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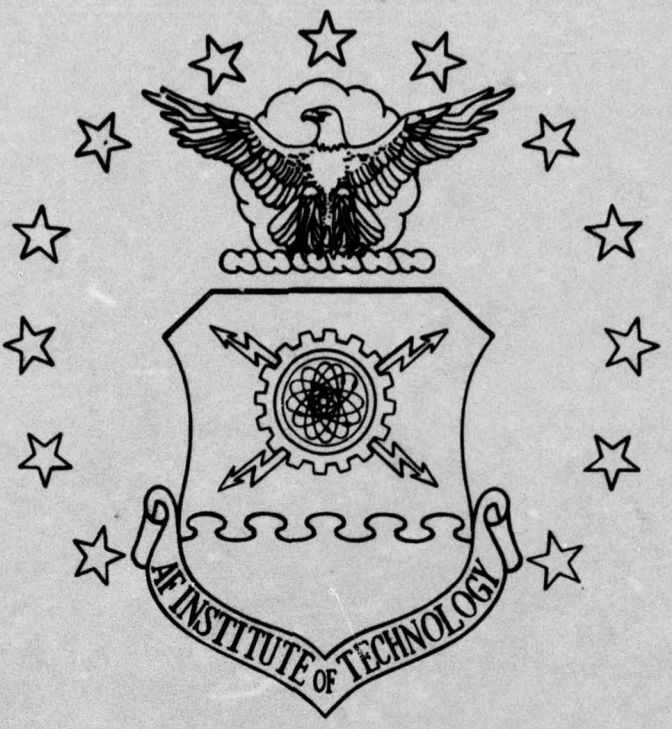
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AIR LAUNCHED CRUISE MISSILE STAGING BASE SELECTION FOR FULL SCALE DEVELOPMENT TEST AND EVALUATION

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THESIS

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Albert E. Hughes
Major USAF

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(14) GSM/SM/76S-12

(6) AIR LAUNCHED CRUISE MISSILE STAGING BASE SELECTION FOR FULL SCALE DEVELOPMENT TEST AND EVALUATION,

(9) Master's THESIS,

Presented to the Faculty of the School of Engineering

of the Air Force Institute of Technology

Air University

in Partial Fulfillment of the

Requirements for the Degree of

Master of Science

by

(10) Albert E. Hughes B. S.

Major USAF

Graduate Systems Management

(11) Sept[redacted]76 (12) 125p.

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Preface

Decision-making is fundamental to the work of a manager. In recognition of the importance of decision-making, the investigator has sought every educational opportunity to gain further insights into decision processes and the importance of the environment in which decisions must be made and implemented. The topic of this thesis has provided an outstanding opportunity to continue that investigation. The opportunity to examine a complex, "real-world" decision-in-the-making from a detached position, free from the influence of organizational parochialism, the pressure of on-the-job schedules and the interference of unrelated issues, has been invaluable.

I am sincerely grateful to Col Charles A. MacIvor, System Program Director, and Lt Col Robert J. Troxell, System Operations Program Manager, Air Launched Cruise Missile System Program Office, for the opportunity they extended and for their unhesitating cooperation and support.

To Dr. Edward J. Dunne, whose guidance and advice was indispensable and to Dr. Ronald A. Luhks, whose editorial assistance and encouragement was invaluable, I extend my heartfelt appreciation. And finally, I wish to express my appreciation to Jeannie Hughes, wife, mother, editorial assistant, and typist for her untiring efforts and understanding and to my children, Shannon and Catherine, who are too young to understand why Papa couldn't play.

Albert E. Hughes
13 August 1976

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Abstract

A management decision is examined using the decision analysis method of Kepner and Tregoe. Four mandatory objectives are established. Twenty-five air base alternatives are examined. Boeing, Wichita (Air Force Plant 57) and Kelly Air Force Base satisfy all mandatory objectives. Edwards Air Force Base does not but is continued in analysis, an option allowed by the method. The three named alternatives are ranked based on the relative degree to which they satisfy each desired objective. Wichita ranks first, Kelly second, and Edwards, last.

A decision risk analysis follows. The likelihood of failing to achieve objectives and the consequences of that failure are examined for each of the three alternatives. Severe consequences are very likely if Edwards is chosen. Severe consequences with less likelihood of occurring are associated with Kelly Air Force Base. Minor consequences with greater likelihood of occurrence are associated with Boeing, Wichita.

Edwards Air Force Base ranks lowest and provides the highest threat of severe consequences. It is considered an unsatisfactory alternative. Both Kelly Air Force Base and Boeing, Wichita are acceptable. Boeing, Wichita, the highest ranked, lowest risk alternative is recommended.

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AIR LAUNCHED CRUISE MISSILE
STAGING BASE SELECTION
FOR
FULL SCALE DEVELOPMENT TEST AND EVALUATION

I. Introduction

Background

During the summer and fall of 1974 the Air Launched Cruise Missile (ALCM) Program Office generated extensive plans for conduct of a Full Scale Development program. Among these plans was a Master Test Plan for combined Development Test and Evaluation/Initial Operational Test and Evaluation. According to this test and evaluation master plan, test planning and operation was to be managed by a Joint Test Force Director assigned from the Air Force Special Weapons Center. He would direct support elements of the System Program Office (SPO), Strategic Air Command, Air Force Logistics Command, Air Training Command, and the air frame/system integrating contractor, The Boeing Company. A Deputy Joint Test Force Director was to be assigned from the Air Force Test and Evaluation Center to act as an independent test planning and operations manager for the Initial Operational Test and Evaluation portion of the flight test program (ALCM Master Test Plan, 1974: 9,10).

This exhaustive test program required two B-52 carrier aircraft, extensive aircraft and missile operations and maintenance support and data reduction facilities. Twenty-seven live launches of the ALCM and an estimated 45 captive carry missions were planned (ALCM Master Test Plan, 1974: 22,23).

Location of the support/staging base became a significant issue. The staging base would have to provide facilities for operation and

maintenance of the carrier aircraft, the flight test missiles and the necessary support equipment. Facilities would also have to provide for preliminary data processing, office space and housekeeping for a Joint Test Force which was to range from 150 to a maximum estimated 350 personnel. These personnel would represent all of the participating agencies listed above (ALCM Master Test Plan, 1974: 8,20,24).

The entire program was patterned to a great extent after the then recently concluded and highly successful Short Range Attack Missile test program. The missile airframe contractor, The Boeing Company, retained responsibility for operation and maintenance of the carrier aircraft, the missiles, and the data reduction facilities. With the test program so oriented, the Boeing Wichita facility was selected for the staging base: it offered lower estimated contract costs, minimum impact to missile assembly, checkout and system integration activities (conducted at Seattle) and minimal risk in obtaining B-52 maintenance. Boeing Wichita had a full B-52 operation and maintenance facility in place, including flight crews and maintenance personnel (Test Base and B-52 Maintenance Capability Review, 1973: 1).

With the above plans and the Joint Test Force cadre standing by, the ALCM System Program Director sought authorization from the Secretary of Defense through the Defense Systems Acquisition Review Council to proceed with Full Scale Development. This permission was denied. The program was directed first to validate the system concept through conduct of a much smaller scale Advanced Development flight test program which is now under way (Program Direction Number 2182-2-76-51, 1975: 1). The Joint Test Force cadre was disbanded shortly thereafter and the Advanced Development test program was assigned to the contractor, virtually in total (Contract Change Order P00068, 1975: Attachment 1, paragraph 30).

As this is written (April-July 1976) the ALCM program office is once again planning for Full Scale Development. Another test organization has been named to replace the Air Force Special Weapons Center which was disestablished in the interim. The Air Force Flight Test Center, Edwards Air Force Base, will have test planning and operational responsibility and will organize the Joint Test Force cadre. The roles of the Air Force Test and Evaluation Center, Strategic Air Command, Air Force Logistics Command and Air Training Command are essentially as before (Program Direction Number 2182-3-76-88, 1976: 1).

The actual choice of staging base has been in doubt. Air Force policy requires the use of government facilities whenever possible (Air Force Regulation 80-14, 1975: 3). Headquarters Air Force Systems Command personnel and others believe that one or more Air Force bases are suitable. In addition, Air Force Systems Command personnel wish to use Air Force data reduction facilities and Air Force personnel and equipment to operate and maintain the carrier aircraft, missiles and support equipment (Troxell, 15 March 1976).

The SPO personnel question this view for several reasons. They anticipate additional costs of providing support at other than the Boeing Wichita facility and believe that successes similar to those of the related Short Range Attack Missile program may be jeopardized if the contractor's role is reduced (Troxell, 15 March 1976).

Relative merits of proposed staging bases and various contractor/Air Force mixes of personnel and facilities are a matter of widely varying opinion. Costs and policy are both at issue and a number of conflicting objectives are being stated or implied. Nevertheless, a decision must be made this summer (1976) in order that a request for proposal (which specifies the staging base) may be issued to The Boeing Company. Ultimately, the

decision is being driven by a need to complete contract negotiations prior to January 1977. This is the directed milestone date for requesting authorization to proceed with Full Scale Development (Master Summary Schedule, 31 December 1975).

The Decision Making Environment

One might be tempted to consider selection of a staging base to be an individual decision. The Program Manager is responsible for the program and though he might receive advice from many quarters, program decisions are, ultimately, his to make. However, a review of regulations and the current activity of the program shows this to be a naive view. The decision will be a group decision, collectively attained through committee deliberations.

The responsible test organization (The Air Force Flight Test Center) is, by directive and in fact, heavily involved. Their coordination must be obtained for the test and evaluation portions of requests for proposals and subsequent contracts (Program Direction Number 2182-3-76-88, 1976: 1). The Joint Test Force Director (assigned from the Air Force Flight Test Center) has formed and is chairman of a working group for Staging Base selection (Minutes of ALCM Test Planning Meeting, 29 March 1976: Attachment 2).

Headquarters Air Force Systems Command is a participant through what is effectively an approval/veto decision power. "Both the RTO (responsible test organization) and SPO are referred to paragraph 2h of AFR (Air Force Regulation) 80-14 and AFSC (Air Force Systems Command) Supplement 1. (The policy requiring maximum use of government/Air Force facilities).... Deviation from this policy will be approved by HQ AFSC (Headquarters Air Force Systems Command) prior to government commitments for FSD (Full Scale Development) testing" (Program Direction Number 2182-3-76-88, 1976: 2).

The Air Force Test and Evaluation Center is also heavily involved. Their coordination is required on test plans (Air Force Regulation 23-36, 1974: 2). They are in fact participants, along with Strategic Air Command and Air Force Logistics Command, in the working group (Minutes of ALCM Test Planning Meeting, 29 March 1976: Attachment 1). Air Training Command could have inputs to the decision as well since they are designated as a participating organization (Program Direction Number 2182-2-76-51, 1975: 1).

Since a decision must evolve from this diverse group, a brief theoretical look at decision making in groups and a categorization of the group established above should provide a helpful prelude to a statement of the purpose of this thesis, the selection of a methodology and an examination of the specific problem and decision process which will be examined.

Classification of the Decision Making Group. Three separate types of groups have been identified by Marshak. He identified groups as teams, foundations, and coalitions (Marshak, 1954: 188-189). The characteristics of these three, as he saw them has been summarized and expanded upon by K. J. Radford:

> In a team, each member has the same group-oriented interests. For this reason, a team demonstrates cohesiveness and solidarity and a definite organizational entity can be envisaged. For the purpose of decision making the members consider themselves as a part of this entity. In a foundation the identity of purpose is less strong. The individual members still subscribe to a group purpose, but individuals see the accomplishment of group objectives to a certain extent in terms of a means of achieving their own objectives. Members of a foundation do not identify themselves absolutely with the purpose of the group and the possibility of conflict within the group is correspondingly greater. In a coalition individual members do not necessarily subscribe to a group objective. They are drawn together...by virtue of the advantages to them of such arrangements in the pursuit of their own goals and objectives.
>
> In the case of a team, it is meaningful to speak of group objectives, purposes and preferences. The group objectives and preferences are easy to infer from those of the individual members of a team, because there is substantial identity of purpose among

> the members. In a foundation, the group purpose is not as easily inferred by observing the preferences and behavior of individuals or of a small group of members. This must be done by taking into account the organizational structure of the foundation and its functioning with respect to the decision processes it faces. In a coalition there is no obvious group objective and the interests of the members are not similar (Radford, 1975: 197,198).

In this context, the specific decision making group discussed above best fits the description of a foundation. The group clearly is not a coalition--there are group objectives; the members do have similar interests by virtue of common membership in the United States Air Force Research, Development, Test and Evaluation community. It seems as clear that the group is not a team. A "cohesiveness and solidarity and a definite organizational entity" is yet to be demonstrated. One cannot infer (group objectives) from the diversity of opinion and implied objectives which has created the need for this investigation.

Diversity of opinion and the resulting "possibility of conflict within the group" is certainly to be expected. The participants come from a wide range of organizational interests within the Air Force community. The objectives perceived by members of the SPO, the Strategic Air Command, the responsible test organization, the Air Force Test and Evaluation Center and others will of necessity be slanted by their variety of experience with this specific program, their career backgrounds, and the specified and implied objectives of their parent organization. In summary then the group is expected to act as a foundation. Conflict likely will be a primary factor in the functioning of the working group.

The Decision Making Process. The working group has been identified as a foundation and the likelihood of conflict has been established. What type of decision process can be expected? There are three candidate processes as shown in Figure 1. The case under consideration is neither completely nor partially specified. There is no evidence that any of the

COMPLETELY SPECIFIED	PARTIALLY SPECIFIED	PERSONALISTIC
Specification of decision process agreed upon in advance of resolution	Only a part of the decision process can be specified	Decision process cannot be specified in advance
No judgmental involvement at time of each resolution	Group reaches final resolution using results from specified portion	Group negotiates each problem on the basis of experience, judgment and beliefs
Resolution is rational; repeated resolutions with same data produce same result	-	Two different groups may reach different decisions

Fig. 1. Organizational Decision Processes
(Adapted from Radford, 1975: 24)

necessary conditions exist. The initial meetings of the group and interviews give every evidence that the participants consider the decision process to be personalistic. This should not surprise anyone. It merely provides an example of theoretical expectations:

> Particular factors that may result in a decision process not being completely specified are the following:
> - the background to the decision is a multiple objective set and no agreement exists with regard to the relative priorities...of the individual objectives;
> - the decision impinges on the personal (organizational) objectives of (the group) in such a way that the group is prevented from acting as a team with respect to the problem;
> - no agreement exists with regard to the perception of the problem, its formulation or the model of the actual decision process involved;
> - there is no agreement on preferences for available options between members of the group charged with resolution of the decision problem and no means of structuring discussions within the group to arrive at agreed preferences;
> - no agreement exists with regard to the criterion of choice between available options.
>
> If one or more of these conditions exists, it is unlikely that the decision problem can be completely specified, although in some cases it may be partially specified (Radford, 1975: 214,15).

Whether the existing decision process is purely personalistic or not is of little practical importance. The tendency toward a personalistic process, however, is important. This tendency should be expected (all of Radford's conditions listed above appear) and has been confirmed by interview and by review of the results of early meetings of the participating parties (Troxell, 15 March 1976; ALCM Test Program, 26 March 1976; and Minutes of ALCM Test Planning Meeting, 29 March 1976).

Satisficing and the Working Group. In most cases the presumed goal of decision making is to select the optimum alternative; i.e., select the alternative that maximizes or minimizes some objective function. Indeed, such is the purpose of most techniques which are collectively the realm of operations research and management science (Terry, 1968: 110-111).

It is the presumed mode of operation of the economic man. For a number of reasons, however, decision makers are often prevented from acting as the economic man and retreat to the position of the "administrative man", a term coined by Simon (Simon, 1961: xxiv-xxvi).

Rather than seek the optimum, the administrative man merely searches until he finds an acceptable solution. If he reaches the optimum it will be by chance and he probably will never know it. Simon calls this process "satisficing."

Maximizing a quantity that measures the achievement of a desired objective is usually the desire of a rational individual (Radford, 1975: 216-17). Yet, decision makers are likely to resort to acting as the "administrative man" for a variety of causes. The decision process may not be fully specified (March and Simon, 1958: 137-141). Significant savings in effort, time, and resources may be realized (Radford, 1975: 217). Insufficient information or time may be available for developing an optimized solution. The cost of data gathering may be prohibitive (Simon, 1961: 81-83). Multiple objectives may increase the complexity of the problem to such an extent that a single objective function may be beyond reach or agreement (Eilon, 1972: 6-7).

> The tendency to satisfice may be embedded in the structure of the organization.... The various components of an organization may have their own set of goals and objectives. The individual managers working in each component may be judged on the basis of their progress in achieving these goals. In many cases, the goals may be generated from below rather than imposed from above. This may be done partially as a defense mechanism and partially as a bargaining ploy in the goal-setting process. Over a period of time, such goals may impose tighter and tighter constraints on the decision making behavior of managers, leading to a greater tendency to satisfice rather than optimize. In extreme cases, the goals may preclude a feasible solution and some sort of crisis in management may result (Radford, 1975: 218).

As summed up by Radford, "Satisficing may...occur under many of the same conditions where decision processes cannot be completely specified. This is not to say, however, that a decision problem that cannot be completely specified must necessarily be approached on the basis of satisficing" (Radford, 1975: 218).

Purpose

It seems highly likely that the rationality of the decision process for selecting a staging base will be bounded. The working group is likely to develop a recommendation through the process of satisficing. The process is not fully specified. The time, resources and personal effort of the participants will be limited and it is unlikely that all pertinent data will be identified or collected in the time allowed. The cost of full data gathering is likely to be high. And perhaps of greatest importance, multiple objectives do exist and it is questionable whether the group can develop a single objective function or criterion by negotiation. And finally, the participants are working for, and will be judged by different supervisors with different organizational objectives and problem perspectives.

It would be presumptuous to state that this thesis is intended to make a decision for the working group or the program manager. The decision is their responsibility. Nor is it proper to assert that this thesis must necessarily develop a better recommendation than that of the working group. The combined knowledge and experience of the group participants obviously outstrips that of any individual. What can be asserted, however, is that an individual with an outsider's view can examine the site selection process without some of the limitations which force a foundation (the working group) toward a personalistic process and toward arriving at a decision by satisficing.

The individual can specify the decision process to a greater degree than can the foundation. The individual can reach "agreement" over the ranking of multiple objectives and develop a single objective function which may well elude the group. The individual with no direct responsibility to the organizations involved is not restricted by the goals and judgments of a parent organization. In short, the individual can increase the specificity of the decision process and as a result, more nearly approach the problem as an "economic" man. Thus the individual is more likely to optimize than is the foundation.

By specifying a decision process and following it to its logical conclusion, the individual can provide insights into the objectives, alternatives and option consequences that might otherwise escape the attention of the group. The purpose of this thesis is to develop those insights. From this purpose, several specific objectives may be stated:

- Specify a decision process by selecting a methodology which is appropriate to the given problem.
- Specify a recommended optimum alternative based on exercise of the selected decision process.
- Develop insights about the decision risks through examination of the option consequences.
- Develop judgments concerning the worth of the specified decision process and state possibilities for applying the process to other decision situations.

