An Evaluation Criteria Model for the Navigation Network System Design

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The classic framework for analysis ultimately follows a series of rules whether or not those rules are consciously applied. The rules usually take the form of: define the problem (system); define a measure of effectiveness; generate alternatives based on analysis; and, weigh and decide. Many methods have been developed and many analytical and quantitative techniques and tools designed for general applications to different models. This paper describes the approaches used in developing the basis for a system design evaluation model. Two well known evaluation cases are modeled, leading to a general model that is then detailed for application specifically to the Navigation Network conceptual designs. Identification of the system attributes and their associated perspectives and the method of scoring and ranking a candidate design are discussed.

I. Introduction

In the conceptual phase of development of any new system, several approaches are taken to ensure the best possible solution of the design problem; several because there is simply no a priori way of knowing which approach will best meet the user's need within a defined set of constraints. Since it is not cost effective to expend resources in constructing different prototypes to physically (actually) test each of the approaches, evaluations need to be performed during the paper stage of design.

There are two factors that make evaluation difficult. First, although attributes such as growth potential and operability tend to be common to all purpose-designed systems, all such systems are not alike. Therefore, the capacity to view each of the attributes in their true relations or relative importance assumes a system uniqueness that makes their definition elusive and time-consuming, especially since both the attributes and their perspectives must have the support of a consensus of those persons representing the organizations that ultimately have a stake in the new system. These are among the matters that must be dealt with at the engineering level of the design organization.

The second factor is that decisions regarding the choice of approach to be used in building the system have to be lived with for many years after implementation. Modifications are expensive and the downtime, for example, may be unacceptable to the system user. In this context, the choice, or decision, is made at the management level but the quality of the choice is heavily dependent upon the degree of professionalism applied in the development and application of the system evaluation criteria at the engineering level.

II. Considerations and Requirements

One of the tasks defined in the pre-Project phase of the Navigation Network Study was the determination of a set of evaluation criteria for the candidate designs, which were to be developed under yet another task.

The principle purpose of the evaluation criteria was to provide Project Management with an acceptable means of judging the merit of each candidate design and an acceptable, uniform method of scoring and ranking each. Subsidiary purposes were to:

(1) Assist the Design Study Team by suggesting topics to consider in their efforts to produce acceptable candidate designs.

(2) Assist in identifying the level of work necessary and the amount to be done in completing a candidate design through the research/reference stage to provide the data needed to respond to relevant evaluation criteria.

(3) Give DSN Management, in association with the Project Report on how designs are ranked, another input to use in reaching a decision whether or not to proceed with the Navigation Network implementation.

The requirement that the evaluation criteria had to be developed separately and independently from the candidate designs themselves posed an initial difficulty in getting a useful word picture, or model, of just *what* would constitute a candidate design. No written, formal definition was available, so a definition was developed and given for practical purposes as a "functional design." To expand this a bit further, the planning configuration design used to develop future budget line items for the Navigation Network served as a useful example. The planning configuration is described here simply as a set of configured generic hardware, and for the sake of completeness as receiving instruments consisting of a 10- or 20-meter antenna, a cryogenic front-end amplifier, the VLBI receiver and sampler, a frequency and time standard (H-maser), a control computer, and the communications equipment (DOMSAT).

III. Model Development Approaches

Three different approaches were investigated, initially, in an attempt to find an acceptable model of the evaluation process: an engineering approach, a library research approach, and a strawman approach.

A. Engineering Approach

In the engineering approach, a survey was made of the work other persons in the DSN had done in the area of evaluation criteria. The results of the survey were so meager they could not be used.

B. Library Approach

Concurrent with the engineering approach, a library research effort was initiated to determine the availability of useful literature on evaluation criteria that could be obtained and used within a reasonable time period. This research also proved fruitless in revealing how an evaluation criteria process might be developed.

C. Strawman Approach

The criteria for the strawman approach were developed from suggestions made by various DSN personnel. The criteria were partitioned under topic headings, for example, Design and Operation, using very flexible rules to afford the semblance of order that was needed because the randomness of criterion input was not conducive to their falling into cognitive relationships. In retrospect, the strawman criteria can be viewed as a set of unstructured attributes mixed-in with system requirements.

