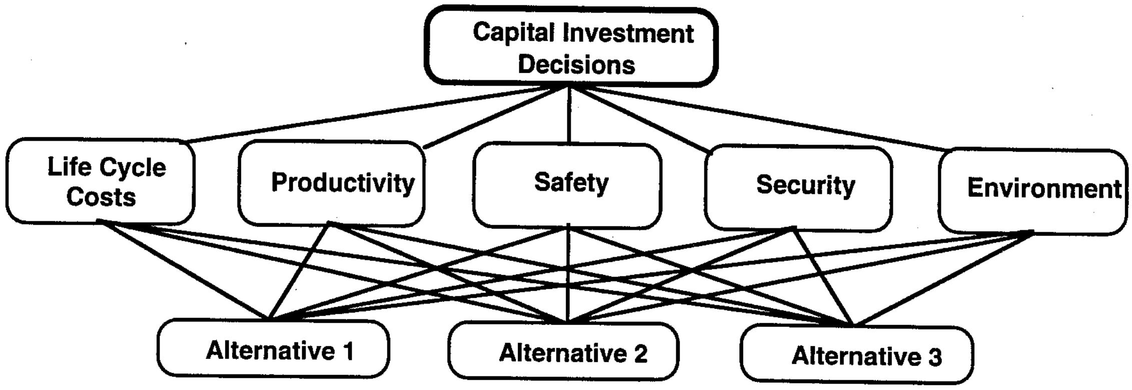

Figure 4 - Capital Investment Decisions

Conclusion

The methodology developed here will be validated and, if shown to be effective, put into practice in our planning community. Since the Army operates similar to any other corporate enterprise, these methods should be equally applicable to long range facility investment planning for municipalities, and other political/economic units. It is very likely, within five years from now, that new policy will govern the preparation of plans for long and short term facilities investments at the installations. This new policy will require tighter interaction between long and short term plans for construction and operations and maintenance investments, specifically addressing the implications from future planning horizons on the operations and maintenance unconstrained resource requirements. The change in policy will likely involve formation of a planning team, composed of planners and functional proponents, where they prepare a unified long and short range plan for investments which simultaneously minimizes the costs over the sum of all program areas. A question which is yet unanswered is how one can take long range planning information, which has high levels of uncertainty, and apply this information in planning decisions.

New research, which is not described here, will specifically address the conditions under which highly uncertain information is applicable for use in long range planning.

Bibliography

[Adiguzel 91] Adigúzel, I. R., T. J. Kim, and D. L. Fields, *An Automated Approach to Global Trends analysis for Installation planning* Technical Report P 91/44 USACERL, September 1991.

[AR 89] Army Regulation (AR) 11 32, Army Long Range Planning System Department of the Army [DA], 10 January 1989.

[ALRP 91] Army Long Range Planning GuidanceDA, June 1991).

[ALRFP 89] Army Long Range Facilities Plan ,Headquarters, Office of the Assistant Chief of Engineers [HQOACE], November 1989.

[Fields 91] Fields, D. L., *The Application of Computer Aided Expert Decision Support System to Developing Countries: A Case of Rural Development in Kenya* Graduate College, University of Illinois at Urbana Champaign, 1991.

[Keeney 76] Keeney and Raiffa, *Decisions with Multiple Objectives* Wiley & Sons, Inc.1976.

[MPCISW 91] Master Planning Capital Investment Strategy Workshop ,HQOACE, October 1991.

[Saaty 88] Saaty, T. L. *The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation* , McGraw Hill, Inc., 1988.

[Stone 80] Stone, P. A. , *Building Design Evaluation: Costs In Use* ,E. & F. N. Spon Ltd., 1980.

[Zelany 82] Zelany, M. *Multiple Criteria Decision Making* , McGraw Hill, Inc., 1982.