Methodology

The first three of the four objectives listed above will be reached through selection and application of a decision analysis process advocated by Kepner and Tregoe. They recommend an eight step process as a systematic means of reaching decisions when presented with complex problems involving multiple objectives. The steps require that the decision-maker:

1. Identify the decision statement
2. Establish objectives in terms of results and resources
3. Classify objectives according to importance
4. Develop alternatives
5. Evaluate each alternative against the objectives
6. Choose the best alternative as a tentative decision
7. Assess the adverse consequences
8. Make (recommend) a final choice (Kepner and Tregoe, 1973: 39,40).

The validity of the method will be demonstrated by comparison with the essential decision-making steps or processes which were synthesized by Radford from the works of Tannenbaum, Eilon, Cyert, March, and Drucker. Their consensus, according to Radford, is that a decision-maker must:

> perceive and formulate the problem
> construct a model of the decision process
> determine (as possible) the quantitative parameters
> specify available options
> evaluate the outcome of each option
> select criteria of choice, and
> resolve a decision (Radford, 1975: 13).

Radford goes on to warn that the steps are not necessarily in the order required or used in a specific situation and that a number of iterations will normally be required through all or some of the steps (Radford, 1975: 13,14). All of Radford's requirements are present in the decision process suggested by Kepner and Tregoe. This will be demonstrated in the following assessment.

Step 1: Identify the Decision Statement. According to Kepner and Tregoe this step should convert a vague awareness "of a need to choose an action" into a focal point for establishment of objectives and generation of alternatives. It is a clarification of the issue under examination (Kepner and Tregoe, 1973: 42).

This step could also be titled "Recognize the Problem." It is the obvious first step in any formal listing of decision steps. As obvious as it is, many failures in the decision process can be traced to a failure to recognize the real problem. To work hard at solving the wrong problem,

or one about which there is considerable disagreement among interested parties, may be more harmful than inactivity. The purpose of this first step then is to avoid working the wrong problem by carefully stating the problem and gaining consensus that it is the real (right) problem. Returning to Radford's list, it is apparent that the first requirement, "perceive and formulate the problem" can be met by step 1.

Step 2: Establish Objectives in Terms of Results and Resources. The entire decision analysis process serves a single end--to select a way to reach desired objectives. A clear and comprehensive statement of objectives is as necessary as is a statement of the problem. It brings out into the open all objectives so that inconsistencies and inaccuracies may be identified and eliminated. In a group context it develops consensus. Kepner and Tregoe identify two classes of objectives--results and resources. Results are those objectives which are expected to derive from the decision. Those objectives which aid, or limit, the decision are classed as resources.

Results are determined from:

viewpoints of others
relationships with other organizations
law, executive order, regulation
personal conviction
problem cause
research and development
target populations or clients
economy
public interest
experience and past practice
policy and procedure
functional specialist's viewpoint
future expectations and trends
past strengths and weaknesses

Resources derive from:

authorization and appropriation
information and know-how
methods, skills, and techniques
personnel ceilings
budget or financial plans
raw materials and supplies
space
time
tools and equipment
operating procedures

(Kepner and Tregoe, 1973: 42,43).

Step two by itself does not satisfy any of the requirements listed by Radford. However, steps two, three and five together "construct a model of the decision process".

Step 3: Classify Objectives According to Importance. Objectives should be categorized as mandatory objectives and desired objectives. Further, the desired objectives will vary in their importance and are to be assigned weights. Kepner and Tregoe are careful to specify how this is to be accomplished (Kepner and Tregoe, 1973: 44-46).

First, the decision maker should identify the mandatory objectives in the list of result oriented objectives. The question to be posed is, "Is it required and necessary that this be achieved? If the answer is no, it is a desired objective. Then, from the list of resource objectives the question to be posed is, "Is there a limit on the available amount of this resource? If the answer again is no, then these are also desired objectives. Those result and resource objectives which remain are mandatory objectives against which all alternatives are initially screened. They are to be stated in measurable terms with absolute limits.

Second, the desired objectives are identified. Most of these, in a sense, are a fallout of the determination of mandatory objectives. They will include results which are desirable but not essential and resources for which there is some range of availability less than some maximum (which may be a mandatory objective).

Third, objectives should be quantified to the extent possible. Whenever possible, mandatory objectives in particular should have specific numerical standards. If this is not possible, then the objective should include a specific normative standard. Desired objectives should be quantified or described in like manner. Otherwise, vague descriptions will not allow meaningful comparison of alternatives when that point is reached.

Finally, the desired objectives must be weighted. In a sense, there is an implied weighting of mandatory objectives at 100 percent. They are

mandatory. But among desired objectives, a relative importance is established. Kepner and Tregoe specify the use of a numerical one to ten scale with the higher numbers representing more desireable objectives.

Returning once again to Radford's requirements for a decision process, the third requirement has been satisfied by step 3. Quantitative parameters have been determined.

Step 4: Develop Alternatives. The search for alternatives should be systematic. While the goal is not to identify all possible alternatives (an impossible task), a multiplicity of alternatives helps to assure that the one finally selected will be as satisfactory as is reasonably possible. This cannot be a haphazard process since satisfaction is determined in relation to the established objectives. In fact, a point by point examination of each objective may lead to alternatives which are not immediately apparent. This search should be conducted by determining separately how each objective might be met. It is also possible that additional objectives may be identified (decision making is iterative in nature). If the new objective is valid, i.e., if it is truly a desired result or required resource, then it must be integrated into the decision process (Kepner and Tregoe, 1973: 46,47).

Radford requires that available options be specified in a decision process. This is accomplished by step 4 through development of alternatives.

Step 5: Evaluate Each Alternative Against the Objectives. The first comparison is made against mandatory objectives. If the alternative does not meet the mandatory standard it is dropped and is not considered further. Borderline cases require judgment. Elimination risks loss of an alternative that may otherwise be very satisfactory. Retention risks extra effort that may be wasted and risks acceptance (at least temporarily)

of possible adverse consequences. If the borderline alternative is retained, it must be tagged as borderline and considered especially carefully in the remainder of the decision analysis.

Those alternatives which pass the first test, comparison with mandatory objectives, are then compared with desired objectives.

Each alternative is scored against each desired objective using a one to ten scale. There are four rules to scoring:

1. Do not consider the weight previously assigned to the relative importance of the objective.
2. Always assign a value of ten to the alternative that best satisfies an objective (ties are acceptable).
3. Be sure that the score reflects the information gathered. The best available information is used.
4. Label information that is inferential or opinion, but do not allow judgments about its validity or reliability to influence the score. This judgment is reserved for steps 7 and 8.

Finally, the preceding judgments must be united. This is accomplished by multiplying the weight assigned to each objective by the score assigned to each alternative for that particular objective. Then the sum of products over all desired objectives is taken as the score for each alternative. This final sum allows a rank ordering of alternatives which shows the relative degree to which each alternative satisfies the complex of objectives. For those alternatives which score closely, it may be necessary to revalidate the information and judgmental evaluations (Kepner and Tregoe, 1973: 47-50). These numerical assignments and manipulations are useful for ranking alternatives but need careful consideration of certain limitations. These limitations will be discussed at the conclusion of this method description and validation.

When combined with steps 2 and 3, step 5 finishes the construction of a model of the decision process. Thus, Radford's second requirement has been met. We have also, with step 5 alone, evaluated the outcome of

each option (alternative), another of Radford's requirements.

Step 6: Choose the Best Alternative as a Tentative Decision. At this point judgment may again be required. If two or more alternatives have similar (high) scores, the choice may not be clear. Review of information and the analysis itself may be in order. Those areas that account for the slight differences in total weighted score should receive extra attention. Changes in the analysis may be in order. Ultimately, one of the highest scoring alternatives must be selected as a tentative decision (Kepner and Tregoe, 1973: 50-52).

Step 7: Assess the Adverse Consequences. At this point, Kepner and Tregoe ask the question, "How well will this alternative hold up in the future? Will it hold up in the face of changing conditions? What if crucial factors were overlooked?" The answers require a forecast of the adverse consequences of each alternative. Several categories are suggested as a means of pursuing negative consequences in a systematic manner:

people	external influences
organization	public service
output	facilities and equipment
material	personal
financial resources	

For each area or category, problems and consequences of choosing the alternatives still under consideration must be assessed. Other helpful questions include, "How valid is the information? What are the short range and long range implications? How will the alternative effect other activities? What are the implications of the new and unfamiliar? What factors are likely to change?"

Once adverse consequences of each alternative have been identified, an estimation of threat must be accomplished. The probability of, and the seriousness of occurence must be estimated. Once again, a one to ten scale

is used. Ten for a probability represents certainty. Ten for seriousness represents a disaster. A 10X10 threat (a certain disaster) is obvious grounds for rejecting an alternative regardless of the total worth score developed in step 5. This procedure can be carried out for several of the better alternatives for the sake of a comparison of risk. This assessment and comparison of risk is a valuable assist to making judgments concerning relative risk. The numbers themselves, other than perhaps a 10X10 and the trivial 0X0, are meaningless if considered alone (Kepner and Tregoe, 1973: 52-56).

Step 8: Make a Final Choice. At this point judgment again is crucial. The decision maker is asked to:

Double check the analysis
Judge the total impact of negative consequences, and
Exercise careful judgment

The final choice should:

Satisfy all must objectives
Best achieve want objectives, and
Incur the least threat from adverse consequences (Kepner and Tregoe, 1973: 57-59).

Taken together, steps 6, 7 and 8 resolve a decision, as required by Radford. Also, in step 8 the decision criteria are explicit, as is stated immediately above. Thus all of Radford's listed requirements have been met.

No conclusion can be drawn that this is the best possible decision process for the specific problem at hand. Selection of an optimum decision process is a separate study unto itself. Nevertheless, the chosen process is presumed to be adequate. It meets the requirements of authorities in the field of managerial decision making (see page 12).

Some may be concerned about the need for multiple objectives, about the use of judgment in what is

intended as an objective decision process, about the validity of weights and scores which are derived from judgment and about the meaningfulness of products and sums derived from those weights and scores. Kepner and Tregoe do not address these concerns in detail but others have. An assessment of this or any similar methodology is not complete without mention of their views.

Multiple Objectives. One might suggest that both the problem and the methodology are unnecessarily complex. If a single comprehensive objective could be formulated then the decision process need only measure alternatives against that objective. The best alternative would immediately become apparent. Peter Drucker has examined this proposition.

> The search for the one objective is essentially a search for a magic formula that will make judgment unnecessary.... All that can be done is to make judgment possible by narrowing its range and the available alternatives... and this...requires multiple objectives.
>
> Objectives are needed in every area where performance and results directly and vitally affect the survival and prosperity of the business (Drucker, 1954: 62,63).

In the Joint Test Force context, the last thought still applies. "Survival" may be an overstatement but "prosperity" can easily be interpreted as efficiency and effectivity in the conduct of the test mission of the Joint Test Force. In fact, as will be shown in Chapter II, there are a number of "area(s) where performance and results directly and vitally affect the..." selection of a staging base and the conduct of the test mission. A process for synthesizing a single comprehensive objective which protects the requirements of each area is not known.

Objectivity and Judgment. One might also object to the liberal use of personal, subjective judgment in an objective decision process. In his development of a somewhat similar decision process, James Miller,III, examined this issue in exhaustive detail:

> ...use of a formal procedure does not necessarily preclude the use of subjective judgment. Quite the contrary, subjective judgment must be used both in assigning measures of worth to various performance consequences and in trading off worth among various criteria.
>
> ...assessment of worth implies investigation of human beings. This concept of worth is a property of human beings. It is a part of their conscious perceptual apparatus. Human beings may formulate notions of worth by observing external objects and activities and by considering situational circumstances; and they may impute or project these notions, once formulated, onto the external objects and activities being assessed; but the real locus of worth remains within the subjective minds of human decision makers. This means that any assessment of worth is by definition a subjective process. Hence, attempts to make assessment procedures "objective" in the sense of "freedom from all subjective human judgment" are misdirected. It may be reasonable to seek "limited objectivity" in the sense of "freedom from particular biases", but it is patently ridiculous to seek "complete objectivity" in the sense of "freedom from all subjective human judgment... (Miller, 1970: 3,14,15).

Judgment and the Assignment and Manipulation of Numbers. In the preceding, Miller established the need for judgment. He continues:

> ...worth assessment implies some procedure for extracting subjective worth judgments from individual decision-makers. A surprising result of empirical investigation shows that quantification contributes indispensably to the very process of formulating and clarifying objectives. There is probably no better way to insure freedom from false assumptions than by stating these assumptions explicitly (numerically), Nor is there a better way to elicit a cross-section of opinion and to establish a consensus of preferences--whenever desireable and possible--than by means of a systematic procedure (Miller, 1970: 15,20).

If the usefulness of a numerical representation of judgment is accepted, there is still the problem and temptation of misleading oneself and others through unwarranted manipulation of the established numbers. (Do they imply an ordinal scale? Interval? ratio? What scale conventions apply?) Certainly, if the final numbers reached, the total scores of the alternatives, are considered meaningful in their own right or if a decision is to be based solely on the numbers, then fears of misleading conclusions are well founded. However, if the numbers and their manipulation are

viewed as an assist for, rather than a replacement of, judgment, then there should be less concern. As Miller concludes on this issue, "Viewed as a decision-motivating device, the (numerical) assessment procedure is not in the least compromised by violation of scale conventions" (Miller, 1970: 24).

Nevertheless, the concern over the meaningfulness of quantified judgments is not trivial. Great care must be devoted to assuring that the relative scores and weights properly represent the judgment of the decision maker and that the temptation to manipulate numbers and accept them in the place of judgment is resisted. On this Miller, Kepner and Tregoe are in agreement (Miller, 1970: 20; Kepner and Tregoe, 1973: 49,58).

Justification Summary. To recap, the preceding has provided a description and justification of the decision methodology to be pursued. It has been shown that the decision analysis process recommended by Kepner and Tregoe meets the general requirements of a decision process as summarized by Radford. Concerns relative to mulitiple objectives, the use of judgment in an "objective" process and the quantification and manipulation of judgments have been anticipated and discussed. The first objective of this thesis has been met. A decision process has been specified through selection of a methodology which is believed to be appropriate to the given problem. The second and third objectives of this thesis will be reached through application of the specified decision process.

Assessment of the Decision Analysis Process. The last objective of this thesis judges the worth of the decision process itself and recommends its applicability to use in wider contexts. This is intended purely as a judgmental evaluation. James Miller, in discussing various aspects and implications of judgment, provides insight into how to proceed:

> ...Worth judgments are in principle untestable by ordinary scientific methods....Worth judgments are neither true or false....The only kinds of "tests" that may be performed on worth judgments are intuitive acceptability and the degree of consensus with which such judgments are held.... The correctness of worth judgments can only be determined on the basis of informed opinion (Miller, 1970: 15).

A personal assessment will be made by the writer--a worth judgment in Miller's terminology. This judgment will address the value of the decision analysis process in the context of the specific problem analyzed, then expand that judgment to cover decision making in broader contexts. The writer will draw heavily on his eleven years experience in the systems acquisition environment. Hopefully, these judgments will provide useful guidance for scholastic and field studies by students and SPO personnel facing complex decision issues.

Data Sources. One of the limitations that faces the working group is that all of the data that one would desire is not available and organized for use. In fact, much data which might be useful cannot be generated until after approval is given for Full Scale Development. Only then will facility design and extensive planning efforts begin. Much of that effort depends on the selection of the staging base. Thus, as is a frequent case, a decision must be made against limited data. That limited body of data, itself, has not been thoroughly sought-out, identified and organized by the working group. The task falls to the investigator.

A major task of this investigation has been to locate as much data as is available and pertinent, and to organize that data so that it provides information of use to the specified decision process. There are many sources.

To determine the appropriate objectives the investigator drew from Air Force regulations for matters of policy and direction, interviewed principle participants in the decision process, and examined letters, telegrams and a variety of formal program documentation received from the program office, the Air Force Flight Test Center, the Air Force Test and Evaluation Center and others. The investigator attended Flight Test Planning Meetings and, where necessary, sought information by telephone.

The initial list of alternatives were developed primarily from those identified by the working group members either individually or collectively. Information concerning alternatives was collected from a variety of Air Force sources and standard published references.

Many of the sources were not formal documents. Interviews, discussions, working papers, memos and drafts were used. Constant diligence was required to keep facts and opinions separated. In general, this separation was maintained by reference to the authority of the source (relative to the subject matter of the fact), the consensus of the working group members, the demonstrability of the fact, or by reference to an independent, authoritative (non-advocating) source. The final sources selected are cited throughout this thesis so that the reader may verify the accuracy of the information presented.

Scope

This investigation examines a decision situation in the context of Air Force Research, Development, Test and Evaluation. It is separate from the official deliberations of the Joint Test Force working group, but has been accomplished in parallel with their efforts. It is based on the data that was available during the period March through early July 1976. The investigator has not set out to generate data.

Rather, he has sought to identify that which is known to, or available to the decision participants and to organize that data so as to provide information for a rational decision process.

The fundamental contribution of this investigation is the emphasis it places on the analytic criteria of efficiency and effectivity. This contrasts with the political criteria of consensus exercised by the working group (See Chapter V). The result has been to provide new insights into the appropriate objectives and the consequences of decision alternatives that may not have developed from the political process.

Limitations. Two limitations were dictated by the ALCM SPO. The first is that regardless of staging base selection all field and intermediate level maintenance of the carrier aircraft, carrier aircraft equipment (peculiar to the ALCM system), missile systems and missile ground support equipment must be conducted on site. As will be seen in Chapter II, this limitation was found to be in agreement with the consensus of the working group. The second limitation was that where ever performed, data reduction must be timely (Troxell, 16 March 1976). As was subsequently determined, this limitation is benign. The choice of a data reduction facility and the choice of a staging base are essentially independent. With modern communication technology available, staging base alternatives were not seriously affected by this limitation.

Perhaps of greatest consequence is the severe limitation on cost data. It has not been possible to isolate all costs that are solely the consequence of selecting various alternatives. The selection of a staging base and subsequent contract negotiations are prerequisite to the determination of major cost elements (see Chapter III on the subject of costs). Thus determination of the relative costs of alternatives has been restricted to the identification of known major cost contributors and the ranking

of alternatives against those contributors. This procedure is entirely sufficient for overall alternative ranking purposes, but has limited utility for determining the amount of the cost differences between alternatives.

Assumptions. Test range selection will be limited to the White Sands Missile Range or the Hill-Dugway-Wendover complex. Selection of a test range is a separate issue. There are no significant test requirements that link the selection of the test range with the selection of a staging base. The only known linking factor is the cost difference associated with fuel and flight time. This is considered to be of trivial consequence given the moderate distance between the two ranges and the various alternative staging bases identified herein.

It is assumed that contractor and government personnel are equally capable in operation and support functions, given that training required for the specific job has been received. No evidence to the contrary has been established.

Overview

The remainder of this thesis closely follows the order of the selected decision process. Those steps of the process dealing with objectives (steps one, two, and three) are addressed in Chapter II. Development, evaluation and tentative selection of alternatives is discussed in Chapter III, and a final risk assessment is made and a choice is recommended in Chapter IV. These chapters (along with Chapter I) meet all but the last of the stated thesis objectives, i.e., an assessment of the decision process itself. This last objective is satisfied in Chapter V.