The strawman criteria were sent to a number of managers who had fiscal, technical, or user interests in the proposed Navigation Network; their comments were solicited, and responses received were carefully reviewed and were interpreted to mean that:

(1) A series of filters or gates were needed to weed out candidate designs that were unresponsive to the desired attributes.

(2) Cost and risk were elements of the evaluation process that should be treated as parameters and not as attributes.

An analysis of the comments received pointed to the inadequacy of the strawman approach to develop evaluation criteria; however, the comments nourished the thought that a generalized case model would be feasible.

IV. Definition of a Case Model

The basic ground rules for a generalized case model were established as simply as possible. The case model:

(1) Should not be associated with the DSN.

(2) Had to be sufficiently complex to require more than a superficial effort to develop.

(3) Had to be one that most people could readily identify with and understand in order to sustain their interest.

The methodology was to distil the underlying philosophy of evaluation from the case model and to adapt it to the current need. With the ground rules in mind, two cases were identified where individuals make large expenditures in relation to their personal income that require prudent consideration at each stage of their involvement: the purchase of an automobile and the purchase of a home.

It was decided to look at both cases to determine what concepts were involved in the respective evaluation processes. Since the Navigation Network could conceivably involve the use of new equipment at new locations, it was further decided that the cases to be defined should be the purchase of a new automobile and a new custom home. In citing the need for new and custom items, it was felt that a greater effort would be required and thus result in a more definite process than cases involving the upgrading of an existing automobile or home.

Although both case study results are available to the interested reader, only one – the purchase of a new automobile – is described further for the purposes of illustration.

A. Purchase of a New Custom Home

Not described further due to time and space limitations.

B. Purchase of a New Automobile

1. Requirement. The requirement for a new car has to be formulated in general terms as a first step in satisfying the need. As an example, the requirement could be for a sedan in which a family may be transported on short urban journeys with economy of operation, after incurring a certain initial cost.

The first logical step is to obtain automobile marketing data, which may be accomplished by obtaining brochures of various models handled by local dealers representing several different manufacturers. At this point the prospective purchaser goes through a preliminary elimination or weeding-out process of candidates by reviewing the contents of the brochures. This will eliminate automobiles that:

(1) Are not sized for that particular family.

(2) Have a fuel consumption that delivers fewer miles per gallon than required.

(3) Exceed the upper cost limit.

2. Technical constraints. Models that meet the initial requirements are then subjected to further scrutiny based upon technical constraints. Here the criteria will reflect personal experience and may perhaps include:

(1) Number of years the model has been available to the public without significant modification or manufacturer's recall to rectify design defects.

(2) Resale value of earlier version of the model.

(3) Opinions of other users of a particular model who are qualified in the eyes of the prospective purchaser.

Additional models may be eliminated at this point through their subjective failure to meet all, or most, of the technical attributes considered relevant by the prospective purchaser. Those candidates that survive are given some preliminary order of preference, based on how well they subjectively meet the technical attributes overall.

3. Optimization evaluation. Each of the remaining candidates then goes through an optimization evaluation to determine how closely certain needs are satisfied. These needs might include:

(1) Driveability.

(2) Passenger comfort and convenience.

(3) Performance improvement.

(4) Appearance.

(5) Safety.

The candidates are then ranked accordingly to how well all the criteria have been satisfied by different manufacturer's models and option combinations.

4. Cost. In parallel with the optimization process, the cost of ownership is being developed. Costs include:

(1) Cost of basic vehicle and selected options.

(2) License fees and taxes, annual.

(3) Insurance, annual.

(4) Estimate of annual fuel costs, based on some arbitrary distance.

(5) Maintenance costs, annual.

5. Additional considerations. The final choice of vehicle, or even a decision to buy one at all, may depend upon additional considerations such as:

(1) Availability of the model in the desired configuration at the needed date.

(2) Dealer concessions on the total price.

(3) Availability and cost of financing under different purchasing plans.

(4) Ability of the prospective buyer to dispose of his existing vehicle at what he considers to be a fair price.

(5) A willingness to relinquish or defer one or more options to meet cost constraints.

(6) Opportunity costs.