II. The Decision Statement and Relevant Objectives

Decisions are made so that objectives may be reached. A decision analysis, then, should include a specific statement of these objectives to provide a standard against which alternative decisions may be measured. This will be accomplished, but first it is important to identify and bound the problem itself. This is done by converting "a vague awareness of a need to choose an action" into a more precise "decision statement" that will act as a visible, supportable focal point for the establishment of objectives and the generation of alternatives (Kepner and Tregoe, 1973: 42).

The problem was stated in Chapter I. It evolved from the background of the ALCM program and the need to reconsider an earlier decision. To summarize, planning for Full Scale Development of the ALCM has reached the point where more specific test planning and preparation requires a basic test program decision. A flight test staging base must be selected for location of the Joint Test Force, the aircraft and missiles, and supporting equipment. The problem is made complex by a multiplicity of objectives and the diversity of perceptions and opinions of the decision participants. However, these complexities are not the problem. The problem to be addressed is the staging base selection itself.

The Decision Statement

An awareness of the problem preceded the first flight test planning meeting. The announcement and invitation to that meeting tasked the participants to consider the composition of the Joint Test Force, the requirements, facilities and location of the Joint Test Force, and the desired extent of contractor participation (ALCM Full Scale Development Flight Test Planning Meeting, 21 December 1975: para 1). Out of that meeting held in January 1976 came a more specific statement of the problem

and decision requirement. "The RTO (Responsible Test Organization--The Air Force Flight Test Center) will exercise the various options and come up with (sic) the cost effective location and will include maintenance of the B-52 carrier" (Joint Test Force working group action items, undated, action item 1).

The desire for cost effectiveness was emphasized at a later date by the Systems Operations Program Manager. In his view, the most cost effective staging base should be chosen with two primary objectives in mind--cost effectiveness, itself, and the ability or ease of maintaining program schedules. The latter objective is considered significant since schedule slips cause additional program costs (Troxell, 29 April 1976).

Cost effectiveness was also stated and implied as the overall goal in a number of formal and informal discussions at the flight test planning meeting convened in May 1976 (Flight Test Planning Meeting, 12,13 May 1976).

The desire for cost effectiveness as an overall goal in the selection process seems clear. Before using cost effectiveness in a decision statement, however, the term should be defined.

In simplified terms, a cost effective decision requires the selection of the lowest cost option among options of equal capability, or for a given cost level, selecting the most effective option (Air Force Regulation 178-1, 1973: 5). As stated by Fisher, "The aim is to 'minimize the costs of accomplishing a certain mission or of maintaining a certain program' or to 'maximize the benefits achieved with a certain level of resources or at a certain level of costs.'" He continues, "the cost analyst focuses attention on marginal costs, rather than directly on average costs or total costs, although it is these latter costs that are his ultimate concern. Marginal cost can be thought of as the 'first derivative' or 'the rate

of change' of a total cost...as the scale of the program...is being slightly altered" (Fisher, 1971: 39).

It seems clear that marginal analysis is not appropriate for this decision analysis. One cannot incrementally select one or another of the alternative staging bases. Nor can a given level of cost or a given of effectiveness be established or equaled for all alternatives. The level of planning conducted to date does not supply the necessary data.

However, one can determine the requirements of the staging base and select the alternative that best offers low (relative) cost and high (relative) effectiveness. The overall requirement is established by treating minimization of costs as an objective. It is balanced with other objectives which are measures of effectiveness. The balance which is desired is determined by the relative weightings assigned to the various objectives.

Fisher makes one other distinction which must be kept in mind. Costs can include more than money expenditure or budgetary commitments. He identifies four categories of costs:

1. Dollar expenditures
2. Other costs that can be evaluated in dollars
3. Other costs that can be quantified
4. Other, nonquantifiable costs (Fisher, 1971: 41).

As used in this thesis, costs include only the first category. The remaining cost categories are implicit in the statement of other objectives.

In summary, for the purposes of this thesis cost effectiveness requires a minimization of dollar expenditures consistent with, or balanced with, the attainment of certain effectiveness objectives.

In the above context the following is selected as the decision statement:

"To select the most cost effective staging base available from among the known, reasonable alternatives."

It must be noted that neither the methodology nor the decision criteria necessarily lead to singularity in decision making. Two or more alternatives may prove to be equally desirable or acceptable. Hopefully, the methodology will narrow the list of alternatives and minimize erroneous assumptions and false logic so that final judgments may be applied to more effectively accomplish the decision statement.

Whose Objectives?

Early in the search for objectives it is necessary to ask, "objectives for whom?" A decision level must be selected in order to make the quest for objectives, alternatives and the ultimate decision a less ambiguous task.

Conceptually, formal organizational objectives are hierarchical in nature. This hierarchy is frequently visualized as a pyramid of objectives, the objectives of each organizational level supporting the objectives of the next higher level until ultimately, the objectives of the highest organizational level are supported and achieved. This hierarchy of objectives exists explicitly or implicitly in every enterprise. It may encompass objectives dealing with enterprises in general, such as objectives that reflect the common good of the public, or society as a whole; but more commonly, it is limited to the objectives within the enterprise of interest (Terry, 1972: 47). This common practice is pursued here recognizing that serious conflict with external objectives is a possibility that cannot be completely ignored.

The "...internal objectives (of the enterprise) must also be compatible with external objectives--those dealing with factors outside a given enterprise in order for the enterprise to function smoothly in the society, technology, and environment within which it exists" (Terry, 1972: 45).

While this investigation has been alert to the possibility of external conflict, the assumption is made that external objectives are not in serious conflict with those internal objectives which are identified.

In answer to the original question, "Objectives for whom?", the "enterprise of interest"--the decision level--is considered to be the United States Air Force. The decision recommendation for selection of the staging base will be made on behalf of the United States Air Force and will be compatible with and supportive of the perceived objectives of that enterprise.

The above decision level was selected for two reasons. First, it is reasonable to believe that the objectives of the Air Force are sufficiently harmonious and supportive of the objectives of higher organizational levels, i.e., the Department of Defense, the Executive, the "will" of Congress, and ultimately, the "will" of the people. By directive, by regulation, by coordination and by supervision the formal, specified objectives and policies of the Air Force are closely bound to and supportive of those higher echelons listed. This is particularly true in the systems acquisition context.

Since the early 1960's the Department of Defense has closely monitored and supervised the systems acquisition objectives and policies of the Armed Forces. During the same period there has been a parallel growth in Congressional interest and supervision of the Executive and the Department of Defense. This growing supervision has been documented and discussed by others and will not be repeated here. The interested reader is referred to articles by Packard and Shillito and the studies conducted by Brady and Lynch which are included in the bibliography of this thesis.

The second reason for selecting the Air Force as the appropriate decision level is that the Air Force is the lowest level that encompasses all decision participants--Air Force Systems Command, Air Force Test and Evaluation Center, the Program Office, Air Force Flight Test Center, etc. (The one possible exception that might be asserted is The Boeing Company, the airframe and system integrating contractor. While Boeing personnel certainly act as advisors and participants in the discussions, The Boeing Company is in a sense an employee of the Program Office and is not a direct participant in the decision process.) Thus the Air Force is the lowest level at which conflicting subordinate organizational objectives (as perceived by the participants) can be resolved. In fact, Headquarters, United States Air Force is specifically tasked to resolve such conflicts (Air Force Regulation 80-14, 1975: 7).

Staging Base Decision Objectives vis-a-vis Test Objectives

Before proceeding to the discussion of actual objectives relevant to selection of the ALCM test staging base, one additional point must be explored. Nowhere in Air Force directives and regulations or in ALCM program documentation are there statements of staging base objectives in terms of results desired. The few direct statements found are in terms of resource requirements. This is to be expected since the staging base itself is solely a program resource. The test staging base is not an end or desired result with intrinsic value in and of itself. Stated or implied objectives of intrinsic value are given in terms of ALCM program objectives, ALCM system objectives, and in terms of system test and evaluation objectives. The distinction between test objectives and staging base objectives is not always obvious but must be kept in mind when stating objectives and making value judgments as to the relative worth of objectives.

ALCM Staging Base Objectives

The appropriate decision level has been selected and a decision has been made to restrict this investigation to those objectives internal to the enterprise of interest. It is recognized that objectives relevant to the selection of a staging base must be derived from the context of the ALCM program, the test and evaluation objectives and the broader systems development and acquisition objectives of the United States Air Force. The objectives which have been derived by this investigation will be stated and justified. In accordance with step two of the selected decision method, each objective will be categorized as either a result expected to derive from the decision, or as a resource available to aid or to limit the decision (Kepner and Tregoe, 1973: 42).

Result Objective: Maximize Realism in Test and Evaluation. The Air Force defines two types of test and evaluation--Development Test and Evaluation and Operational Test and Evaluation. The former is the Air Force Systems Command's primary concern and is conducted to verify accomplishment of development (usually contractual) objectives. The latter is the primary concern of the Air Force Test and Evaluation Center and the operating commands. Their tests are conducted to estimate system military utility, operational effectiveness, operational suitability, and to identify deficiencies. Frequently, the two types of testing and evaluation are combined to minimize duplication of tests. This test consolidation is desirable in the interest of cost savings but only to the extent that separate test objectives and purposes are not compromised. In combined test programs, such as has been directed for ALCM Full Scale Development, the program manager is specifically responsible for accomplishing his own development test and evaluation objectives and for integrating the

initial operational test and evaluation requirements into the total test program (Air Force Regulation 80-14, 1975: 2,3).

Whether combined or separate, the Air Force guidance is emphatic about one objective of all test and evaluation programs. "Test and Evaluation will be conducted in the most realistic operational environment that is practicable and economically prudent" (Air Force Regulation 80-14, 1975: 3). This policy is repeated and made more specific for each type of testing. "It is especially important to provide a realistic as possible operating environment for the initial operational test and evaluation to assure that performance, safety, maintainability, reliability, human factors and logistic supportability criteria can be evaluated under conditions similar to those that will exist when the system is employed" (Air Force Regulation 80-14, 1975: 5).

Major objectives of development test and evaluation include an assessment of performance capabilities in an operating environment as realistic as practicable (Air Force Regulation 80-14, 1975: 4). Performance is defined to include more than ALCM flight performance. It includes compatibility with other related systems, reliability, maintainability, logistic supportability and cost of ownership of the total system (ALCM Master Test Plan, 1975: 14,17).

It seems clear that realism is a valid test and evaluation objective. Realism can also be stated as an objective to be attained through selection of a staging base. Test and evaluation is seen as extending beyond ALCM flight performance to include all ground operations, the effect of the ground operations on the mission readiness and effectiveness of the system and the effect of the system on other existing systems. The staging base will provide the facilities and environment for the ground portion of test

and evaluation. These facilities and the related environment should be realistic to the extent they impact the assessment of the total system.

Result Objective: Support Test and Evaluation Activities Beginning with the Arrival of the First Aircraft. Ultimately, all ALCM program schedules are derived from certain directed milestone dates which are stated in the Decision Coordinating Paper, the Program Management Directive, and the "Form 56" program direction from Air Force Systems Command. As with other program schedules, test and evaluation schedules are developed from the directed milestones and are responsive to them. The first live launch of the Full Scale Development program is to occur in February 1979 in order that directed milestones may be met with some assurance (Master Summary Schedule, 31 Dec 1975). This test and evaluation schedule objective implies a corresponding objective for staging base selection.

In order for the first free flight to occur on schedule, considerable preflight activity is required at the staging base to run ground checks and support several captive carry missions. Thus the staging base must be able to support the program well prior to the first free flight. It might be possible at some future date to state several schedule sub-objectives that would recognize a gradual buildup of staging base capability. Such detailed planning is yet to occur and likely would depend, to some degree, on the staging base selected. Thus as a matter of practicality the assumption is made that all staging base resources must be available and operational for the arrival of the first aircraft. This allows for some build-up of capability prior to arrival of the first aircraft in order to support earlier arrival and checkout of aircraft and missile support equipment, and both flight ready and dummy ALCM and Short Range Attack Missiles which are known to be required (Stewart, 13 May 1976).

Result Objective: Support System Turnaround Time and Sortie Rates. To date, flight test scheduling is keyed to actual missile launches. This is only part of the activity which must be supported by the staging base. Each live launch of an ALCM is likely to be preceded by one or more captive carry missions. Other flight requirements also exist, especially in the first few months of operation (ALCM Master Test Plan, 1974: 21). In order for the live launches to proceed on schedule in support of directed milestones, all of these flight test missions must be supported without interference or delay caused by the selected staging base. (For planning and decision making purposes at this early date, it is assumed that all missions are required in sequence and that delay of a mission automatically delays all following missions by a equal amount. This may not be literally true in some cases, but exceptions cannot be identified until detailed test planning is accomplished.) Thus, to maintain program schedules the staging base must be able to support minimum system turnaround time and maximum sortie rates.

Result Objective: Support Data Recovery and Analysis Turnaround Time. One additional schedule related objective has been identified. Testing is not accomplished as an end in itself. Evaluation is required (Air Force Regulation 80-14, 1975: 3). In many, perhaps most cases, some evaluation is required of a test before the succeeding mission may be fully planned and conducted. Earlier ALCM program planning conducted in 1974 outlined the general facilities, participants and responsibilities thought to be required. That planning has only been partially updated in the current program context. Additional changes are expected, especially in terms of participant roles (Klung, 13 May 1976). Yet similar evaluations will have to be conducted (ALCM Master Test Plan, 1974: 28,29; and ALCM Master Test Plan, 1975: 26-27).

However the analysis is conducted and notwithstanding by whom, the selection of the staging base should not interfere with the conduct of tests by extending the data recovery and analysis turnaround time beyond that required for efficient test planning, scheduling, and conduct. The assumption made for the previous schedule related objective, that tests are sequential and that delay of a test delays all succeeding tests, is made here for the same reasons.

Resource Objective: Provide Maintenance of the Aircraft, Missiles and Support Equipment On-Site. It will be recalled from Chapter I that one of the limitations placed on this investigation was the requirement of on site maintenance. To restate, "...regardless of staging base selection all field and intermediate level maintenance of the carrier aircraft, carrier aircraft equipment, (peculiar to the ALCM system), missile systems and missile ground support equipment must be conducted on site at the staging base." This objective has been accepted by the Flight Test Working group (Joint Test Force working group action item, undated, action item 1) and has been treated as an established objective since the first Joint Test Force planning meeting in January (Klung, 23 March 1976).

Resource Objective: Provide Office Space and Housekeeping Facilities and Services for the Joint Test Force Personnel. The Joint Test Force will be on site and in operation for two years if current schedules are maintained. For an assignment over such a time period, many participating Air Force personnel will be permanently assigned at the staging base (Air Force Regulation 36-20, 1973: 6-1 and Air Force Regulation 39-11, 1971: 6-1). To minimize travel and per diem costs many contractor personnel can be expected to locate to the area as well. The staging base or immediate locale must provide full time office or work space and housekeeping services

for administrative, maintenance, operations, planning and analysis activities that will be carried on by personnel representing three ALCM subsystem contractors and at least seven distinct Air Force organizations (LaJunessee, 20 January, 1976; Fink, 20 January 1976; and ALCM Test Program, 26 March 1976: para 13B). In addition to work space and housekeeping (utilities, janitorial services, food services, etc.), off duty housing must be available in the immediate locale for these permanent party personnel and for personnel on temporary duty.

Resource Objective: Minimize Costs to the United States Air Force. The general desire for minimization of cost throughout the Air Force is established by regulation (Air Force Regulation 178-1, 1973: 1). In the test and evaluation context, test agencies are required to minimize duplication of test events, avoid testing where useable data from previous tests will meet the needs of current evaluation goals, conduct tests that are practicable and economically prudent, use already existing government facilities and other resources rather than rent or build new facilities, combine development and operational tests when cost savings can be realized and budget for test and evaluation resources (Air Force Regulation 80-14, 1975: 3,6,7). These requirements are a consequence of the overall Air Force requirement for cost minimization as applied to the test and evaluation context. The objective of cost minimization must apply as well to selection of the test staging base.

Resource Objective: Maximize Use of Existing Air Force Resources. Use of government resources has been mentioned in the preceding paragraph as a means of minimizing costs. It may not appear to be a separate objective. However, as a separate objective it may be supported conceptually, by reference to regulations and by reference to ALCM flight test

planning meetings. It should be understood that resources may include real property, instrumentation, computer hardware and software, tools, techniques, and the personnel required to manage, operate and maintain those resources.

The tendency to maximize the use of organizational resources is expected. Social organizations, including bureaucracies, tend to perpetuate themselves and their capabilities through maintenance of current roles, relationships and resources and through a tendency to expand in size, complexity and capacity. This tendency is identified by Katz and Kahn through application of systems theory to explain the social psychology of organizations. They maintain that organizations are analogous to open systems and assert:

> Open systems which survive are characterized by a steady state. There is a continuous inflow of energy from the external environment and a continuous export of the products of the system, but the characteristics of the system...remain the same. Though the tendency toward a steady state in its simplest form is homeostatic,...the basic principle is the preservation of the character of the system. In preserving the character of the system moreover, the structure will tend to import more energy than is required for its output. To insure survival, systems will operate to acquire some margin of safety beyond the immediate level of existence (Katz and Kahn, 1966: 23,24).

This leads Katz and Kahn to a statement of the maximization principle.

> The managerial structure, like all the substructures of the organization, has a self-maintenance dynamic (which seeks) to develop and preserve stable patterns for the whole organization. But every subsystem also attempts to maintain itself. The managerial structure, as the decision-making group for the whole system, is thus concerned with the preservation of the entire organization, though this sometimes is perceived as the preservation of the particular management group....There is considerable resulting stability, but there is also growth, expansion, and change in almost all social systems. In fact, one of the basic properties of social systems of the bureaucratic type is that they move toward maximization, toward growth and expansion (Katz and Kahn, 1966: 99).

It is accepted that maximization or at least homeostasis exists in bureaucratic organizations. It is believed that perpetuation of

organizational capabilities is a valid general objective so long as the fundamental need for which the organization was formed remains valid. This is a judgment of worth which is susceptable to personal opinion. Not every one may agree on the degree of "need" for the United States Air Force or certain of its facilities and capabilities. Nevertheless, it is assumed here that the fundamental objectives of the United States Air Force are valid and that its general capabilities should be sustained.

In periods of temporary drawdowns in either activity or available monetary resources, homeostatic tendencies may be especially evident. Stressing the use of in-house capabilities not only saves on costs but maintains existing capabilities and readiness as much as is possible through exercise of both facilities and personnel. It is maintained that Air Force test and evaluation activities have been and still are in such a drawdown period, especially compared to the early 1950's when aircraft development was at high levels and compared to the early to mid 1960's when missile system developments were pace setters. The requirement for maximum use of Air Force and Air Force Systems Command facilities, personnel and other test resources as stated in Air Force Regulation 80-14 and the Air Force Systems Command supplement to that regulation take on new meanings separate from pure cost concerns when viewed from this perspective (Air Force Regulation 80-14, 1975: 3; and Air Force Systems Command Supplement to Air Force Regulation 80-14, 1975: 2).

As a final tie to this specific investigation, it has been noted that this objective (maximum use of Air Force resources) is a specific concern of the Joint Test Force Director (Klung, 13 May 1976).

Specification of Objectives

Having stated the objectives relevant to selection of a staging base, the selected methodology requires an initial ranking of these objectives through the separate identification of mandatory objectives and desired objectives.

Mandatory objectives are obviously of the highest (and equal) rank. They will be stated in measurable terms with absolute limits to serve as standards against which alternatives will be screened. Desired objectives need not be stated in absolute terms but may indicate the desirability of maximizing or minimizing some objective. For either type of objective, quantified specifications will be stated to the degree that such information is available. Mandatory objectives will either be quantified or described with a normative statement. Desired objectives will also be quantified, when possible. However, cases will arise where desired objectives are not readily measurable. Even so, a specific indication of achievement will be stated.

Finally, the desired objectives will be given a numerical weighting relative to importance. A score of 10 indicates the most important objective (Kepner and Tregoe, 1973: 43-45).

Before continuing, a summary listing is provided to establish an overview of the objectives which have been established.

RESULTS

Maximize realism in test and evaluation
Support test and evaluation activities beginning with the arrival of the first aircraft
Support system turnaround time and sortie rates
Support data recovery and analysis turnaround time

RESOURCES

Provide maintenance of the aircraft, missiles and support equipment on site

Provide office space and housekeeping facilities and
services for the Joint Test Force personnel
Minimize costs to the United States Air Force
Maximize use of existing Air Force Resources.

In the following paragraphs objectives will be identified as mandatory or desired and will be further specified. Weights will be assigned to the desired objectives. The chapter will close with the matrix of weighted objectives against which all alternatives will be measured.

Three objectives are directly related to schedules. Other objectives are also related to schedules, though indirectly. It is necessary to understand the importance of schedules in the ALCM program perspective before continuing.

It may be argued by some that schedules are not, or at least should not be mandatory; that cost overruns of past programs have been traced to an obsessive desire to meet untenable schedules without regard to other objectives. That there may be a significant element of truth in this assertion would not be argued. However, in the context of this decision analysis several points should be kept in mind.

First, the decision level for this investigation is the United States Air Force. Though detailed program and test schedules are developed by the Air Staff and lower echelons (and may be changed by them), the basic milestones upon which they are based are directed from above the decision level by the Department of Defense. They are givens which should be and in practive are considered mandatory. If one may assume that detailed schedules represent the best available plans for meeting those given milestones with assurance, then significant late deviations from those schedules hazard those milestones.

Second, the staging base itself is a resource, an input, not the desired program output. Given the objectives and schedule of the total program, it seems unreasonable to allow the selection of one resource (an initial planning decision) to hazard the overall program schedule unless it can be shown that the directed milestones are impractical.

Third, we have alluded to the schedule impact on costs. Schedule delays directly increase costs by sustaining the Joint Test Force longer than necessary. It will be seen that the Joint Test Force involves the expenditure of a large amount of manpower. A slip of even one month in schedules can be costly.

And lastly, there are difficult to assess, but very real, political costs to be borne if the selection of a staging base is allowed to hazard program schedules. The program is in direct competition with the Sea Launched Cruise Missile program of the United States Navy. Delays that violate directed milestones may seriously effect the likelihood of receiving an approval to proceed with the Full Scale Development Program.

For the reasons specified above, the following schedule related objectives of this decision analysis are considered mandatory.

Mandatory Result Objective: Support Test and Evaluation Activities Beginning with the Arrival of the First Aircraft. It is mandatory that the selected staging base "support test and evaluation activities beginning with the arrival of the first aircraft". Two statements are required to make this objective meaningful. First, the planned date of the arrival and the total available preparation time must be specified. Second, a definition of necessary preparations must be given.

Planning schedules show 1 September 1978 to be a very significant date. Modification of the first B-52 is to be completed on that date.

The B-52 should be available to the ALCM flight test program at that time. Second, initial aerospace ground equipment is to be delivered on that date. Third, 1 September 1978 is shown as the start date of the flight test program. And fourth, the first flight test missile will be delivered to the staging base just prior to that date. That missile will clear the Missile Integration Laboratory on 30 June 1978 and clear the Systems Integration Laboratory (both at Boeing, Seattle) and be shipped to the staging base sometime in August (Production Planning Schedule, 12 February 1976; and Minutes of ALCM Test Planning Meeting, 29 March 1976, attachment 3).

It should be stated that one of the referenced schedules is a Boeing schedule. It does assume that the Boeing Wichita facility will be the staging base. Nevertheless, that schedule is valid (short of a full program restructuring). The first missile flight date, February 1979, is not dependent on the staging base selection. Tests required at the staging base prior to that flight are also independent of staging base selection. They include a variety of mechanical and electrical ground checks and compatibility tests beginning 1 September 1978 plus at least two (estimated) captive carry missions. For all the above rationale, 1 September 1978 is selected as the specific date for this mandatory objective.

In addition to a mandatory operational date, the time available to make the staging base ready should also be specified. Preparations at the selected staging base cannot begin the day of selection. Authorization to proceed with Full Scale Development must be received from the Secretary of Defense. He judges the program merits based, in great part, on the recommendation of the Defense Systems Acquisition Review Council. This council will review the ALCM program for justification of Full Scale Development authorization in January 1977. If a favorable decision is given, then authorization to proceed is expected in February 1977

(Master Summary Schedule, 31 December 1975). It is unlikely that costs of preparing a staging base could be authorized or charged prior to that time. Thus the selected staging base would have to be prepared in a period of eighteen months--from February 1977 to September 1978.

Finally, there is a need to define necessary preparations. This will be accomplished by specifying two other mandatory objectives which will follow. They require on-site maintenance, office space, and housekeeping facilities and services. Thus necessary preparations, as applied to this schedule objective includes all preparations required at the staging base to provide the mandatory facilities and services which will be specified.

In summary, this mandatory objective requires that all necessary preparations be made in a period of eighteen months and that the staging base be capable of providing all mandatory support beginning 1 September 1978.

Mandatory Result Objective: Support System Turnaround Time and Sortie Rates. The rationale which justifies the mandatory nature of schedule related objectives was previously stated. That rationale remains valid for this objective. Specification of this objective requires a definition of turnaround time and the development of an estimate for average and maximum sortie rates. Activities and facility limitations at the selected staging base must not interfere with or prevent the test program from preparing for and launching missions according to those rates.

Current planning calls for 25 live launches of ALCM's and 35 captive carry missions in a period of 20 months. (Captive carry missions include launch rehearsals and trouble shooting missions.) In addition, a ten percent abort rate is assumed to allow for equipment failures and weather aborts enroute. The average sortie rate for the program, then is 3.3 per month ((25+35+6)/20=3.3).

The maximum sortie rate is based on the four month period July through October 1979. During that period two live launches are shown for each month. Assuming two captive carry missions per live launch and the 10 percent abort rate, the sortie rate for this period is 7 per month (2+4+1=7) (Flight Test Summary, 30 March 1976; Production Planning Schedule, 12 February 1976; Planning notes, undated; and Full Scale Development Planning factors, undated).

At 7 per month, a rate of two sorties per five working days will occur frequently. With two carrier aircraft, and with the assumption that the carrier aircraft will alternate missions, normal turnaround time for the carrier aircraft should be on the order of five working days.

Alternation of missions is expected as a product of reliable, conservative planning and is likely to be required as well to allow for data recovery and sufficient analysis of on-board equipment performance between missions, especially when malfunctions are experienced. It is possible, however, that the same aircraft might on occasion be required to fly two consecutive missions with a short turnaround. This might well happen with an abort and quick fix of a trivial fault such as occurred on the first Advanced Development mission. The selection of a staging base, therefore, should not preclude an occasional turnaround time of as little as two days.

Under the conditions described above it is likely that one aircraft could fly twice in one five day work week while the other flew once. Thus it is expected that three sorties will occur in a week at some point during the program. It is far less likely that both aircraft will experience a quick turnaround the same week. Therefore, the maximum sortie rate is estimated to be three per week. This rate will have to be supported by the selected staging base on an occasional basis.

In summary, the peak sortie and turnaround times which must be supported are three per five day work week and two days, respectively.

Mandatory Resource Objective: Provide All Maintenance of the Aircraft, Missiles, and Support Equipment On Site. That this objective is mandatory has been suggested twice previously. In chapter I it was stated as a limitation of this study. In this chapter, the general acceptance of mandatory on-site maintenance by members of the flight test working group was established. The objective will be specified in terms of the equipment and facilities required to operate and maintain the system. They are stated in one of two groups--those that are aircraft related and those that are missile related. Aircraft requirements will be considered first.

Dedicated hangar space is required for simultaneous use by both the B-52G and B-52H carrier aircraft. These aircraft will be received from Strategic Air Command inventories (ALCM Master Test Plan, 1975: 26). Equipment and space suitable for gear retraction, phase inspection, corrosion control, and fuel cell maintenance are required. Fuel cell maintenance requires an explosion proof hangar.

Logistics functions necessary for support of the G and H model aircraft will be required. Spares must be stocked to support the established sortie rates and an average mission time of 6 to 7 hours. Petroleum, oils and lubricants must be available in the quantities implied by the sortie rates and mission times.

B-52G and H peculiar support equipment must be on hand and must be provided sufficient space and power. This will include equipment for avionics maintenance, field maintenance (mechanical, hydraulic, electrical systems, metal fabrication and parachute) and organizational maintenance

(including inspection, support and supervisory functions). Figure 2 outlines a typical Strategic Air Command B-52 maintenance organization. Not all maintenance functions shown in that figure will be required--at least not of a scope that Strategic Air Command would require to support an operational wing. However, figure 2 is indicative of the variety of support which must be provided--both in terms of equipment and personnel. And finally, ramp parking space, taxiways and runways must be suitable for all-weather B-52 operations (Notes of the System Operations Program Manager, undated).

The assumption has been made that the ALCM Missile Maintenance Facility and the Short Range Attack Missile Integrated Maintenance Facility are to be treated as one overall missile maintenance facility. There is some controversy over this issue due to unresolved safety considerations. However, it is assumed that these considerations can be resolved. For convenience, the term Missile Maintenance Facility will be inclusive of ALCM and Short Range Attack Missile functions.

The Missile Maintenance Facility requires a high-bay with an over head hoist to handle missiles, pylons, rotary launchers and missile handling equipment. The area must be suitable as a hazardous item handling area and must accommodate missile test equipment, missile test stands, and dummy loads for the Short Range Attack Missile, and three guided missile test stations, special test equipment, and support equipment for the ALCM. The Missile Maintenance Facility is expected to require:

120/208 volts 3 phase 60 hertz 60 kilovolt-amperes
115/200 volts 3 phase 400 hertz 43 kilovolt-amperes
28 volts direct current 40 amperes

Hydraulic pressure, 3000 pounds per square inch, 3/4 inch supply, 1 inch return.

Water (quantity unspecified).

AIRCRAFT MAINTENANCE ORGANIZATION

I. Avionics Maintenance Squadron
- A. Mission Systems Branch
  - 1. Bomb Navigation Systems Shop
    - a. Photography Shop
  - 2. Fire Control Shop
- B. Communication Navigation Branch
  - 1. Electronic Countermeasures Systems Shop
  - 2. Inertial Navigation Shop
  - 3. Radio Shop
  - 4. Doppler Radar Shop
- C. Analysis Branch
- D. Training Branch
- E. Instruments Branch
  - 1. Flight Instruments Shop
  - 2. Auto Pilot Shop
- F. Precision Measurements Equipment Laboratory Branch
- G. Quality Control Branch
- H. Production Control
- I. Administration

II. Field Maintenance Squadron
- A. Pneudraulics Branch
  - 1. Mechanical Accessories Shop
  - 2. Hydraulic Shop
- B. Engine Branch
  - 1. Engine Test Cell (if required)
- C. Electrics Branch
  - 1. Generator/Alternator Shop
  - 2. Battery Shop
- D. Aerospace Systems Branch (Repair and Reclamation)
  - 1. Egress Shop
  - 2. Wheel and Tire Shop (Brakes)
  - 3. Corrosion Control Shop
  - 4. Flight Controls Shop
  - 5. Landing Gear Shop (Retraction System)
- E. Powered Aerospace Ground Equipment
- F. Fabrication Branch
  - 1. Sheet Metal Shop
  - 2. Machine Shop
  - 3. Welding Shop
  - 4. Parachute Shop
  - 5. Drag Chute Shop

Figure 2. B-52 Aircraft Maintenance Organization

III. Organizational Maintenance Squadron
- A. Flight Line Branch
  - 1. Crew Chiefs
  - 2. Maintenance Team
- B. Inspection Branch
  - 1. Phase Inspection Team
  - 2. Basic Post-Flight Inspection Team
- C. Support Branch
  - 1. Non Powered Support Equipment
  - 2. 780 Equipment
  - 3. Support Equipment Drivers
- D. Supervisory Branch
  - 1. Administration
  - 2. Training
  - 3. Production Maintenance Control
  - 4. Publications

Figure 2 (continued) B-52 Aircraft Maintenance Organization
(From Notes of the System Operations Program Manager, Undated)

Additional functions will have to be accommodated. A weight and balance station, receiving and inspection area, tool, material and spares stores, instrumentation repair and Precision Measuring Equipment Laboratories should be provided. A wing shelter is required for missile to pylon/launcher loading and checkout. A storage igloo(s) will be required to accommodate 5 Short Range Attack Missiles and an undetermined number of ALCM missiles. In addition to this hazardous storage area, a fuel/defuel cell is required for ALCM, along with an engine ground runup facility (uncertain requirement).

A weapon maintenance and inspection facility for evaluation of payload buildup is also desired but is considered optional. This facility can be provided at another location.

A last but necessary facility is a telemetry ground station used to checkout missile telemetry transmissions prior to test missions.

Minimum acceptable floor or area space requirements for all functions has not been estimated. However, The Boeing Company is suggesting use of 24,345 square feet at the Boeing Wichita facility exclusive of dedicated office space and aircraft maintenance (hangar and shops) space. This figure is useful as a guide but will not be used as a firm figure for descriminating between alternatives (Notes of the System Operations Program Manager, undated; Full Scale Development Planning Factors, undated; Headquarters Air Force Test and Evaluation Center ALCM, 23 March 1976; ALCM Test Program, 26 March 1976, para 15; ALCM Test Program, 21 April 1976: 1).

Mandatory Resource Objective: Provide Office Space and Housekeeping Facilities and Services for Joint Test Force Personnel. The most recent estimate of total Joint Test Force personnel calls for 350 to 400 participants, including 250 contractor personnel and 110 Air Force military and civilians (ALCM Test Program, 26 March 1976: para 13B). These figures are exclusive of aircraft maintenance and data reduction (the latter not necessarily a

staging base requirement). This office and shop space would normally be located in the operating area. In addition, some of the 250 contractor personnel will be missile and support system technicians not requiring office space on a full time basis. Therefore, it is assumed that provisions of full time dedicated office space for 350 will be adequate. It must be noted that the exact mix of contractor and Air Force personnel is an undetermined issue at this point. It is assumed that the estimate is based on manning to accomplish functions, regardless of the source of the personnel. Therefore the total number of personnel is not expected to change significantly regardless of the actual contractor/Air Force mix.

No minimum office space requirements have been established nor is it expected that such a figure will be forthcoming. However, The Boeing Company is suggesting 12,720 square feet of hangar space to be dedicated to office areas if Wichita is chosen. This is <u>not</u> a requirement (it is simply what is available and proposed for one alternative) and should be used only to indicate what is believed to be adequate space. This amounts to 36 square feet per person including space taken up by partitions and walkways--not an excessive allocation in the view of the investigator (Full Scale Development Planning Factors, undated).

In addition to the purely space considerations, desks, chairs, file cabinets, safes, bookcases and the like must be provided for 350 personnel. Also, janitorial and utility services would be required.

Off-duty housing will be treated as a separate objective.

<u>Desired Result Objective: Maximize Realism in Test and Evaluation</u>. To qualify as a mandatory objective, the objective under consideration must be essential and must be identifiable with absolute limits. Desirable objectives are expressed more generally and a critical level of accomplishment

is not identified (Kepner and Tregoe, 1973: 44,45). Realism fits the latter of these descriptions. By regulation such phrases as "most realistic...that is practicable and...prudent" and "a realistic as possible operational (test) environment..." indicate ranges of acceptability with no absolute requirements (Air Force Regulation 80-14, 1975: 3,5). Nor in the specific case of the ALCM is it possible to specify a minimum essential degree of realism (Fink, 13 May 1976). What is desired is maximization of test realism consistent with other goals.

While specific limits or targets of acceptability cannot be specified, realism can be better defined. In the limited context of the staging base, the selected alternative facilities will provide a degree of realism for evaluation of system electrical and mechanical compatibility (carrier aircraft equipment, support equipment, ALCM and Short Range Attack Missile), reliability in the ground environment (of the ALCM, support equipment, and carrier aircraft equipment), system maintainability (loading, ground handling, system checkout, buildup, tear down, and maintenance) and logistic supportability (Headquarters Air Force Test and Evaluation Center ALCM, 23 March 1976).

Realism for these tests is a product of the equipment used, the personnel using them and location (environmental effects) of the selected alternative staging base.

With regard to equipment used, that equipment has been specified in the requirement for on-site maintenance. The degree of realism that can be provided by the equipment is a function of the design and configuration (placement) of that equipment. Equipment design is independent of staging base and need not be considered further.

Placement of equipment is determined by the design of the Missile Maintenance Facility. The goal here is to provide a facility and equipment

configuration as realistic as is possible, where maximum realism is defined as the exact configuration of the Missile Maintenance Facility (yet to be designed) that will service both operational ALCM and Short Range Attack Missile systems.

Regardless of which alternative is finally chosen, that facility must be designed and built (Klung, undated: 4,5). Thus equipment placement also is essentially independent of staging base.

With regard to personnel, realism is accomplished by having all operations and maintenance functions performed by military personnel with appropriate skill levels. These personnel are being included in the planning and programming activities of the Air Force Test and Evaluation Center for Initial Operational Test and Evaluation requirements. These personnel will be provided regardless of staging base. (Operational Test and Evaluation Test Program Outline, 20 February 1976: 3-7). Thus personnel considerations are also independent of staging base and need not be considered further.

The preceding leaves only location (environmental) differences as a discriminating factor between alternatives. Realism demands an environment similar to that of Strategic Air Command bases at which Short Range Attack Missile and ALCM systems will be located. In general, these bases are in northern locations near the Canadian border. They are characterized by hot, humid summers and extremely cold winters with heavy snow and severe icing conditions. Based on Short Range Attack Missile program experience, the winter conditions are especially critical to test and evaluation realism. Numerous problems due to ice and snow conditions have been experienced in ground handling operations of the Short Range Attack Missile. They were not anticipated or discovered during test and evaluation (Carlton, 7 May 1976).

Desired Result Objective: Minimize Data Recovery and Analysis Turnaround Time. Where absolute limits cannot be identified, an objective must be treated as a desired goal. Such is the case with data recovery and analysis turnaround time. No data analysis specifications or detailed test plans exist. They will be written subsequent to authorization of Full Scale Development. Thus it is not possible to specify the data analysis timelines between specific missions or to determine the minimum (most demanding) turnaround time that is likely to be required.

What can be done is to minimize delays that might result due to the selection of a particular staging base. It will be assumed that delay due to data transmission times between the staging base and selected computer (data reduction) facilities is inconsequential. Electronic transmission of data is nearly instantaneous.