C. Workability of the Case Model

The workability of the two case models must be demonstrated; the best way would be to use them in the respective process of new car and custom-home purchasing. Since neither activity is feasible, the next best thing is to obtain the opinion of experts as to the usefulness of the case models.

1. Expert opinion, model 1, new custom-home. This case model was first reviewed separately by two practicing civil engineers. They both agreed that the process was acceptable but recommended changes and additions to the evaluation criteria, which were included in the model.

The revised model was then reviewed by a mechanical engineer who is in the process, personally, of constructing his own home. He agreed that the process was essentially correct and that although he thought that some more evaluation criteria might be included, the model was adequate for the present purposes.

2. Expert opinion, model 2, new automobile. This case model was reviewed separately by two managers who had recently purchased new vehicles for themselves. Each one agreed that the process was essentially the one they had gone through, although neither one had written it down on paper. Both remarked that they would use some additional criteria and these were added to the model used in this report.

Based upon the interview statements, it was concluded that the evaluation processes of the two case models were workable and useful.

D. Word Representation

A word representation of the evaluation process was developed for each of the two case models. A comparison revealed a close degree of correspondence in their respective structures. The result of that comparison may be characterized as follows:

(1) Requirements have to be expressed in terms of:

(a) What has to be done.

(b) How well the purpose has to be done.

(c) A ball-park cost limit expressed in terms broad enough to invite effective competition.

(2) A wide range of candidate designs, products, properties, and services already exist to satisfy the most discriminating of needs. The market has to be researched for those that might qualify for candidacy.

(3) An initial evaluation is necessary to eliminate those candidates:

(a) That do not meet the functional and performance requirements.

(b) That exceed the upper cost bound.

(4) Survivors of the preliminary requirements evaluation then have their capabilities subjected to a technical attributes evaluation where some feelings as to order of choice are expressed and some final candidate rejections may be made because the risks and inconveniences outweigh the benefits and conveniences of ownership.

(5) The initially ranked candidates are studied in detail and the optimization of the attributes within the physical constraints imposed by a particular design are evaluated. Then for each feature of design, the evaluation results of the candidates are compared and a final order of technical preference is established.

(6) In parallel with the optimization evaluation process, the fixed, one-time costs and the continuing costs are estimated to an accuracy that is consistent with the available data.

(7) The decision to procure any of the final candidates is developed from weighing different financing plans, for example, outright purchase, deferred payments, leasing or rental, and constraints (a set of evaluation criteria reflecting the state of family affairs) imposed by the business climate against the technical capabilities to be offered in each case. The choice may also be influenced by the ability of any of the final candidates to tolerate changes of certain feature optimizations in order to meet cost limitations while still being able to perform the essential task.

Alternative representations are often useful in developing additional perspective on a problem. Figure 1 shows a top-level block diagram of the generalized evaluation criteria process, derived from the word representation of the case models.

In practice, the expansion of each of the block diagram boxes to give increasing detail of the internal processes will be dependent upon the point in the diagram that the action has reached. Initially, it is desirable to minimize the work to be done because the number of candidates will be greatest. Therefore, it would be expected that the processes at the top of the block diagram would be simplest; i.e., the go/no go kind.

At the next level, more judgement and consideration would be needed in evaluating each attribute of the candidate, with rejection still being a more or less probable result. At the technical optimization evaluation and life cycle costing stage, however, more detailed processes would be expected since more precise data need to be generated to satisfy the desire to "get the best for the least." It is also conceivable that the block diagram process as a whole may be repeated more than once if some of the criteria applications reveal marginal technical capabilities that can be relieved only by changing the functional, performance, or initial cost requirement.

V. Definition of the Evaluation Criteria Process

Figure 2 shows the top level flow chart that evolved from the task of developing the Navigation Network evaluation criteria process from the general model. It has the same essential flow of data as shown in Fig. 1. The major change has been to differentiate between the processes and decisions to emphasize the progressiveness of the acceptance or rejection of candidate designs.

The flow chart (Fig. 2) may be regarded as being divided into four stages in series. The first stage consists of the functional requirements, performance requirements, and upper cost limit gates. Simple decisions are made here on whether a candidate design will be able to do all things it is supposed to do and do all of those things as well as it should at an affordable cost.