Desired Resource Objective: Provide Adequate Off-Duty Housing for Joint Test Force Personnel. Adequate housing is primarily a personal objective of the Joint Test Force personnel. It is an objective of the Air Force only indirectly as a matter of morale and response time when off duty and as an implied obligation to house military personnel. As a personal objective, what is deemed adequate is an individual matter. No minimum requirement can be set. As an Air Force objective no specific requirements exist. Thus adequate housing can be expressed only as a desire to be measured in a relative sense when comparing alternatives.

Relative adequacy must be considered both in number and in kind to meet the needs of the personnel that local housing and services must accommodate. Both military housing availability and local housing markets and services must be considered. It is estimated that the selected staging base and the surrounding locale will have to accommodate the following

influx of permanent party personnel and their families:

Officers	28
Enlisted	66
Civilians	17
Contractor	250
Total	361

These figures, other than for contractor personnel, were estimated by extending Air Force Test and Evaluation Center estimates for their personnel to account for the estimated total of 110 Air Force Military and civilians (Operational Test and Evaluation Test Program Outline, 20 February 1976; and ALCM Test Program, 26 March 1976). They do not include personnel for aircraft maintenance or data reduction. Depending on decisions relative to choice of Air Force or contractor maintenance, choice of staging base and choice of data reduction facility, these figures may have to be adjusted.

Desired Resource Objective: Minimize Program Costs to the United States Air Force. Program budgets for Full Scale Development are stated at the level of "Test and Evaluation direct costs" and "Initial Operational Test and Evaluation." No detailed breakouts are available. Thus specific cost targets for staging base selection are unavailable. In the absence of absolute limits no mandatory cost objectives are established (Weapon System Budget Estimate, 31 December 1975).

For the purposes of this decision analysis, costs will be defined as expenses likely to be incurred by the United States Air Force. This will include expenses of contracts, salaries, supplies, etc. Only identifiable cost differences between alternatives will be considered significant.

Desired Resource Objective: Maximize Use of Existing Air Force Resources. As has been pointed out before objectives which maximize or minimize some factor without specifying absolute goals must be treated as desired objectives. Though regulations specify use of Air Force and Air

Force Systems Command resources, they include such phrases as "use whenever possible," "insofar as is practicable," and when "technically sufficient" (Air Force Regulation 80-14, 1975: 3 and Air Force Systems Command supplement to Air Force Regulation 80-14, 1975: 2). These inclusions imply a range of acceptability with indistinct bounds, a desire to be fulfilled with due regard for the other objectives of the specific program involved.

The meaning and intent of Air Force resources require further definition. Both regulations cited are written in the context of test and evaluation. Therefore, in the event of a choice between Air Force, Air Force Systems Command and other command facilities preference will be given (for the purposes of this specific objective) to test and evaluation facilities regardless of command (it is realized that Systems Command facilities are more likely to be test and evaluation resources). If further distinctions are required to rank alternatives against this objective, then the estimated cost to rent, lease, contract, or buy will be used as a determining factor. The staging base offering the greater cost savings will be preferred.

Weighting of Desired Objectives

The last step in the specification of objectives requires the weighting of desired objectives. A numerical one to ten scale is used with ten being assigned to the most important objective (Kepner and Tregoe, 1973: 45). The following desired objectives have been identified:

Maximize realism in test and evaluation
Minimize data recovery and analysis turnaround time
Provide off-duty housing for Joint Test Force personnel
Minimize costs to the United States Air Force
Maximize use of existing Air Force resources

Provision of off-duty housing for Joint Test Force personnel is assigned the lowest relative value, a weighting of 3. This is justified on the basis that this objective is only indirectly an Air Force objective. The direct

needs of the selected decision level, the Air Force, are overriding in priority. All other objectives identified are direct objectives of the United States Air Force.

In ascending priority, maximum use of existing Air Force resources is assigned a weighting of 5. Facility utilization is specifically made subservient to practicality (cost and schedule) and technical sufficiency (performance capabilities) (Air Force Regulation 80-14, 1975: 3 and Air Force Systems Command supplement to Air Force Regulation 80-14, 1975: 2). This is taken to mean that use of Air Force facilities is desirable but not to the extent that basic program cost, performance and schedule objectives are placed in jeopardy. All mandatory objectives and the remaining desired objectives relate directly to, or were derived from cost, performance, and schedule objectives of the basic ALCM development program or the combined test program. The objective of maximizing the use of Air Force facilities must then, be subordinate to those objectives. It is noted however that other objectives, mandatory on site maintenance, desired minimization of costs and desired realism in test and evaluation, are likely to support the probability of maximizing use of Air Force facilities.

The next in ascending importance is maximum realism in test and evaluation. It is assigned a weight of 7. Realism is made subordinate to cost by regulation. Realism is to be limited by economic prudence. (Air Force Regulation 80-14, 1975: 3). Realism is also considered subordinate to minimum data recovery and analysis turnaround time because this latter objective impacts costs and also is related to maintenance of directed (mandatory) schedules. Thus realism is subordinate to both.

The relationship between cost and schedule is direct and pervasive. It has been pointed out that two schedule related objectives are mandatory.

If data turnaround times could be better specified, that objective would be deemed mandatory as well. Yet if a staging base target could be specified, a mandatory "not to exceed" cost objective would result. Thus, a weighting descrimination between these two objectives is difficult to assess. Since schedules are viewed as affecting costs, the schedule related objective will be viewed as a sub-objective of costs for the purposes of weighting. This judgment is also made in the context of the rather stringent cost climate that Air Force research and development is "enjoying". Thus minimization of data recovery and analysis turnaround time is assigned a weight of 9 and minimization of cost is assigned a weight of 10.

A final point on weighting is in order. The selected rank order of desired objectives is defended by the above rationale. However, the numeric weights assigned cannot be defended by reference to any document or by discussion with any authority. They represent the best judgment of the investigator as to the relative value of the objectives that have been identified.

Objective Matrix

To summarize this chapter, a matrix of objectives is stated. These objectives will be used to measure the relative acceptability and worth of the alternatives which are identified in the following chapter. With this matrix, the first three steps of Kepner and Tregoe's method are complete.

MANDATORY OBJECTIVES

Support test and evaluation activities beginning 1 September 1978
Support system turnaround times and sortie rates
Provide maintenance capabilities on site
Provide office space and housekeeping facilities

DESIRED OBJECTIVES

Minimize costs to the United States Air Force	10
Minimize data recovery and analysis turnaround	9
Maximize realism in test and evaluation	7
Maximize use of existing Air Force resources	5
Provide off-duty housing for Joint Test Force Personnel	3

III. Alternatives and the Tentative Decision

A decision statement has been selected, and nine decision objectives of varying importance have been stated. To proceed, alternatives must be developed and evaluated. The best of those alternatives will be selected for a tentative decision (Kepner and Tregoe, 1973: 46-52).

This investigation has set out "To select the most cost effective staging base available from among the known, reasonable alternatives." Two qualifications were placed on the alternatives to be examined--known and reasonable. The first is a natural limitation. Unknown alternatives cannot be analyzed. The second limitation requires judgment. It follows that alternatives may be placed in one of three categories--those of which the decision maker is unaware, those which are both known and reasonable, and those which are "outside the sphere of discretion" (Terry, 1972: 117).

Terry did not elaborate but discretion means "individual judgment, undirected choice, (or) according to one's judgment," and implies the "quality of being discreet; prudence;..." (Webster's New Collegiate Dictionary, 1956: 237). Thus the third category is understood to include known alternatives that are possible but which are excluded from further investigation because they either are held to be unreasonable or are unlikely to support the decision objectives (at least relative to those alternatives that are considered to be known and reasonable).

One might investigate the hundreds of known alternatives. Much of this effort, however, would be wasted. The practical unsuitability of many of them is immediately evident. Consider--known alternatives include every military and civilian base and airport in the free world with runway capacities and hangar space capable of servicing B-52 aircraft. Even this large population of alternatives is not all inclusive. The

possibility of expanding hangar and runway facilities has been excluded. Further judgmental exclusions will be made to restrict this investigation to a list of known, reasonable alternatives.

The Sphere of Discretion

All alternatives outside the contiguous 48 United States are excluded from further consideration to avoid anticipated cost escalations and personnel hardships for which no return benefit is perceived. With one exception commercial alternatives are excluded to avoid anticipated cost escalation, priority and other conflicts with the civilian sector, and military personnel hardships, also without perceived return benefit. Alternatives available through use of government facilities other than those of Air Force Systems Command, Air Force Logistics Command, and Strategic Air Command are also perceived to require cost escalations and priority conflicts with the missions of other commands, also without benefit.

Alternatives within the three remaining commands, Air Force Systems Command, Air Force Logistics Command, and Strategic Air Command, and the one commercially operated facility, are further restricted to those which satisfy at least one of the following conditions: B-52G or B-52H support capabilities are already in place or a reasonable degree of test and evaluation resources are already in place and B-52 support is possible. Within these restrictions there still remain 25 alternatives which should be investigated.

Strategic Air Command (host or tenant) Bases with B-52G or B-52H and Short Range Attack Missile Facilities.

Loring	K. I. Sawyer	Griffiss
Grand Forks	Seymour Johnson	Minot
Ellsworth	Wurtsmith	Robins
Fairchild	Mather	Blytheville
Kinchloe	Barksdale	Beale

Strategic Air Command Bases with B-52G and B-52H Facilities.

Castle

Air Force Logistics Command Bases with B-52G or B-52H Facilities.

Tinker Kelly

Air Force Systems Command Bases with Significant Test and Evaluation Facilities.

Edwards Patrick Eglin
Kirtland

Commercial Alternative with B-52G, B-52H and Limited ALCM Facilities.

The Boeing Company, Wichita (Air Force Plant 57)

Air Force Logistics Command Bases with Test and Evaluation Facilities.

Hill Wright-Patterson

Assessment of Alternatives Against Mandatory Objectives

Mandatory objectives are standards against which apparently reasonable alternatives are screened. Those which fail to meet any of the mandatory objectives are immediately eliminated from further consideration. Those alternatives which are borderline require an extra measure of judgment. If eliminated, an alternative which may otherwise compare favorably might be lost. If kept, there is an added risk that adverse consequences will be realized should that alternative be selected (Kepner and Tregoe, 1973: 44,47,48).

This investigation has identified four mandatory objectives. Each will be restated in turn and those bases eliminated by that specific objective will be identified.

Provide All Maintenance of the Aircraft, Missiles and Support Equipment On Site. There are six alternatives for which a B-52 maintenance organization does not currently exist. They are Edwards, Kirtland, Patrick, Eglin, Hill and Wright-Patterson. An essential element to B-52 maintenance

at these or any other location is the "Table of Allowance Support Equipment." These are B-52 peculiar equipments that are required to maintain the basic aircraft, avionics, and flight systems.

The current Tables of Allowance for the B-52, TA-356, -369, -802 (organizational support equipment) and 739, 738A, and 739 (intermediate level aerospace ground equipment) contain approximately 1000 major line items exclusive of several hundred common and special hand tools, common Aerospace Ground Equipment, and B-52 spares. These 1000 line items are valued at 2.5 million dollars (original cost). In general, these systems have been out of production since the early 1960's (Haynes, 7 June 1976 and Full Scale Development/ALCM Support Requirements, 11 June 1976: 1).

The most recent attempt to set up a B-52 maintenance facility occurred in 1974 at Castle Air Force Base. This required extensive efforts over several months to locate excess Table of Allowance Support Equipment items through a search of Air Force Logistics Command and Strategic Air Command inventories. The search was not entirely successful. Numerous "work-arounds" had to be developed to compensate for missing equipment and some items had to be procured. In some cases the original manufacturer had gone out of business. New sources had to be developed. It took two years to develop new sources and receive the necessary equipment (Haynes, 7 June 1976 and Rameris, 8 June 1976).

In addition to the problem of locating available items, one may anticipate the need for extensive depot repair and refurbishment and the need to transport, install, calibrate and certify those items which may be found. As an example, an excess Bomb Navigation System Mockup bench has been located at Beale. It may be available to the ALCM program but requires extensive refurbishment. It is currently tagged for shipment to Barksdale Air Force Base to support the operational wing there (Haynes,

7 June 1976). Strategic Air Command requirements for any other excess support equipment that may be found is unknown.

To search for, locate, refurbish, repair, install, calibrate and certify inventory equipment, or to procure equipment and develop new sources is at best extremely risky. There is little reason to believe that such an approach would provide full support by the mandatory date, 1 September 1978, given the eighteen months available to accomplish these tasks.

In view of the hazards and uncertainties involved, in locating, making available and refurbishing Table of Allowance Support Equipment, The Oklahoma City Aeronautical Logistics Center has recommended that "utilization of a non B-52G/H Short Range Attack Missile base location be deleted as a consideration for the ALCM flight test program" (Klung, undated: 3).

It appears that logistics personnel at the Air Force Flight Test Center (the Responsible Test Organization) agree with the assessment of difficulties, if not with the conclusion of Oklahoma City personnel:

> In the area of support equipment, AFFTG/LGX stated that 'obtaining major items of test equipment (test benches) would be impractical. Lateral support (is recommended)...for trouble shooting and repair of these major items (avionics and on-equipment (sic) check lists) and that Air Force Flight Test Center support be limited to remove and replace and on-equipment troubleshooting.' Engine support would be based upon pre-positioned spare engines utilizing a Strategic Air Command base as Queen Bee to offset lack of test cell and off-equipment maintenance capability (Klung, undated: 3).

This approach to B-52 maintenance is presumed to be necessary at all bases not having currently operating B-52 maintenance facilities. Limitation to on-equipment troubleshooting and to remove and replace maintenance with lateral support for repair clearly does not meet the mandatory on-site maintenance objective. This is sufficient justification to eliminate Edwards, Kirtland, Patrick, Eglin, Hill and Wright-Patterson from further consideration.

The method selected for this investigation allows for retention of a substandard alternative if in the judgment of the investigator there may be redeeming features, i.e., if the alternative may possibly compare favorably with other alternatives when compared against other objectives (the desired, non-mandatory objectives.) There is a risk in retaining a substandard alternative. If selected, adverse consequences may result (Kepner and Tregoe, 1973: 47,48).

One of the six bases listed above is considered worthy of additional investigation. The Air Force Flight Test Center, Edwards Air Force Base, has been designated the Responsible Test Organization. A significant percentage of Joint Test Force personnel are located there. Edwards has extensive test and evaluation resources and it is located near the two likely test range options. Further, though on-site B-52 maintenance is not likely to be provided, one can not say with certainty that it is an impossible task. For these reasons, Edwards will be retained for further investigation with the realization that adverse test schedule consequences are likely to accompany the choice of Edwards as the staging base. Kirtland, Patrick, Hill, Eglin and Wright-Patterson offer one or another of these features but do not offer all of them. Relative to Edwards, these do not warrant further consideration.

Kelly and Tinker are Air Logistics Centers with B-52 overhaul responsibilities. The mandatory requirements established by this investigation were transmitted to both centers. Center personnel were asked to make a preliminary assessment of their ability to host the Joint Test Force (Test Planning for Full Scale Development/ALCM, 11 June 1976).

The reply from Tinker was discouraging on two counts. It cast doubt on the practicality of their supporting required aircraft turnaround times,

but not conclusively. More conclusively, their reply shows serious facility limitations when compared to established maintenance objectives.

Two hangars at Tinker are large enough to accommodate the program--hangar 3102 and hangar 240. Hangar 3102 is used for post dock operations for A-7, C-135 and B-52 aircraft. It supports the primary mission of the Air Logistics Center and cannot be made available for the ALCM program.

Hangar 240 does not meet established requirements for an explosion proof hangar. It cannot receive fueled aircraft. Modification to explosion proof standards would require extensive facility modifications at an estimated cost of $751,000. This would require Military Construction Program funding (Air Force Regulation 80-22, 1972: 2,3). In addition, the hangar is currently used for C-135 maintenance. Transfer of this operation to scattered locations about Tinker would be required to accommodate the ALCM program. This would result in a greatly reduced effectiveness of the C-135 operations (Test Planning for Full Scale Development/ALCM, 21 June 1976).

From the above, hangar 240 is also considered to be unavailable. The potential for disruption of the C-135 operations, the uncertainty of Military Construction program funding and the high cost of hangar modification compounded by the stated reservations regarding support of turnaround time lead to the conclusion that Tinker should be excluded from further consideration.

The reply from Kelly was more encouraging. Current and programmed reductions in B-52 depot activities create several options for both B-52 support and missile support. Hangars are available and Kelly personnel express no reservations about supporting turnaround times and sortie rates (Test Planning for Full Scale Development/ALCM, 26 June 1976).

Support System Turnaround Times and Sortie Rates. Subsequent to the March Flight Test Planning Meeting Strategic Air Command was asked for a command position on the possibility of hosting the Joint Test Force and providing B-52 maintenance at a Strategic Air Command base (ALCM Test Program, 26 March 1976: para 13).

Their reply stated, "Location...at an operational Strategic Air Command base is impractical. The limited physical capability of an operational Integrated Maintenance Facility, coupled with the introduction of non-Department of Defense civilian personnel (contractors) into an operational weapons storage area presents an unacceptable risk to operational commitments and weapons security" (ALCM Test Program, 28 May 1976: para 3). The message also identifies current and forecasted shortages of B-52 maintenance personnel at operational bases "which already are causing deficit support of operational commitments."

In spite of Strategic Air Command's opposition, a decision to locate the Joint Test Force at an operational base could be imposed by the Headquarters, United States Air Force (the decision level.) B-52 maintenance is available and if use of an operational Integrated Maintenance Facility is unacceptable, then another could be built for use by the Test Force.

The priority of maintenance support, however, is a critical obstacle. It is inconceivable that the Strategic Air Command operational commitments would be subordinated to the Test and Evaluation mission. Thus, maintenance of the two carrier aircraft would be handled on an availability basis. With Strategic Air Command maintenance already short of personnel and in view of Strategic Air Command reluctance to host the Test Force, required system turnaround times and sortie rates are not likely to be sustained.

Thus, all fifteen Strategic Air Command operational bases listed in the first category must be excluded from further consideration.

Castle Air Force Base, a training base without operational commitments, was specifically excluded by Strategic Air Command. "Location...at Castle Air Force Base is considered undesirable ....There is very little flexibility...to handle resource competition or conflicts that may be introduced.... The resources...at Castle have been saturated by training demands and will continue to be so for the foreseeable future" (ALCM Test Program, 28 May 1976). Castle's training mission has priority. With maintenance resources already saturated, turnaround times and sortie rates of the test program are not likely to be met. Castle is also excluded from further consideration.

Support Test and Evaluation Activities Beginning 1 September 1978. Three alternatives remain in contention: Kelly, Wichita, and Edwards. No reason is known to exclude Kelly and Wichita based on this objective. B-52 support is in place now. Construction of Missile Maintenance Facilities can be accomplished with program funds or with Military Construction Program funds within the time available (Air Force Regulation 80-22, 1972: 2 and ALCM Test Program, 21 April 1976).

Should an attempt be made to provide on-site maintenance at Edwards there is a considerable risk that full support will not be provided by 1 September 1978. This was established previously. Nevertheless, Edwards will continue under investigation.

Provide Office Space and Housekeeping Facilities. This objective does not limit the selection of any of the remaining alternatives. Kelly, Edwards and Wichita facilities are known to be adequate (Klung, undated: 2; Full Scale Development Planning Factors, undated; and Test Planning for Full Scale Development/ALCM, 26 June 1976).

Assessment of Alternatives Against Desired Objectives

Desired objectives represent conditions or situations that are wanted but which are not critical. There is flexibility in the degree to which they are to be accomplished. They also vary in importance (Kepner and Tregoe, 1973: 44,45). The relative importance of these objectives was established in Chapter II. Weightings of one to ten were assigned. The next task is to determine the relative degree to which the alternatives meet the desired objectives.

Three alternatives remain in contention. Kelly and Wichita meet all mandatory objectives. Edwards, a substandard alternative, is being retained for further investigation with the realization that adverse consequences may result if Edwards is selected. These alternatives will be assigned a numerical rating of one to ten for each desired objective based on the available information. The "best" alternative will receive a rating of 10. The final step will be to unite these separate rating judgments by multiplying each rating by the respective weighting and taking the sum of the products for each alternative. This sum provides a basis for rank ordering each alternative. The alternative with the highest sum of products will be selected as a tentative decision (Kepner and Tregoe, 1973: 48-52).

This investigation has identified five desired objectives. Each will be restated in turn. Alternatives will be ranked against each objective.

Minimize Data Reduction and Analysis Turnaround Time. In the view of System Program Office personnel, the selection of a data reduction facility is independent of staging base selection so long as data reduction and analysis can be performed in a timely manner (Troxell, 16 March 1976). With modern methods of data and facimile transmission, such as are being used on the ALCM Advanced Development program, there appears to be no

reason why this independence cannot be maintained--the current Advanced Development program is staging from Wichita with data reduction being accomplished at Seattle. Quick look (24 hour) reports and 30 day analysis reports are being generated on time. No test has been delayed because of data reduction and analysis difficulties with this arrangement.

It is the opinion of the investigator, and others, that while co-location of data reduction facilities with the Joint Test Force is not necessary, co-location does contribute toward minimizing data recovery, reduction, and analysis turnaround times, particularly when data reduction problems are found (Klung, undated: 8; and Troxell, 16 March 1976). For alternatives to be compared equitably, then, co-location of the data reduction facilities with the Joint Test Force at the selected alternative is presumed where possible. To presume otherwise--to assume a particular data reduction facility and then compare alternatives--biases the comparison in favor of the data reduction locality.

Adequate data reduction facilities are available at Edwards, at Boeing, Wichita, and at Boeing, Seattle (Klung, undated: 8). Both Boeing facilities are mentioned since Boeing personnel intend to accomplish some data reduction and analysis with Boeing, Seattle computer programs, depending on the proximity of analysis personnel and other internal factors. The data reduction activities at Seattle will exist to some degree regardless of selected staging base and primary data reduction facility (French, 23 June 1976).

Insofar as co-location is a factor there is no discrimination between Edwards and Wichita. Co-location is possible in either case and the Seattle activities will occur in either case. If Kelly is selected, either Edwards or Wichita (and Seattle) data reduction facilities may be used. For

minimization of data recovery and analysis turnaround time due to co-location, the alternatives are ranked:

Edwards	Kelly	Wichita
1	2	1

Data reduction and analysis turnaround times may also be influenced by conflicts with other programs. The likelihood of conflict with other program has been assessed:

> Conflict with other mission: At any test base there is some competition for resources to conduct programs. At Edwards nearly all programs are Research and Development. At Wichita there have been no significant conflicts between the Advanced Development/ALCM program and other programs conducted there. Unknown is the potential for conflict between Full Scale Development program (sic) and other Boeing B-52 workloads at Wichita during time period (sic) of the Full Scale Development program. In summary, Wichita is considered to have a slight edge over Edwards in relation to this evaluation factor (Klung, undated: 8,9).

The investigator agrees with this assessment. Edwards facilities likely will have to accommodate ALCM, B-1, and F-16 test programs among others. While the full extent of program competition at Edwards cannot be assessed, it is presumed that such conflict is likely to be significant, compared with the minimal research and development activity at Wichita. It is also believed that B-1 and perhaps F-16 priorities are likely to exceed ALCM priorities. No priority conflicts are expected at Wichita.

Selection of Kelly requires use of data reduction facilities at Edwards or Wichita. The best option (in terms of program conflict) is to use Wichita. This will be assumed. For minimization of data recovery and analysis turnaround time due to fewer program conflicts the alternatives are ranked:

Edwards	Kelly	Wichita
2	1	1

No other basis for discrimination between alternatives has been established. The investigator believes, however, that the effect of program conflict is likely to be more severe than the effect of a data reduction facility that is not co-located. This judgment is based on the experience of the Full Scale Development Short Range Attack Missile and Advanced Development ALCM programs. In both programs some experience has been gained with remote data reduction facilities without significant detriment to data recovery and analysis turnaround times. On this basis, the alternatives are ranked:

Edwards	Kelly	Wichita
3	2	1

Wichita is assigned a score of 10. Kelly is assigned a score of 8. The effect of non-colocation is not severe but is significant. Edwards is assigned a score of 7 since the effect of program conflict is greater than the effect of non-colocation.

Maximize Realism in Test and Evaluation. Realism in test and evaluation is a product of the equipment used, the personnel using them and the location (environmental effects) of the selected staging base. Environmental effects alone are a function of staging base location.

Wichita operations experience freezing temperatures 100 days out of each year as opposed to 45 days at Edwards and 20 days at Kelly. During the winter months the mean monthly minimum temperature at Wichita runs five to ten degrees colder than Edwards and 15 degrees colder than Kelly. During the same period the mean monthly relative humidity at Wichita is 75 percent as opposed to 70 percent at Kelly and 50 percent at Edwards. Also during the same period, the mean monthly precipitation at Wichita is one and one half inches (rain equivalent) compared with two inches at

Kelly and less than one inch at Edwards. Mean annual snowfall at Wichita is 12 inches compared to much less than 8 at Kelly and Edwards.

During summer months the mean monthly maximum temperature at Edwards is generally five degrees cooler than Wichita and Kelly except during August when Edwards temperatures exceed 100 degrees, five to ten degrees above Kelly and Wichita mean maximums. Throughout the summer, mean monthly relative humidity at Wichita and Kelly is over twice that at Edwards (The National Atlas of the United States of America, 1973: 98-111).

From the above it is concluded that the Wichita environment more nearly approximates the environment of Strategic Air Command's northern B-52/Short Range Attack Missile bases. Colder temperatures, higher humidities and greater quantities of precipitation are more likely to result in the snow and icing conditions similar to conditions at operational bases. The high temperatures of summer combined with high humidity also more nearly approximate the environment of those bases on the northern interior plains. On this basis, Wichita is assigned a score of 10.

Neither Edwards nor Kelly offers realistic winter conditions. Edwards is too dry for significant icing and snow conditions and Kelly, in general, is too warm. Kelly is believed to have a higher chance of significant icing and snow conditions due to the constantly higher winter humidity and precipitation and the occasional freezing temperatures (20 days per year).

Kelly is also believed to have more appropriate summer conditions. While Kelly and Edwards have maximum temperatures of 95 and 100 plus degrees, respectively, Kelly has realistically high humidity where as Edwards does not.

It has been pointed out that in every regard except weather, no difference in realism can be discerned between alternatives. Thus an extreme

variance in score (high discrimination between alternatives) cannot be justified. However, the variance in realism provided by the weather to be expected at Kelly and Edwards is significant, especially in view of the Short Range Attack Missile operational experience. Therefore, Kelly is assigned a score of 8 and Edwards is assigned a score of 7.

Maximize Use of Air Force Resources. Air Force resources may include weapon systems, real property, instrumentation, computer hardware, and software, tools, and the personnel required to manage, operate and maintain those resources. For purposes of ranking alternatives, not only the degree of use but the type of use must be considered. Alternatives which make greater use of test and evaluation resources will be scored higher than those which use other Air Force resources.

Twelve categories of resources have been identified for alternative comparisons:

*B-52/Short Range Attack Missile weapon system
*B-52 support equipment
B-52 maintenance personnel
*Missile Maintenance Facility
Real property
*ALCM weapon system
instrumentation
data reduction hardware and software
data reduction personnel
*Test and Evaluation personnel
(the Joint Test Force)
*Missile peculiar carrier
aircraft equipment
*tools

Those categories which are asterisked are relatively independent of alternative selection. The B-52/Short Range Attack Missile and all support equipment belong to the Air Force even though they might be operated and maintained by contractors. The Missile Maintenance Facility will be assigned and built under contract and will be the property of the Air Force regardless of location. The ALCM will be designed and built under contract and ultimately will belong to the Air Force regardless of staging base. Test and Evaluation personnel will not change in skills or source of employment regardless of staging base. Nor is ownership of carrier air-

craft equipment and tools (in general) dependent on location.

Every remaining category favors Edwards or Kelly insofar as ownership of resources is concerned. At Wichita, B-52 maintenance personnel will be provided by the contractor. At Edwards, some contractor personnel may be required, particularly if some degree of support equipment is obtained for Edwards but a full maintenance capability at Edwards is unlikely. Use of lateral support will favor the use of Air Force Logistics Command and Strategic Air Command personnel resources. At Kelly, only Air Force Logistics Command resources are likely to be used. For use of military (including civil servant) maintenance personnel resources, the alternatives are ranked:

Edwards	Kelly	Wichita
2	1	3

Real property is owned by the Air Force at all three bases. However, Edwards is a Test and Evaluation resource operated by the Air Force. Kelly is operated by the Air Force but is not a Test and Evaluation resource. Wichita is operated by contractor personnel and is not an Air Force Test and Evaluation resource. For use of Air Force real property resources the alternatives are ranked:

Edwards	Kelly	Wichita
1	2	3

While specific examples are not stated, it is believed that location at Edwards or Kelly enhances the likelihood that general instrumentation will be Air Force owned. Certainly the Edwards or Kelly Precision Measurement Equipment Laboratory will be tasked and at least some instrumentation will likely come from Air Force inventory. Again, Edwards represents test and evaluation resources whereas Kelly does not. The alternatives are ranked:

Edwards	Kelly	Wichita
1	2	3

Data reduction hardware, software, and personnel at Edwards represent Air Force Test and Evaluation resources. Those at Wichita do not. Either Edwards or Wichita data reduction facilities may be used if Kelly is the selected staging base. The alternatives are ranked:

Edwards	Kelly	Wichita
1	2	3

Overall ranking for use of Air Force resources is Edwards then Kelly, and last, Wichita. Edwards is assigned a score of 10. Kelly is assigned a score of 8. All-Air Force aircraft maintenance partially compensates for not being a Test and Evaluation resource. Wichita is assigned a score of 6. Seven of the twelve categories examined are Air Force resources even if located at Wichita.

Provide Adequate Off Duty Housing. Adequacy of housing is primarily a personal consideration. It is an objective of the Air Force as a matter which affects morale and response time and due to the implied obligation to house military personnel.

Total Joint Test Force personnel has been estimated at 360. These figures require adjustments for Edwards and Wichita. Approximately fifty of the Air Force personnel (military and civilian) are already located at Edwards. Only those personnel programmed by the Air Force Test and Evaluation Center, about 60, and the contractor personnel, 250, will need to be relocated to Edwards. Thus a total of 310 new families must be accommodated. If Wichita is selected all 110 Air Force families and all contractor personnel from the Seattle area will have to be relocated. Since some contractor personnel will be located at Wichita less than 250 new families will have to be accommodated. Most contractor personnel

associated directly with ALCM are located in Seattle. It is presumed that 200 of the 250 families will have to be accommodated.

In summary, selection of either Edwards or Wichita requires that housing be available for 310 families. Kelly will have to accommodate all 360. Edwards requires 50 less military moves and Wichita requires 50 less contractor moves. Additional personnel for aircraft maintenance are not a factor. At Wichita and Kelly they are in place. At Edwards, presumed extensive lateral maintenance support obviates the need for significant increases in maintenance personnel.

Wichita is a city of 275,000 population. In addition there are several small towns and McConnell Air Force Base adjacent to the Wichita facility (The National Atlas of the United States of America, 1973: 366-417). It is presumed that adequate housing for 310 new families can be found within close proximity. Family housing on McConnell Air Force Base is an unconfirmed possibility for military families.

Kelly is located at San Antonio, Texas, population 625,000 (The National Atlas of the United States of America, 1973: 336-417). It is presumed that adequate housing for 360 families is available. On-base housing is likely to be available. In addition, San Antonio has virtually unparalleled military facilities with four major Air Force bases nearby.

Edwards Air Force Base is located in an isolated semi-desert region in California. Local population centers include:

Town	Population	Highway Milage to Edwards
Mojave	3,000	23
Barstow	15,000	56
Rosamond	1,500	20
California City	not listed	20
Lancaster	28,000	31
Palmdale	7,400	38
Bakersfield	65,000	90

(Standard Highway Milage Guide, 1973: 368-369 and the National Atlas of the United States, 1973: 336-417).

It is presumed that adequate housing can be found in this rather wide area, total population, over 120,000. The nearest city of consequence however, appears to be Lancaster, 31 miles distant. Other than for the facilities on Edwards Air Force Base the nearest urban facilities, services and homes are at least that far away. It is presumed that Edwards base housing (a rather extensive complex) can absorb those military members who would choose to reside on base.

Kelly is assigned a score of 10 based on the combination of extensive urban/suburban housing, facilities and services and extensive military personnel facilities and services.

Wichita is assigned a score of 9. No limitations in facilities or services are expected in an urban area exceeding 275,000 population. Edwards is assigned a score of 5 due to remoteness and the expected limitations of facilities and services relative to San Antonio and Wichita.

Minimize Costs to the United States Air Force. In Chapter II costs were defined as expenses likely to be incurred by the United States Air Force. For purposes of alternative ranking, costs that may be incurred due to the selection of each alternative are important only in a relative sense. Cost elements which do not vary significantly between alternatives are irrelevant.

Personnel at Edwards and at Kelly are known to advocate selection of their respective bases (Klung, undated; and Fairey, 24 and 29 June 1976). As far as is known System Program Office personnel and contractor personnel advocate Wichita without exception. Detailed cost estimates would have to originate with these personnel. They are, with their supporting staffs, the authoritative source of information for their respective bases. With advocates of various positions, backgrounds and levels of program knowledge making cost estimates for requirements which are known only in a general

sense, the accuracy of any resulting cost comparison would be in serious doubt.

In addition, at least one critical estimate is completely unavailable. It has been estimated that Air Force Logistics Command would require over 2000 manhours of effort to determine the location and availability of B-52 support equipment and develop a cost estimate for establishing B-52 maintenance capabilities at Edwards (Full Scale Development/ALCM support requirements, 11 June 1976: 6; and Haynes, 7 June 1976). They decline to make this effort until a staging base is selected unless directed to do so. If Edwards is selected, then they will make the effort (Flight Test Planning Meeting, 12-13 May 1976).

With the above in mind, an attempt to assign exact dollar values to all cost elements would be impractical and of questionable value.

Fortunately, a detailed cost estimate is not necessary to rank alternatives. Major recurring and non-recurring cost elements can be identified and estimated, at least to the appropriate order of magnitude. These cost contributors do provide sufficient discrimination to rank order alternatives against each cost contributor. These individual ranks lead to a summary ranking with adequate confidence so that alternatives may be scored against this objective--minimize costs to the United States Air Force.

The following major cost contributors vary significantly with alternative selection:

Telemetry Ground Station
Aircraft Recorded Data Processing Facility
Missile Maintenance Facility
Personnel Transfers
Establish Spare Stocks
Establish Table of Allowance Support Equipment
Temporary Duty

The staging base must provide a telemetry ground station for checkout of the missile telemetry systems. A $100,000 state-of-the-art telemetry

system presently is operational and is supporting the Advanced Development ALCM program at Wichita (Full Scale Development/ALCM Support Requirements, 11 June 1976: 5). It is compatible with the planned Full Scale Development ALCM and will be available for that program. For any staging base other than Wichita the station at Wichita must be dismantled, shipped, installed, calibrated, and certified at the staging base. The cost of providing a telemetry ground station at each alternative is estimated by the investigator to be:

Edwards	Kelly	Wichita
$50,000	$50,000	-0-

The staging base must provide a carrier aircraft recorded data processing facility so that data recorded on board the aircraft may be recovered and formatted for use in further data processing. That system has also been developed at Wichita at a cost of $250,000 and will be available to the Full Scale Development program (Full Scale Development/ALCM Support Requirements, 11 June 1976: 5). The minimum cost for providing the recorded data processing facility at each alternative is estimated by the investigator to be:

Edwards	Kelly	Wichita
$100,000	$100,000	-0-

The staging base must provide a missile maintenance facility to accommodate both the Short Range Attack Missile and ALCM systems. The systems to be contained by that facility will include both contractor furnished and government furnished equipment. These equipments are independent of staging base except those already at Wichita which would have to be moved. The basic facility, however, is not independent of location. At Edwards, no adequate facility exists. It must be built at a total estimated cost of $700,000 (Klung, undated: 4). At Kelly adequate structures exist

but will require some modification for power, partitions, water, etc (Test Planning for Full Scale Development/ALCM, 26 June 1976; and Fairey, 29 June 1976). At Wichita, the Advanced Development ALCM is using some of the area that would be used by the Full Scale Development program. Some modification will be required to expand within the same building to accommodate the larger Full Scale Development program (Full Scale Development Planning factors, undated). It is believed that construction of a new facility (real property) would cost more than the modification of existing facilities. It is further believed that modification of a facility which meets Advanced Development ALCM requirements would cost less than modification of a facility which has no features specifically designed for ALCM support. On this basis the investigator estimates the following costs:

Edwards	Kelly	Wichita
$700,000	$400,000	$300,000

Costs for transfer of personnel will be significant. Not all these costs, however, are relevant to alternative ranking. Those contractor personnel who will have to move from Seattle and those Air Force personnel programmed by the Air Force Test and Evaluation Center (originating at Kirtland and at Strategic Air Command bases) will have to move regardless of alternative selection. Cost differences for these personnel transfers are insignificant. The significant moves will be the 50 fewer moves to Edwards or the 50 fewer moves to Wichita which were estimated in the discussion on adequacy of housing. Given these estimates, selection of either Edwards or Wichita saves 50 moves at perhaps $5,000 per move (The difference in total cost of transferring military vs. contractors is believed to be insignificant) compared to selection of Kelly. On this basis the alternatives relative cost is:

Edwards	Kelly	Wichita
-0-	$250,000	-0-

A major cost item which must be considered is the establishment of a spares stock for the B-52 carrier aircraft. This is estimated to include a minimum of 6000 to a maximum of 14,000 line items not including spares and repair parts for Aerospace Ground Equipment. Costs will be incurred to define the required spares list, establish computer records for the list, prepare storage facilities and requisition, receive, inspect, and store the initial spares. Similar costs will be incurred to establish the required 2000 manual Technical Order library (Full Scale Development/ ALCM Support Requirements, 11 June 1976: 3). These costs would be incurred only at Edwards. They are sunk costs at Kelly and Wichita. The investigator estimates:

Edwards	Kelly	Wichita
$500,000	-0-	-0-

A similar situation exists for establishment of the table of allowance support equipment required for maintenance of the B-52 carrier aircraft. The final mix of lateral and on-site support that could be accomplished at Edwards is unknown. Given that on-site maintenance is desired (this has been established and repeatedly confirmed) it may be assumed that the maximum possible support equipment will be attained. Costs would be incurred to locate, transport, repair, refurbish, install, calibrate and certify a significant percentage of the 1000 major line items required. In addition, costs would be incurred to establish storage areas for this equipment (Full Scale Development Support Requirements, 11 June 1976: 2). These costs are essentially sunk at Kelly and Wichita and would be incurred only at Edwards. The alternative costs are estimated at:

Edwards	Kelly	Wichita
$3,000,000 plus	-0-	-0-

All of the preceding cost elements are non-recurring costs. Several other non-recurring costs have been considered but have not lead to significant alternative discrimination. They are costs to prepare administrative facilities, set up communications and set up Short Range Attack Missile and ALCM support equipment and spares. These costs are believed to be similar regardless of staging base.