In the next stage, the remaining candidates are evaluated and scored for their compliance with Technical Attributes and given a preliminary ranking. If there is an obvious dichotomy in that ranking, those candidates in the lower subset will be eliminated at the Technical Ranking gate. Candidate design rejections occurring at this point will further reduce the amount of detail work that has to be done in the third stage. Here the surviving candidate designs go through two parallel processes.

In the one, they are evaluated and scored on how well the competing needs of Implementation and Operations are satisfied, and the Intermediate Ranking that follows is critically reviewed to determine if there are any obvious inconsistencies in that ranking, caused by scoring subjectivity, that need to be corrected. Any subsequent ranking changes are justified and documented. In the second parallel process, the life cycle cost of each candidate is estimated to a level of accuracy consistent with the available data.

These two data components constitute the output requirements of the Navigation Network study and are two of the inputs to the Management Review process. Other inputs include the alternative funding plans that are created to meet the different costs of each of the candidate designs and business constraints, such as the choice of performing the detail design of the selected system in-house, or to let a system mode contract.

To define the system attributes needed at the Technical Evaluation stage, the various constraints to be placed upon each candidate design were considered. They were loosely identified as Implementation, Operation, Management, and User; a general question was formulated in each case to relate them to the Navigation Network. Typically, for the Operation constraint the question was, "How will this design affect existing operational activities and procedures?" Answering this question made it easier to see the relationship between the constraints and the system attributes, as well as between the constraints and the general model, so as to be able to place them in the model accordingly.

Each attribute needs one or more perspectives in the shape of a question that will act as an evaluation criterion or discriminant. This part of the task is difficult to do because a thorough knowledge of each of the constraints is needed. So both the attributes and the perspectives have to be developed and refined through iterative discussions with the numerous persons possessing the appropriate knowledge and an interest in the quality of the final design.

To define the system attributes and perspectives for the third or Technical Optimization stage (see Fig. 2) the constraints considered were Implementation, Operation, and Cost. The question used, for example, to relate the Implementation constraint to the general model was "Is this candidate system easy to design?"

An essential part of the evaluation process is the recording of how effectively a candidate satisfies a particular criterion. The purpose of setting score values for the evaluation criteria is to provide the evaluators with a first indication of how the various designs rank against each other. To decide on the score values, the set of evaluation criteria has to be complete; that is, the system attributes to be evaluated and the wording of the associated perspective statements must have had consensus approval before development of the scoring can begin. The set of evaluation criteria have to be searched for a theme that can be used to partition them into subsets. If more than six subsets result from this process it is probably too many and another theme should be considered. In the Navigation Network evaluation task, four different levels of risk were conceived and used to score the evaluation criteria as follows:

(1) Criteria that must have a positive response since failure to satisfy them could mean failure of the design to meet the user need.

(2) Criteria related to those areas of relative inflexibility, and therefore high risk, that could impact costs severely if it turns out later that the wrong decision had been made. For example,

    (a) Key equipment characteristics that, once fixed, cannot be changed without impacting operational requirements, commitments, and costs.

    (b) User costs.

(3) Criteria related to Operations where the risks may be considered as next lower, because of the potential for flexibility and work-around.

(4) Criteria that are considered to be related to the lowest, most controllable risks.

Clearly, four scoring values are needed. There is, however, a second condition to be satisfied. Some of the perspectives are worded to determine whether the candidate design will be advantageous, neutral, or disadvantageous in terms of the attribute being assessed. In such instances the scoring value is given a plus and minus range.

Those criteria concerned with the highest risk were given a yes/no response. The next level was given a score of 10. No attempt has been made to differentiate between the criteria in this subset in order to establish the range of severity of risk. It is felt that if any such differentiation becomes necessary it will occur naturally during the ranking review when each case will be argued on its own specific merits. The subset of criteria whose level of risk is associated with "flexibility" and "workaround" is given a scoring value of 6 while those criteria associated with the lowest level of risk are given a scoring value of 3.