An examination of most recurring costs is inconclusive. The salary and support costs of the 360 members of the Joint Test Force are relatively immune to changes in alternatives. The manning requirements are independent of location.

No certain discrimination can be developed based on aircraft maintenance. At Wichita, the maintenance is contractor provided. An estimate is available. At Edwards, a scaled down contractor effort will provide some aircraft maintenance, supplemented by lateral support. No meaningful estimate is available since neither the cost of lateral support nor the ratio of lateral support to contractor maintenance can be established. At Kelly, this support is "on station" and available but is certainly not free. Maintenance resources there are available due to current programmed reductions in B-52 depot operations. These resources would be retained to support ALCM rather than being released (Fairey, 29 June 1976). The programmed direct and indirect cost savings would have to be foregone to support the ALCM program. The full extent of these costs are not known but may not be significantly different from Boeing costs if all Air Force costs are considered.

It may be argued by some that costs are minimized by using Air Force personnel and material and by operating on an Air Force base. If this

were true then operating and maintenance costs might show a variance. The investigator rejects such generalized arguments. Costs may appear to be less if only one type of appropriation or a few Air Force accounts are examined. Using "free" military material or labor from another command or obtaining lateral support for maintenance from another command may save the program some funds but such transfers of cost within the United States Air Force do not constitute a savings. Nor has the total overhead cost to the Air Force for these in-house efforts been established. It is certainly significant. One may as easily claim that in-house efforts cost more as to claim that they cost less. Thus no discrimination can be claimed in the abstract. Only a specific, exhaustive cost analysis can establish a variance between military and commercial alternatives.

An examination of temporary duty costs is inconclusive when Edwards and Wichita are compared, but do contribute to extra costs if Kelly is selected. Selection of Wichita involves extensive temporary duty by personnel of the responsible test organization (Edwards) (Klung, undated:7). Conversely, selection of Edwards would require extensive temporary duty by Wichita personnel since they include B-52 design support personnel and B-52/ALCM peculiar instrumentation design and support personnel (Full Scale Development/ALCM Support Requirements, 11 June 1976: 3). Location at Kelly will result in extensive travel by both groups. Only the roughest of estimates is possible for the 20 months of test operations:

Edwards	Kelly	Wichita
-0-	$200,000	-0-

No other significant discrimination between alternatives has been developed. The following are sums of the previously identified costs. These costs are very rough estimates of relative costs and should not be used for any purpose other than ranking the alternatives:

Edwards	Kelly	Wichita
$4,350,000	$1,000,000	$300,000

Wichita is assigned a score of 10. Kelly is assigned a score of 8 since there appear to be significant additional costs associated with location there. Edwards is assigned a score of 4. The cost of establishing B-52 maintenance and spares is a very high cost item compared to all other cost differences. While that cost is not known with precision it is certainly a multimillion dollar effort. All other cost differences examined are in the $50,000 to $500,000 range.

Scoring Summary for Desired Objectives. The following tabulation provides a summary of the desired objective weights established in Chapter II, the scores assigned in this chapter and the products and sum of products for each alternative.

SCORING SUMMARY

DESIRED OBJECTIVE	EDWARDS WT X SC = P	KELLY WT X SC = P	WICHITA WT X SC = P
MINIMIZE COST	10 X 4 = 40	10 X 8 = 80	10 X 10 = 100
MINIMIZE DATA TURNAROUND TIME	9 X 7 = 63	9 X 8 = 72	9 X 10 = 90
MAXIMIZE REALISM	7 X 7 = 49	7 X 8 = 56	7 X 10 = 70
MAXIMIZE AF RESOURCES USE	5 X 10 = 50	5 X 8 = 40	5 X 6 = 30
OFF DUTY HOUSING	3 X 5 = 15	3 X 10 = 30	3 X 9 = 27
SUM OF PRODUCTS	217	278	317

The Tentative Decision

The preceding summary indicates a clear choice. The alternative which was substandard borderline is also the lowest in score. Of the two alternatives which meet mandatory requirements, there is a clear separation of scores. The highest scoring alternative, Wichita, is the tentative decision recommendation.

IV. Decision Consequences and the Final Recommendation

> Knowledge of the past and present is likely to be accurate; and it does not change. Information about the future can never be so reliable. Yet it is in the future that alternatives are implemented. The nagging questions are: How well will this alternative hold up in the future? Will it hold up in the face of changing conditions? What if crucial factors were somehow overlooked? (Kepner and Tregoe, 1973: 52).

The possibility of adverse decision consequences cannot be ignored. Regardless of which alternative is selected there is the possibility that one or more objectives will not be realized when the decision is implemented. An assessment of adverse consequences then, requires a look at the possibility of not meeting objectives and the seriousness of that failure.

For each of the alternatives still being considered one should ask; what could go wrong? What problems could this decision alternative create? Once the possible consequences are identified, both the likelihood of occurence and seriousness of the consequence must be estimated. Once again, a numeric scale will be used. Likelihood of occurence will be assigned a score of one to ten. The seriousness of that consequence, given that it occurs, is rated on a similar scale. As an example, a decision consequence that rates a 10 x 10 score promises certain disaster. An alternative with such a consequence must be dismissed from further consideration (Kepner and Tregoe, 1973: 53-55).

Scores for probability of occurence and seriousness are judgments of the investigator. No formula generates these numbers, nor can authoritative sources be called upon for proof. Nevertheless, the scores provide a necessary basis for making one last and crucial judgment.

A list and count of the consequences for each alternative is not enough. One must be able to distinguish between alternatives with numerous low-threat consequences and those with only a few, but high-threat

consequences. The former alternative may be preferred. One might choose to tolerate numerous low-threat nuisance consequences rather than court disaster.

Most of the twenty-five alternatives examined in this study were eliminated for failure to satisfy mandatory requirements. Two alternatives survived this initial culling. A third, which did not, was continued in analysis with the expectation that it might otherwise compare favorably.

The final scores show a significant discrimination between alternatives. The alternative that meets all mandatory requirements and best meets desired objectives is readily identifiable. Nevertheless, all three alternatives which were scored will be examined in turn for adverse consequences. A summary comparison will lead to the final recommendation.

Decision Consequences--Edwards Air Force Base

Edwards Air Force Base has been continued in analysis in spite of its failure to meet a mandatory objective--on-site maintenance. As might be expected, this shortfall is a source of significant risk.

Failure to provide adequate maintenance. In Chapter III it was shown that any site which does not have a B-52 maintenance capability is unlikely to provide full on-site maintenance when required. To search for, locate, obtain possession, refurbish, repair, install, calibrate and certify inventory maintenance equipment, or to procure equipment and develop new sources, was seen to be a very high risk approach. Personnel in Air Force Logistics Command and logistics personnel at the Air Force Flight Test Center are in agreement that such an approach is impractical.

Earlier, in Chapters I and II, it was established that immediately available (on-site) maintenance is vital to assure that flight tests occur

on schedule. This has been accepted explicitly by many and at least implicitly by all members of the Joint Test Force Working Group through their acceptance of on-site maintenance as a mandatory requirement. Thus it is likely that on-site maintenance will be attempted if Edwards is chosen. The likely result will be a moderate degree of on-site maintenance augmented by extensive lateral support.

A remove and replace maintenance activity that depends on lateral support cannot likely stock parts for all possible malfunctions, nor can multiple parts always be stocked in anticipation of repeat failures. Failures will occur for which there are no immediately available replacements. These replacements will have to be obtained primarily from Strategic Air Command resources.

While there is little doubt that lateral support could be provided, the timeliness of that support is in question. Strategic Air Command has already warned of shortages in maintenance personnel. When operational requirements conflict with the test program, operational requirements will be met first. Delays in filling orders due to such conflicts will compound the normal delays experienced in placing and filling orders and transporting spares to the staging base. Reliable support of established minimum turnaround times and maximum sortie rates, two days and three per week, respectively, is highly suspect especially over the long duration of the test program (It is just such considerations that led to the conclusion that on-site maintenance is vital.)

With the vital nature of on-site maintenance an established consensus, with the uncertainties imposed by lateral support, and with known shortages of Strategic Air Command maintenance personnel, it seems nearly certain that dependence on lateral support will result in test delays. One cannot maintain that delays are inevitable but the probability is very high and

is assigned a score of 9.

Given that program delays are likely to be caused by dependence on lateral support, what is the seriousness of these delays? The gravity of scheduled delays was discussed in Chapter II. That discussion provided the basis for establishing the mandatory nature of schedule related objectives. Schedule slips drive up costs. A 360 man test force is maintained longer than is otherwise necessary and every test cancellation that involves the test range creates cancellation and rescheduling costs.

Severe political penalties may occur when cost and schedule milestones are violated, especially in view of the direct competition with the Navy for program approval and funds. A breach of established milestones could lead to a denial of production authorization.

While the seriousness of failure to provide maintenance is grave, it will not necessarily be catastrophic. Programs have survived milestone violations before, but the existing severity of cost constraints and the seriousness of the competition with the Navy cannot be overstated. A seriousness score of 8 is assessed.

In summary then, for failure to provide timely maintenance, Edwards is assessed a threat of:

$$9 \cdot X\ 8$$

Contract cost growth. As far as is known, The Boeing Company position is that Wichita is preferred. One may speculate that if Edwards is selected against contractor "wishes" that the contractor cost proposal for test and evaluation tasks will be bid-up to either force a change in staging base location or to attempt to increase profits. While either motive may be possible, devious intent is not required to force up contract costs. Consider the position of the contractor if Edwards is selected.

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The contractor has developed an estimate for maintenance of the two B-52's at Wichita. There should be little uncertainty (from his viewpoint) in that estimate. Boeing has perhaps two decades of experience in the business of operation, maintenance, and modification of B-52's at Wichita. If Edwards is selected, Boeing must estimate the cost of maintaining the aircraft at Edwards. The Air Force will not be able to tell them the appropriate mix of contractor support and lateral maintenance. That requires the 2000 hour study mentioned in Chapter III. Air Force Logistics Command likely will not complete that study and establish committed resources before the proposal is due (this fall).

The contractor will have several possible courses of action: he may estimate a level-of-effort and absorb any extra costs (unlikely); he may estimate a level-of-effort and claim a change in contract scope after the contract is signed (increased costs with an uncertain ceiling); he may pad his estimate to cover the uncertainty (thus charging the Air Force for costs that may never be incurred); or he may ask for a time and materials or a renegotiation arrangement (either of which is a costly way to write a contract).

In addition, the SPO has estimated a 10 to 15 percent surcharge for contract maintenance away from Wichita. This would also indicate the likelihood of increased contract costs at Edwards. Costs other than for maintenance may also increase in response to uncertainty.

There is a high probability, then, that for a given level of effort, contract costs will be bid higher at Edwards due to the aforementioned surcharge and due to the uncertainty with which Boeing must contend. The investigator hesitates to claim certainty of this cost growth but expects it based on the SPO estimate and based on his own 11 years of experience in the management of development contracts. Uncertainty costs. The

contractor must bid higher to protect his interests. At the same time, the Air Force negotiating position is severely weakened when contract requirements cannot be made specific. A probability of 8 is estimated for contract cost growth.

The gravity of cost growth has been discussed in conjunction with schedule risks in the previous section on failure to provide timely maintenance. While cost growth is serious, it is not so grave in this case since it appears to be decoupled from the schedule issue. It should have lesser consequences if kept within bounds. Therefore, a lesser seriousness score of 5 is established.

In summary, for contract cost growth, Edwards is assigned a threat of:

8 X 5

Failure to provide timely maintenance due to increased sortie rates. The Boeing Company has proposed an accelerated test program that would terminate five to six months earlier than current plans. This would be accomplished by increasing the average sortie rate for the program without a significant decrease in testing requirements (Stewart, 12 May 1976). The maximum sortie rate and minimum turnaround time probably would not change. The average rate, however, would place additional strains on the ability of the test force to obtain lateral support in a timely manner.

The SPO has not accepted the Boeing suggestion as yet and the Joint Test Force seemed cool to the idea at the May Flight Test meeting. Nevertheless, the proposal has the potential for decreasing costs due to a shortening of the test program, and may have political appeal as a program enhancement to competition (The Navy program claims to be ahead of the ALCM program.) Thus there is a significant possibility that the suggestion

will be accepted prior to completion of contract negotiations. This possibility is assigned a score of 3.

The failure to provide timely maintenance due to increased average sortie rates will have a seriousness similar to that assessed in the earlier discussion on the difficulties of lateral maintenance and is assigned a similar score of 8.

In summary, for failure to provide timely maintenance due to increased sortie rates, Edwards is assigned a threat score of:

3 X 8

Schedule delays due to priority conflicts. The possibility of priority conflicts with other programs at Edwards has been mentioned previously. The B-1 and F-16 programs, among others are likely to be operating from Edwards. The possibility of conflict has been acknowledge by the Air Force Flight Test Center (Klung, undated: 8).

Yet this possibility must not be overstated. Workarounds and other accommodations can minimize the actual incidence of unresolvable conflict. Such unresolvable conflicts are assessed a probability score of 3.

Should significant incidences occur both program costs and schedules would be affected. Political costs may follow. A seriousness score of 5 is assessed with rational similar to that used in assessing the seriousness of cost and schedule milestone violations due to failure to provide timely maintenance. A lower score is assessed in this case since the frequency and severity of delay is likely to be less. Through careful management of resources at Edwards, the test director will have some control over the severity of delays. He would have very little control over delays caused by lateral support.

In summary, for schedule delays due to priority conflicts Edwards

is assigned a threat score of:

3 X 5

Decision Consequences--Kelly Air Force Base

Kelly and Tinker are both Air Logistics Centers with similar missions--depot maintenance. Elimination of Tinker raises questions about the risks which might be encountered at Kelly.

Failure to provide adequate maintenance. In their reply to requirements for turnaround time and sortie rates, Tinker personnel stated that:

> Operation and test level tasks are not compatible with Air Logistics Center structure...which is organized to accomplish depot level type workload. Capability is maintained to support end items for which we are assigned (responsibility) and those specific tasks generated by the aircraft...work packages. Specific equipment capability to support the full spectrum of operation and test would require development (Test Planning for Full Scale Development/ALCM, 21 June 1976).

The implication seems clear. At Tinker, there would have been some risk due to organizational peculiarities (and priorities) of an Air Logistics Center and there was some doubt that all necessary equipment was available on-site. In fact, neither Tinker nor Kelly provides maintenance to both G and H model aircraft. Thus some equipment shortages are almost certain.

It is assumed that a similar situation exists at Kelly. With most of the equipment for B-52 maintenance likely to be present, the risk of failure to provide adequate (timely) maintenance is believed to be significant but not large. The primary contributors to this risk are the suspected organizational incompatibility and priority conflicts. A probability of 3 is assigned.

Should Kelly fail to provide adequate (timely) maintenance the seriousness of that failure would be similar to that assessed against Edwards. The same score, 8, is assessed.

In summary, for failure to provide adequate maintenance, Kelly is assigned a risk threat of :

3 X 8

Contract cost growth. Selection of Kelly causes a risk similar to that at Edwards. The same arguments apply with one critical difference. While uncertainty and the effects of working away from the contractor's plant may drive up costs, the critical uncertainty of contractor maintenance plus lateral support will not exist. The Air Force will have responsibility for maintenance. Thus the possibility of contract cost growth (for a given level of effort) due to uncertainty and remote operation are greatly reduced but are still believed to be significant. A possibility score of 3 is assigned.

The severity of that cost growth, and thus the seriousness of this consequence, is also reduced by the absence of contractor maintenance responsibilities for the B-52. A seriousness score of 3 is assigned.

In summary, for contract cost growth Kelly is assigned a threat score of:

3 X 3

Failure to provide timely maintenance due to increased sortie rate. The possibility of increasing average sortie rates was discussed under Decision Consequences--Edwards Air Force Base. That discussion need not be repeated. The possibility of occurence is believed to be similar. The decision to accelerate the test program should be relatively independent of staging base.

While Kelly is in a better position than Edwards in terms of maintenance equipment, Kelly may suffer the added consequences of depot incompatibilities and priority conflicts with the test operation. This may lead

to response time difficulties with an accelerated program. Therefore, a possibility score of 3 is assessed as was the case with Edwards.

The gravity of such an occurrence would also be similar to previous discussion concerning Edwards. The rationale is similar. A seriousness score of 8 is established.

In summary, for failure to provide timely maintenance due to increased sortie rates, Kelly is assigned a threat score of:

3 X 8

Decision Consequences--Wichita.

Most of the risks associated with selection of Edwards and Kelly derive from the magnitude, complexity and uncertainty of the B-52 maintenance problem and the possibility of mission priority conflicts. These risks are virtually non-existent at Wichita. Boeing experience and capability in maintenance has been acknowledged and is being demonstrated in the Advanced Development program. Risks at Boeing, Wichita derive from totally different considerations.

Contract cost growth due to sale of Wichita. The Air Force owns the Wichita plant and plans to sell it in July, 1980. It is very likely that contract costs would increase to cover the additional expenses that would be incurred by Boeing--presuming they are the new owner (Klung, undated).

The possibility of this consequence revolves about the likelihood that the program will be in existence at the time. Current schedules call for test completion in September 1980. By this schedule some cost increases (for August and September) can be anticipated. Unless--the proposed program acceleration is attempted. If successful, that program could end in April 1980 by sustaining a test rate of two launches per month, a rate that is

planned currently for the period July through October 1979 (ALCM Full Scale Flight Test Summary, March 1976).

The likelihood of accelerating the program was previously assigned a score of 3. The converse situation, no acceleration should then receive a score of 7. This score is assigned to the likelihood of cost increases due to sale of Wichita.

The seriousness of that increase is a function of the time period that the increase could be in effect. According to present plans that period will be two months. This will be the last two months of the program and a program phase-down should be expected this late in the program. Thus, the impact should be minimal.

Programs do slip and one cannot presume that the ALCM program is immune to schedule difficulties. On the other hand, the contractor does believe that the current schedule is very conservative. This has allowed him to propose the schedule compression of five months (Stewart, 12 May 1976). Thus it may be presumed that sufficient safety factor is built in to the current schedule that only a very severe problem would extend the total life of the program.