The ranking of the Navigation Network design evaluations is to be carried out in three phases. Candidates that reach the Technical Attributes Evaluation stage are evaluated and scored. Their scores are then individually totaled and the preliminary rank is decided on the relative total score so that the highest scoring candidate will be ranked first. A similar activity takes place at the Technical Optimization Evaluation stage. Here the scores for a candidate design are added to those it obtained at the previous level of evaluation to produce a total score on which to base the intermediate ranking. This ranking is not the final arbiter. A review of how each score is obtained and how it influences the ranking may uncover doubtful or unacceptable conditions existing among the rank leaders and underrated or highly attractive conditions lurking among the rank trailers. This situation can only be resolved by a round of evaluation that concentrates on the perceived inequities created by the first round. This review will be conducted by the Navigation Network Project team. Their determination of the ranking with the reasons for any changes that they make will be presented to the Technical Steering Committee with an open forum for comment. Further reasons for ranking changes made at this meeting will be considered by the Project Manager before he makes his ranking recommendation to the DSN management.

Some dissimilarities have been noted between the general model evaluation process and the Navigation Network evaluation process; these are:

(1) Detailed designs for new homes and production models of new automobiles are readily available from which the individual may make a choice; whereas the Navigation Network functional designs have yet to be developed. This dissimilarity may be disregarded, however, because if no candidate designs are developed the Evaluation Criteria will serve no useful purpose.

(2) The intent to procure a new home or automobile has to be of a high order or the individual will not undertake such a time consuming task, whereas the decision to build a Navigation Network is an institutional, rather than an individual, decision. Since the decision is outside the scope of the Evaluation Criteria this dissimilarity may be disregarded.

(3) There is an opportunity in the Navigation Network evaluation process to modify candidate rankings by a review procedure that was not observed in the general mode. There are two possible reasons for this. First is that an individual who is evaluating automobiles or home designs is most likely doing that job with little formality, the "scoring" being done mentally. So the need for the ranking review would not arise. Second, one or two persons with fairly identical interests will be concerned in an automobile or new home purchase whereas a number of users having considerable diversity of interests are concerned in getting the greatest group use out of a unique facility such as the Navigation Network.

(4) The costing of a new home or automobile at the detail level is a very much simpler task than costing a new design for a Navigation Network at the conceptual level. Also, the differences in cost are of several orders of magnitude greater for the Navigation Network compared with the car or home.

Table 1 lists the complete set of Evaluation criteria that will be used in the evaluation process of the Navigation Network as illustrated in Fig. 2. Considerable care was exercised in writing the various perspective statements. As a result they are concise, and to stimulate discussion during their development a short note was written about each one to explain the background and to suggest how a candidate design under consideration might be scored. A subset of these notes that refer to the Implementation constraint are appended below.

A. Maturity

The purpose of the question is to find out: (a) if the theory of the basic principles of the design has been developed to the satisfaction of the scientific community concerned with such matters, and (b) if these principles have been adequately demonstrated in practice through the use of purposefully designed hardware/software. A "Yes" answer to the question should get the maximum score. There is also a case for considering the question to rate "Yes" or "No" only, with acceptance of the design for a "Yes" response and rejection for a "No." This approach, however, has not been selected for these Evaluation Criteria.

B. Buildability

If the design under consideration is considered to be so specialized that a qualified electronic equipment manufacturer would need special facilities, tools, or skills to do the job, then the design should be given a zero score. If, on the other hand, it is considered that the design can be built commercially with a very low probability of a cost overrun or late delivery, or both, then the questions should receive the highest possible score.

C. Practicability

If the baseline geometry permits view periods of sufficient duration to enable the ground station equipment to acquire necessary and sufficient data to satisfy the needs of all the expected concurrent users, then the question should receive the highest score. Otherwise, the specific design under consideration should receive a lower score.

D. Testability

The purpose of the first question is to ensure that the design, if built, can be tested simply and easily whenever necessary to ensure that the capabilities are within specification. In addition, the testing has to be accomplished with ordinary test equipment used by trained maintenance technicians in a short time span at low cost. There is a strong desire to be able to test the design performance by independent means. This could be accomplished by using other DSN equipment or the facilities of other organizations. These independent verifications, therefore, will have to be done infrequently because of the coordination effort required and the extra cost involved. If the answer to either question is "Yes," then the design should be awarded the highest score. For a "No" answer the score should be zero.