Contract cost growth likely can be restricted to the last two months of the program. The seriousness of this consequence is therefore minimal and is assessed a score of 2. In summary, contract cost growth due to sale of the Wichita plant is assessed a risk threat of:

7 X 2

Delay of program and cost increases due to non-colocated dated reduction. Selection of a data reduction facility and selection of a staging base are independent decisions. To prevent a biasing of alternative comparisons, this study presumed colocated data reduction facilities when possible.

It is possible, however, that even if Wichita is selected, the Edwards data reduction facility might be used. Use of that facility, in fact, is strongly advocated by responsible test organization personnel (Klung, undated: 8).

Conversely, SPO personnel tend to advocate the use of Boeing data reduction facilities though a strong advocacy has not been evidenced. The possibility score for not having a colocated data reduction facility at Wichita is set at 8 due to the positive advocacy of the responsible test organization.

The seriousness of non-colocated data reduction facilities is minimal as was discussed in Chapter III under the objective to minimize data reduction and analysis turnaround time. There should be no significant schedule effects but there will be minor cost effects (relative to total test program costs) due to additional communication requirements and possibly extra temporary duty requirements (Klung, undated: 8). These costs consequences are assigned a seriousness score of 3. In summary, for delay of program and cost increases due to non-colocated data reduction, Wichita is assigned a risk threat of:

$$8 \times 3$$

Threat Summary

On the basis of available information, the opinions of knowledgable decision participants, and based on his own experience in systems development, the investigator has estimated the known risks that accompany the selection of the three serious contenders. They may be viewed as "known unknowns." Undoubtedly, there are "unknown unknowns" as well that will accompany the selected alternative. One cannot fail to act, however, for fear of such unknowns. A decision must be made.

> Bear in mind that all new actions carry risks. Pulling out information about the probability and seriousness of each adverse consequence is an excellent way to put risk in perspective. It is not the purpose of adverse consequences to make everyone afraid to take action. Instead, a tool is needed for identifying those alternatives that are clearly unsatisfactory (Kepner and Tregoe, 1973: 55).

In summary, the decision alternative, carry the following threats as a consequence of their selection:

Consequence	Edwards	Kelly	Wichita
Failure to provide timely maintenance	9X8	3X8	
Contract cost growth	8X5	3X3	7X2
Failure to provide timely maintenance, sortie rate increase	3X8	3X8	
Schedule delay due to priority conflicts	3X5		
Non-colocation of data reduction			8X3

Final Recommendation

This investigation has established objectives, has prioritized those objectives, has rated alternatives against those objectives, and has assessed the risks involved with selection of the three alternatives most likely to be selected. Edwards, one of the three, was continued in investigation in spite of its failure to meet a mandatory requirement for on-site maintenance. It was expected that Edwards might compare favorably with other alternatives when desired objectives were considered.

Edwards did compare favorably for one desired objective, Maximize use of Air Force resources, but was last in all other comparisons. It scored lowest in total score and was ranked last against desired objectives.

The failure of Edwards to meet mandatory objectives is critical in the threat summary. The high possibility of severe consequences combined with lowest accomplishment of objectives appears decisive. Edwards Air Force Base is unsatisfactory and should not be considered for location of the staging base.

Either of the remaining two alternatives, Kelly and Wichita, might be selected. Though Kelly scored lower than Wichita, overall, it scored first in one category and a close second in all other categories. Kelly is a viable candidate as is Wichita. Though more of a threat is perceived with Kelly, (higher consequences, though lower probabilities) the difference is not conclusive.

> ...a manager is rational if he chooses the option he prefers or sees as best. If he carries out all the steps in the decision process...and arrives at the resolution stage with an evaluation of options and a criterion of choice between these options, he is regarded as rational if he chooses the option that is selected as best by this process (Radford, 1975: 19,20).

The process, as specified by Kepner and Tregoe, should result in a choice of the alternative that:

> Satisfies all mandatory objectives;
>
> Best achieves desired objectives; and
>
> incurs the least threat from adverse consequences (Kepner and Tregoe, 1973: 59).

The choice is clear. Wichita satisfied all must objectives, scored highest in achievement of want objectives, and incurred the least anticipated threat from adverse consequences. It is the rational, unambiguous choice.

This investigation concludes that Wichita should be selected as the ALCM staging base for Full Scale Development test and evaluation and so recommends.

V. Assessment of the Decision Analysis Process

> Worth judgments are in principle untestable by ordinary scientific methods.... Worth judgments are neither true or false.... The only kinds of "tests" that may be performed on worth judgments are intuitive acceptability and the degree of consensus with which such judgments are held.... The correctness of worth judgments can only be determined on the basis of informed opinion (Miller, 1970: 15).

As a postlude to this thesis, the investigator offers some personal judgments on the worth of Kepner and Tregoe's decision analysis process, recommends its application to individual and group decision making situations in the context of Air Force systems development and closes with suggestions for further research by aspirants to the graduate degree in Systems Management. These judgments draw heavily on the investigator's eleven years experience in systems development as a basis from which to extrapolate the present success with this method to future decision situations.

The investigator believes the process is suited to use in both academic and non-academic environments, not only as a technique for individual decision making but as a process that can be used with certain restrictions in group decision-making. As for "tests" or proof of the correctness of these judgments, the investigator defers to the informed opinion of the reader and to the conclusions of future research.

Assessment

This investigation was begun in response to an expressed need to resolve conflict in a group decision making environment. Strong differences of opinion existed among the group members. An impasse threatened, yet a decision was required.

The Decision Environment. The cause of conflict was found early in the investigation. It was discovered that the group was in fact a foundation as defined by Marshak (see page 5). In a foundation, group members

do not perceive a strong identity of purpose. While individual members subscribe to a group purpose, they see the accomplishment of group objectives in terms of a means of achieving their own objectives. As these individual objectives are likely to be divergent, the possibility of conflict is strong.

It was further established that the decision process would likely be personalistic: there was no agreement on the identity and ranking of objectives; the required decision impinged on the personal (parent organizational) goals of the individual members; there was no agreement on a decision process to be used; and there was no agreement on the criterion of choice.

In a personalistic decision process, the group negotiates a problem resolution on the basis of individual experiences, judgment, and beliefs. This is done in the absence of specified objectives, priorities, and criterion. The optimum not only is not achieved, it cannot be defined or attempted. Satisficing occurs.

Satisficing by negotiation is in essence a political process. Rather than seeking optimality through systematic analysis, emphasizing analytic criteria of efficiency and effectivity, the group emphasizes the political criteria of consensus (Shultze, 1968: 35). That consensus is subject to, and is influenced by, the relative powers of persuasion, position and intellect exercised by members of the group--both personally and by right of the relative influence of their parent organization within the overall structure of the Air Force development, test and evaluation community. Through this process, members of the group attempt to maximize individual (parental organizational) goals rather than the implied group goals which brought them together.

It is the thesis of this investigator that the United States Air Force cannot ignore the diminuition of efficiency or effectivity that resort to political processes implies. Where decisions are required to promote the interests and objectives of the United States Air Force, conflict and sub-optimization at subordinate levels should not be allowed to result in undue maximization of subordinate level goals at the expense of Air Force goals.

Purpose Revisited. It has been asserted (page 10) that the investigator can examine the site selection process without some of the limitations which force the working group toward a personalistic process and toward arriving at a decision by political processes. To this end, the investigator specified a decision process, identified and ranked multiple objectives and specified an objective function and decision criteria. This was accomplished at the Air Force decision level so as to avoid sub-optimizations that emphasize the goals of subordinate organizations. Through increased specificity in the decision process the resolution of conflict was made rational rather than political. The purpose was to emphasize analytic criteria of efficiency and effectivity on behalf of the United States Air Force.

The Decision Process. The vehicle chosen for this rational decision process was the decision analysis method suggested by Kepner and Tregoe. It is the specified decision process selected in advance of resolution (Figure 1, page 7). The acceptability of the method was demonstrated in Chapter I, Methodology. The defense of that validity will not be repeated here. However, qualitative conclusions can be stated.

Perhaps the most obvious feature of the decision analysis process is the efficiency it lends to the collection of data and the subsequent

analysis effort. This efficiency is the result of separating objectives into mandatory and desired categories.

The investigator first collects only that data which will allow an assessment of alternatives against mandatory objectives. This may be done for one mandatory objective at a time. If an alternative fails to meet an objective it (normally) is dropped from further consideration. The effort, time, and expense of collecting data about that alternative for all the remaining comparisons against mandatory objectives and the analysis required by those comparisons is avoided. The limited time and resources of the investigator may then be used to collect data only for those alternatives that remain.

Only those alternatives that meet all mandatory requirements require detailed data collection, analysis and ranking against desired objectives. The preliminary culling of alternatives against mandatory objectives thus avoids the greater part of the effort otherwise required. (The investigator believes that comparisons against desired objectives normally will be more time consuming and complex due to the less specific nature of desired objectives. Whereas compliance or non-compliance with exact mandatory objectives can be compared with ease, far more effort seems to be required to establish a reliable, unambiguous ranking of alternatives against desired objectives.)

Early in the investigation, some members of the flight test working group expressed concern about wide ranging issues which later proved (to the satisfaction of the investigator) to be irrelevant. In retrospect, the cause of these concerns seems clear. In the absence of specified unambiguous, justifiable objectives, and in the absence of a specified decision level, the members expressed concerns relative to their own

individual (parent organizational) goals. Thus, some issues of great relevance to them were interjected into the deliberations of the working group with resulting obfuscation of the central issues. Such issues as selection of a data reduction facility and the selection of a test range were discovered to be independent and of no bearing on this study. It was discovered that most of the concern over test realism was futile since much of the ultimate realism is a product of system and facility design which is essentially independent of location.

Early in the investigation concerns were heard about the distance between alternatives and the (yet to be specified) test range. This turned out to be an insignificant issue in cost terms due to the required flight times to initialize the missile system and the overriding nature of other costs.

The investigator observed that, in general, only costs that were bearing on various individual's organization were of concern. A view of total costs to the United States Air Force was not in evidence. This observation is believed to be consistent with expectations of a group operating as a foundation without a specified decision level that encompasses all their objectives. Ambiguity and omissions must be expected under these conditions as was evidenced on the issue of cost. This effect could operate in other areas as well. However, application of the decision analysis method increased the efficiency of the decision process by eliminating these ambiguities and requiring a look at cost and other issues as they effect the decision level.

At no point do Kepner and Tregoe discuss the need for selecting a decision level. Nor, obviously, do they discuss the importance of establishing the decision level early in the process. Nevertheless, the investigator found that the necessity of a specified decision level was implicit

in the statement of objectives. What is desired can only be stated in terms of who desires it. If the decision level is not selected when stating the objectives then the method demands it when an attempt is made to rank and weight the objectives. The investigator found that attempts to rank and weight objectives resulted in ambiguity until a uniform decision level was selected for all objectives. Further, early attempts at identifying objectives included compound objectives and vague wordings. Ambiguities existed until all objectives were split out separately. As an added benefit, this process of reducing objectives to their simplest form helped to split out trivial considerations and independent issues.

In summary, the tasks and task order specified in the methodology forces a clarification of objectives and their relative importance. The investigator believes that that clarification is the key contribution of the method and of this thesis.

The "unpleasant surprise" is a spectre that haunts the shadow of every decision maker. No one can totally eliminate the chance of adverse consequences but this method reduces such chance by forcing a consideration of all known unknowns. In effect, it tests the theoretical optimum against the realities of the environment in which the decision must be implemented. No method can be asked to do more than account for the known unknowns.

Few decision makers have total authority over the implementation of their decisions. Their decisions, and the one resulting from this thesis, are in fact recommendations which must be "sold", or at least defended. The methodology pursued herein is believed to be an effective device for that sales effort. If the data used is correct and pertinent and the judgments are reasonable, then the methodology provides a rational justification which can be repeated and verified by any who doubt the recommendation. It provides the basis for answering challenges of those who would

advocate other alternatives.

Implementation of decisions may sometimes be deferred. Analysis may reveal that a decision which at first seemed urgently needed, may in fact be less pressing. If the decision analysis method has been used, the decision maker, in effect, has established a model for a future decision process. He has recognized the problem, has established the objectives and decision criteria and has an established method for comparing alternatives. He will also have identified some alternatives and collected available data concerning those alternatives.

Though change must be expected, much of this work need not be repeated. The model should be relatively stable. Future considerations of the decision need only require a check of the model and previous inputs and the input of new alternatives and data as they are developed. Thus the proposed decision may be incrementally or continuously improved up to the point of implementation without repetition of the entire process. The savings in time and other resources is evident.

As a final contribution, once the decision has been made the decision analysis provides a specific body of information that is useful to decision implementation. Instructions may be quite specific and perhaps most importantly, those who will implement the decision will understand the underlying rationale and objectives.

Applicability

As discussed by Kepner and Tregoe, the decision analysis process is intended for use by individual decision makers (Kepner and Tregoe, 1973: 39). As a general procedure, no organizational restrictions were placed on its use. It appears useful in any endeavor so long as specificity and rationality of decision processes are desired.

It is of little use if political criteria and concerns are paramount, unless by happy circumstance one's political position also happens to be desirable as measured against generally agreed upon decision criteria. This agreement is unlikely to occur since in a political process, objectives and decision criteria are seldom made explicit. To do so minimizes the chance of the desired consensus (Schultze, 1968: 49).

In the Research, Development, Test and Evaluation context there are times when everyone seems involved in a decision--the SPO chief, all of his division chiefs, Air Force Systems Command, the Air Staff, the Department of Defense, Congress, contractors, and lobbyists for a variety of interest groups. The resulting complexity and diversity of opinion and political influence often results in apparently hazy objectives, excessive effort and resultant high costs and long delays. They are a fact of the business, to be regretted perhaps, but to be recognized. The work must get done; decisions must be made.

The chance for acceptance of optimal decisions can only be enhanced by careful, methodical, objective, rational processes which are demonstrably repeatable and supportable in the face of opposing opinion and influence. Judgment, diverse opinions and political opposition will always be present. So long as decisions are subject to review, one should specify as many aspects of the decision process as is possible. The Kepner and Tregoe method offers an effective, efficient means of stating those specifications and supporting rational decisions.

The investigator believes that the process need not be restricted to individual decision making situations. Where a group can act as one--a team according to Marchak--the process seems useful. Agreement on objectives, ranks and weights could be reached based on the combined knowledge and

perceptions of the members. The strengths of numbers should enhance the thoroughness and speed of decision making through the contributed information and varied backgrounds of the members.

The process may also be useful where the group acts as a foundation (members subscribe to a group purpose but concentrate on their individual goals). So long as strong positions of advocacy do not exist the group process of selecting a decision level, and stating, ranking and weighting objectives could change the very character of the group. As consensus on objectives is gained the group will act more as a team, seeking established group objectives rather than individual objectives.

Where the foundation contains strong, unrelenting advocates, or where the group acts as a coalition the process will be of little value to the group. By definition there will be no concensus on group objectives and decision criteria. The decision will be reached through political processes stressing compromise of individual objectives, rather than optimality of the group purpose.

It is likely that strong advocacy positions will exist any time members of the group belong to different organizations. They will bring with them the political positions and varied perspectives of their parent organizations. Only within a common organization, under one manager, can group members likely view a decision process from common perspectives and act as a team or a foundation which tends toward the team characteristics of common group objectives. This leads the investigator to recommend the Kepner and Tregoe method to group decision making for committee or staff use where all members work for a common "political" unit, i.e., a unit of organization that is cohesive and to which the members of the group perceive a common affiliation.

Such groups are likely to include staffs and committees whose members belong to a single SPO, or the members of a SPO division or branch. Other possibilities include general officer staffs, some ad hoc groups (if there is a rough unity of purpose among the members) and established, functioning test teams. Other possibilities may exist. The key questions to be asked are; is there at least a rough identity of purpose? Are there strong advocates seeking to gain individual goals? If the answers are yes and no, respectively, then the group is likely to find the decision analysis method of Kepner and Tregoe useful in making rational, supportable decisions.

Further Research

The investigator's recommendation for use of the decision process in group decision making is untested as far as is known. Kepner and Tregoe do not discuss this possibility.

Validation of this recommendation could be accomplished in a thesis effort. One could examine several actual decision situations in one or several SPO's, reporting on the type of group (team or foundation) member receptivity to the method, membership cooperation and their ability to reach agreement, especially on objective statements, ranks and weights.

Two basic approaches could be tried. In one, the method could be described to the entire group so that the entire procedure would be overt. Alternatively, the process could be described to the chairman only, so that he could lead the committee through the procedure without revealing future steps in the procedure--a covert approach to the committee members. The former approach is likely to be useful when the group is perceived as a team. If the tendencies of a foundation are present, the later approach might prove desirable to prevent possible advocates from

"gaming" the procedure. Results are likely to be worth judgments of use in determining whether the procedure is amenable to group processes.

It may be difficult to find an organization that will accept modification to their normal decision making processes, especially against real world problems with which they are faced. If this proves to be an insurmountable barrier, a last alternative would be to structure a laboratory situation, with artificial groups and "test" problems. This is likely to work in a team context but is not likely to be practicable in a foundation context. It would be difficult to generate artificial advocacy positions and harder yet to relate those positions to realistic work situations.

In spite of the difficulties involved, such a study should be rewarding. The Kepner and Tregoe method has the potential not only for generating optimal, rational decisions, but has the potential to generate a stronger, more cohesive team through the process of reaching consensus on objectives, ranks, and weights. The result likely will be better, more reliable decisionmaking through the melding of the strengths, knowledge, and backgrounds of all the team members.

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SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER GSM/SM/76S-12 ✓	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* AIR LAUNCHED CRUISE MISSILE STAGING BASE SELECTION FOR FULL SCALE DEVELOPMENT TEST AND EVALUATION ✓		5. TYPE OF REPORT & PERIOD COVERED MS Thesis
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Albert E. Hughes Major USAF		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Air Force Institute of Technology (AFIT-EN) ✓ Wright-Patterson AFB, Ohio 45433		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE September 1976
		13. NUMBER OF PAGES 118
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. *(of this report)* Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

Approved for public release; IAW AFR 190-17

Jerral F. Guess, Captain, USAF
Director of Information

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

AIR LAUNCHED CRUISE MISSILE
TEST AND EVALUATION
FULL SCALE DEVELOPMENT
DECISION ANALYSIS

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A management decision is examined using the decision analysis method of Kepner and Tregoe. Four mandatory objectives and five desired objectives are established. Twenty-five air base alternatives are examined. Boeing, Wichita (Air Force Plant 57) and Kelly Air Force Base satisfy all mandatory objectives. Edwards Air Force Base does not but is continued in analysis, an option allowed by the method. The three named alternatives are ranked based on the relative degree to which they satisfy each desired objective. Wichita ranks first, Kelly second, and Edwards, last.

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cont

A decision risk analysis follows. The likelihood of failing to achieve objectives and the consequences of that failure are examined for each of the three alternatives. Severe consequences are very likely if Edwards is chosen. Severe consequences with less likelihood of occurring are associated with Kelly Air Force Base. Minor consequences with greater likelihood of occurrence are associated with Boeing, Wichita.

Edwards Air Force Base ranks lowest and provides the highest threat of severe consequences. It is considered an unsatisfactory alternative. Both Kelly Air Force Base and Boeing, Wichita are acceptable. Boeing, Wichita, the highest ranked, lowest risk alternative is recommended.