E. Compatibility

Integration of the Navigation Network with the DSN could disturb the planned or implemented compatibility of the major interfaces. These interfaces involve equipment, software, RF links, technical information, data and operations. Some of these interfaces will be of interest only if a Project is in a flight phase; if a Project is in any pre-flight phase then all of the interfaces would be of interest. If any interface:

(1) Will remain unchanged, then a zero score should be awarded.

(2) Is changed in a beneficial way, then it should be given a positive score.

(3) Is changed in a way that creates any new burden or imposition, then it should be given a negative score.

F. Growth Potential

Past experience had shown that DSN equipment has been used in a capacity or has served a purpose that was not perceived at the time of its original design. On other occasions, equipment has been modified to do additional tasks without detriment to the original task. But here we are concerned with equipment in the conceptual stage and yet to be built. If we know that the capability has been deliberately limited for reasons of time or cost, we know that there is growth potential. If we can observe a recognizable innovation rate in the technical field of interest, we can expect growth potential. Those designs that have an identifiable growth potential should receive a positive score, whereas those with obvious growth limitations should receive a negative score. Designs with no identifiable growth potential and no obvious limitations should be given a zero score.

G. Schedule

At the conceptual level, the only schedule data available is the PERT/CPM chart maintained by the Project Office. If that chart shows completion on schedule for a particular design then a maximum score should be given.

H. Safety

The question here is not whether the equipment can be designed to meet federal or state safety standards, since that is mandatory. The question is how fault tolerant can the equipment be designed to localize failure damage, and will the risk to life be no worse than already experienced within the DSN, keeping in mind the need to implement a highly automated system. A design meeting such requirements should be given the maximum score.

Table 1. Navigation Network evaluation criteria

	Navigation Network evaluation criteria requirements	
Attribute	Perspective	Response
Functional	Can the measurement types required to navigate all missions in the mission set be obtained?	Yes/No
Performance	Can the most stringent accuracy requirements of the ground based system be attained?	Yes/No
Cost	Is the preliminary cost estimate within the limitation set by management?	Yes/No
	Technical attributes evaluation process: Implementation	
Attribute	Perspective	Score range
Maturity	Is the technology of the design well understood?	0 - +10
Buildability	Can the design be built in a production environment to meet the requirements?	0 - +10
Practicability	Can the design acquire data often enough and long enough to meet user requirements?	0 - +10
Testability	Can the design performance be validated	
	Simply and repeatably?	0 - +10
	By an independent technique?	0 - +10
Compatibility	Will implementation be favorable to ground/flight interface compatibility at the following points for any approved mission?	
	Tracking and data system (TDS)/mission design?	−10 - +10
	TDS/spacecraft?	−10 - +10
	TDS/launch vehicle?	−10 - +10
	TDS/mission operations system?	−10 - +10
	TDS/integrated systems?	−10 - +10
	Will the implementation have a favorable interface compatibility with other TDS data types?	-10 - +10
Growth potential	Can the design:	
	Serve additional purposes without modification?	-10 - +10
	Be modified to serve additional purposes without affecting the original purpose?	-6 - +6
	Can the system capabilities improve with anticipated advances in technology?	-10 - +10
Schedule	Can the design be implemented in time to meet the need date?	0 - +3
Safety	Under fault conditions can the design be made to fail without damaging equipment or injuring personnel?	0 - +3
	Technical attributes evaluation process: Operation	
Operability	Is the approach consistent with unattended operation?	0 - +6
Availability	Can the system operate for an extended time period without the need for maintenance?	0 - +3
Restorability	Can the system operation be restored after failure by using DSN resources alone?	0 - +3
Repairability	Can all equipment be repaired by using DSN resources alone?	0 - +3
Capability	Will implementation increase DSN capacity to meet operational commitments?	-10 - +10
System validation	Can the system performance be validated within the TDS?	-10 - +10
	Can the user product be validated within the TDS?	-10 - +10
	Technical attributes evaluation process: Management	
Communications	Will implementation be favorable to existing and planned DSN communications arrangements?	-6 - +6
Data Processing	Will implementation be favorable to existing and planned DSN computing capabilities?	-6 - +6
Energy	Will implementation be favorable to DSN mean energy consumption?	-6 - +6
Manageability	Will implementation be favorable to existing management arrangements?	-10 - +10

Table 1 (contd)

Attribute	Perspective	Score range
	Technical attributes evaluation process: User	
Spacecraft	Will implementation be favorable to existing spacecraft operations and the spacecraft design of all approved but unflown projects?	-10 - +10
Mission operations system	Will implementation be favorable to MOS arrangements for all existing spacecraft and all approved but unflown projects?	-10 - +10
Data processing	Will implementation be favorable to existing and planned computing arrangements?	-10 - +10
Costs	Will implementation be favorable to user costs?	-10 - +10
	Technical optimization evaluation process: Implementation	
Ease of design	Is the task within design organization experience?	0 - +10
	Are all the functions easy to understand?	0 - +6
Ease of installation	Can installation be done without any:	
	Site preparation?	0 - +6
	Special equipment?	0 - +6
	Specially trained personnel?	0 - +6
Ease of modification	Are all the functions mechanized simply?	0 - +6
	Are the functions nearly independent?	0 - +6
	Are the function interfaces simple?	0 - +6
	Technical optimization evaluation process: Operation	
Ease of operation	Are the periods of operator activity short?	0 - +6
	Are there few periods of operator activity in a duty cycle?	0 - +6
Ease of maintenance	Is there sufficient time in the duty cycle to perform necessary maintenance?	0 - +10
Ease of repair	Will failed equipment be repairable in a reasonable time period without the need for high skills, long experience, or special equipment?	0 - +6
	Life cycle cost	
	Perspective	**Response**
	What are the life cycle costs for each design?	Dollar value
	What is the DSN differential life cycle cost for each design?	Dollar value
	What is the annual differential cost to each user for each design?	Dollar value
	Are there any costs that are soft or fuzzy?	Yes/No
	Is the implementation favorable to DSN cost-effectiveness in terms of user hours per dollar of DSN funding?	Yes/No

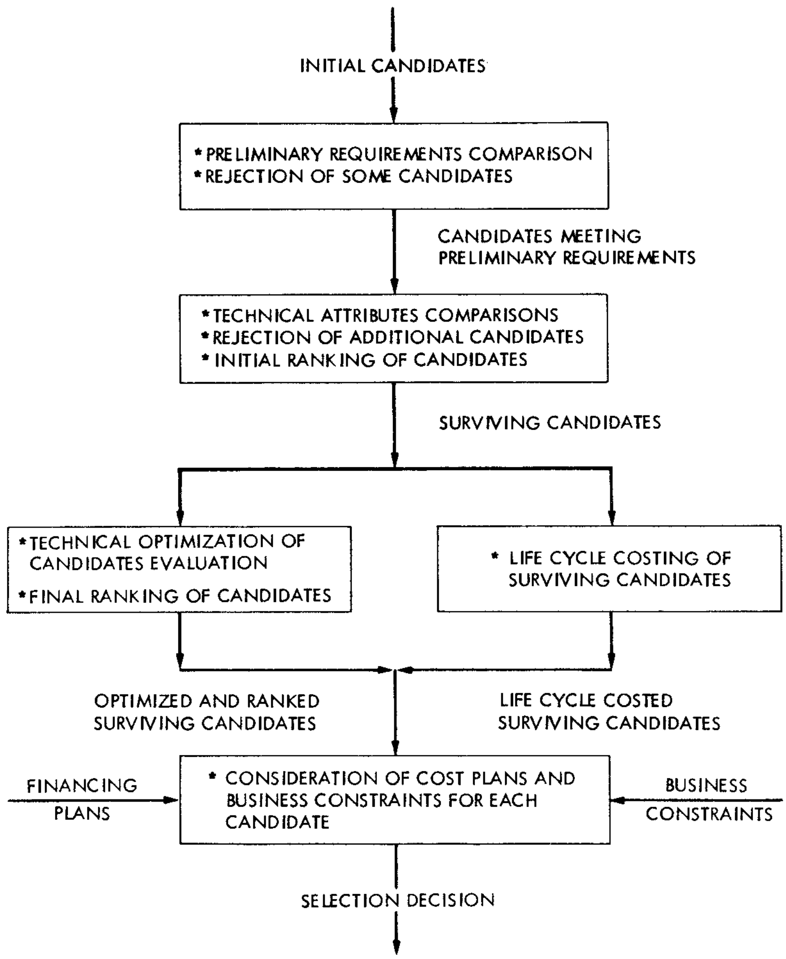

Fig. 1. Top level block diagram of the generalized evaluation criteria process for selecting a design candidate

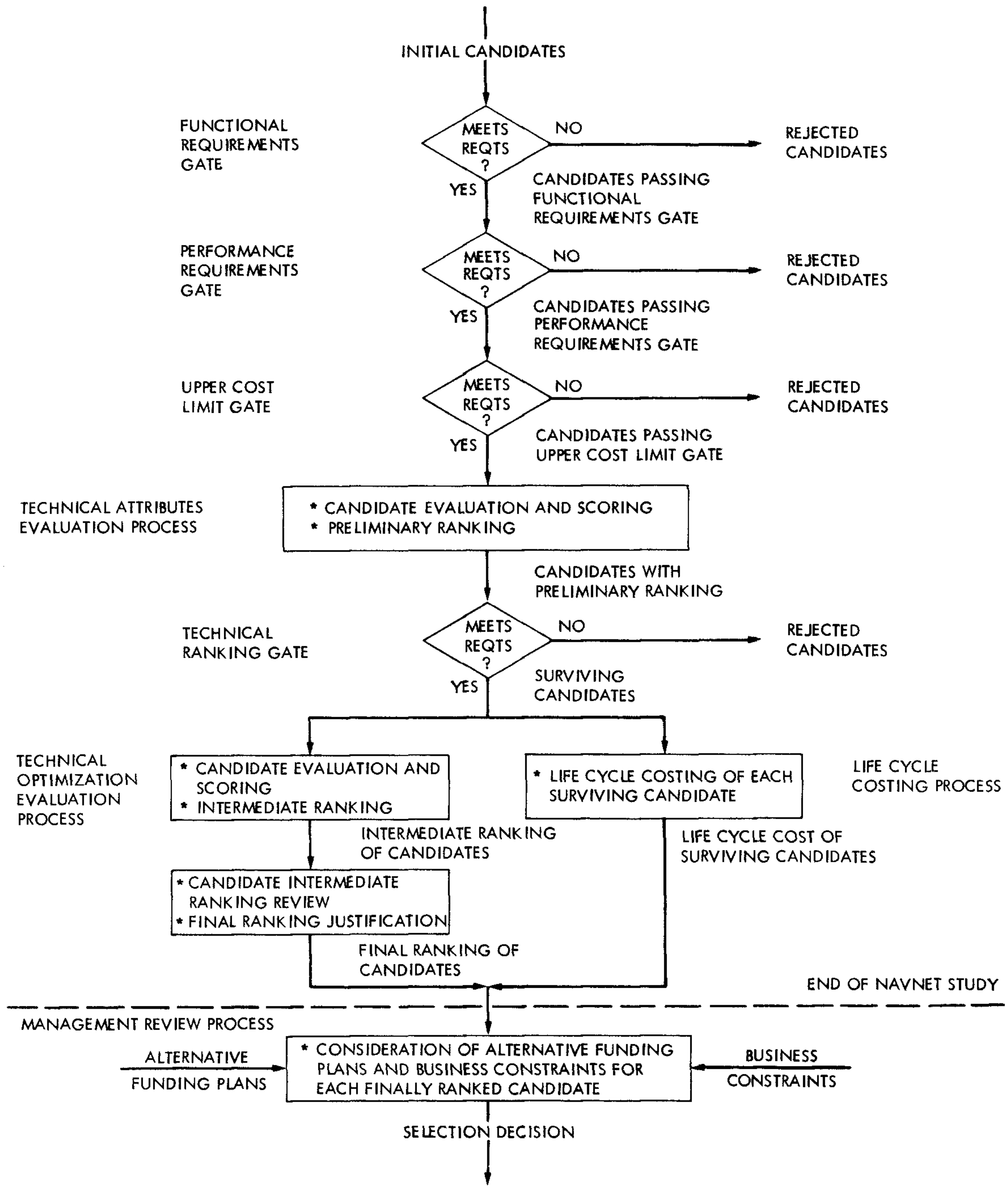

Fig. 2. Top level flow chart, NAVNET project evaluation criteria process