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IDENTIFICATION OF TERMS TO DEFINE UNCONSTRAINED AIR TRANSPORTATION DEMANDS

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SECTION I

INTRODUCTION

Air travel demand has shown a general trend of significant increases over the past several years. Consequently, airports are experiencing high levels of air and land congestion, and communities are feeling the impacts, both economic and environmental, of the inadequacies of the situation. There is every indication that these trends will increase, and so near term improvements, which are essentially evolutionary in nature, being based on current technology and procedures, will probably not be capable of accommodating the demands beyond the year 2000. Instead, major modifications or the development of entirely new concepts of vehicles and air transportation systems will be required. These new concepts may not be limited by current environmental, social, political and regulatory settings, and thus will be called <u>unconstrained</u>. It is quite likely that they will be revolutionary in nature rather than pursuing the evolutionary approach which has been common ever since the advent of jet aircraft.

Evaluation of the feasibility of these new vehicles and systems will be unusually difficult. Key decisions will have to be made by a large and diversely motivated group of evaluators while the vehicles and systems are still in a very early design stage, involving concepts which are still vague to the user community and technology which may be unproven. Also the optimum operational concepts for using the vehicles may differ considerably with past procedures and hence be unfamiliar to the evaluators.

In effect, each new system must be acceptable to the potential user having a need for efficient transportation; it must not result in unacceptable impacts on the economic or environmental quality enjoyed by the general public; and it must attract the financing required to assure its implementation. Thus, there is a significant need for a methodology to analyze and evaluate the many candidate systems which are certain to appear in the future and compete for both public and private support. Among the desirable features which should be included in the methodology are:

- allow for active participation of all groups or individuals involved in this system,
- protect against bias or special interests of various evaluators,
- properly weight the importance of various interactions,
- provide a quantitative measure of effectiveness,
- be amenable to a straightforward mathematical formulation, and
- permit quick response to sensitivity analysis with respect to changes in components.

It is essential that any methodology selected for use in evaluating new concepts in their earliest design stages properly address all of the issues and aspects which will be important in the construction and operation of the system. It is not clear that these topics can be identified and defined by historical means. Rather, it is quite likely that the innovations incorporated in these new concepts will transcend historical precedent, as is implied by the description of the concepts as unconstrained. Thus, the analyst concerned with such systems must have guidelines in the form of factors, variables, or characteristics (collectively referred to as descriptors) which must be examined in any comprehensive feasibility analysis and evaluation.

In order to place the current work in its proper perspective relative to the evaluation of unconstrained transportation systems, a brief analysis of the total evaluation process is in order. For present purposes this process can be considered as consisting of four basic steps.

1. Problem Definition

   How can the concept be described so that all of the issues involved are clearly identified and stated in terms that can be understood by the evaluators and will place the issue in its proper context?

2. Selection of Evaluators

   Which groups and individuals should be involved in providing an input to the evaluation process, and what information does each require, and in what form, in order that their contributions may properly reflect their capabilities and interests?

3. Evaluation Procedure

   What method will be used to process the information obtained so that it will be most useful to the individual(s) responsible for making the final decision?

4. Review and Final Decision

   (a) Who should have the responsibility for this role?

   (b) What relative values should be placed on the various inputs to the evaluation procedure?

   (c) What other factors of a political, social, or institutional nature should be included in the decision?

Another matter which must be considered is the time frame of the evaluation. Again for the purposes of this discussion, the history of the development of a system from beginning to end can be divided into four distinct phases.

1. <u>Conceptual Development</u>

   A relatively small effort to transform innovative or inventive ideas of an individual or a few individuals into a form which can be communicated to others and provide a means to stimulate discussion, and lay the groundwork for a much broader review if warranted.

2. <u>Feasibility Analysis</u>

   A thorough paper study of all aspects of the concept, sometimes including a limited amount of R & D work. The amount of funding involved is at least an order of magnitude greater than Phase 1, and maybe even more.

3. <u>Prototype Development</u>

   Considerably larger sums of money are involved to physically produce a limited number of the key components of the system, and perhaps operate some of them in a limited way to test the concept in practice.

4. <u>Production</u>

   Full committment to the implementation of the concept.

Before making a decision to proceed with any of these phases of the development of a system, some sort of evaluation must be made. The nature and extent of that evaluation, as characterized by the four basic steps mentioned above, can vary widely depending on the phase involved. As a general rule, the first major decision will probably be made after the results of the feasibility study are in hand--since the next phase can become very expensive. Therefore, this should be a point of very careful evaluation. The decision to undertake the feasibility study is a less serious matter, since costs for this phase are usually not excessive, and rarely is such a study made without producing some results of value in some context to the agency or company. Conceptual design studies proposed by key personnel are generally encouraged without elaborate evaluation.

However, it should be emphasized that no matter what developmental phase is involved, the first two steps of the evaluation process should be considered as independent of the last two. That is to say, no matter what procedures are used to make the evaluation and reach a final decision, the definition of the problem and the selection of the evaluators must be done well. Furthermore, these tasks should not be a function of the evaluation procedure. In fact, it is not necessary or perhaps advisable to select an evaluation procedure until the first two steps can be completed and the information studied.

Thus, in the current work the objective is to address these first two steps of Problem Definition and Evaluator Selection in the most general way possible. The work will be described in the following sequence. Section II is devoted to a discussion of the general analysis of the requirements imposed by the unconstrained approach and the overall methodology (not procedure). The results of this study are presented in Section III, while Section IV contains a summary and the conclusions and recommendations which can be drawn from the study.

SECTION II

METHODOLOGY FOR THE EVALUATION OF UNCONSTRAINED SYSTEMS

Because of its extreme importance to the present work, it may be well to review again what is implied by the use of the adjective "unconstrained" in describing a transportation system. Such a system would probably be characterized by all of the following attributes.

(a) New technology will be involved.

(b) Changes from current concepts will be more than incremental.

(c) The implementation of the system will most probably involve new issues of broad scope (e.g., social, political, environmental, etc.).

(d) Elements of design or operation must be considered which are difficult to quantify (either due to lack of historical background or of a basis for perception).

(e) Normal methods of forecasting or prediction may not be valid.

In other words, there is a very good chance that the ability of the designer to synthesize in an unconstrained manner may bring about a system which has many major differences of various kinds with past experiences. This fact leads to one of the basic postulates of an evaluation methodology for such systems, viz., the evaluation must always be made in a comparison mode with something which is familiar to the evaluators, and hence represents the most common application of the current state-of-the-art in the particular area involved. Throughout this document, this current reference scenario is designed as the NORM. To illustrate, if the unconstrained concept is involved with airline operation of a hypersonic transport for passenger service, then the NORM would probably be the present service with the 747 aircraft.

It is also necessary to assure that the scope of the comparison is adequate. In the above illustration, if the new vehicle required extensive changes in airport location or operation, then these factors would need to be included in both the new and the NORM scenarios. This is a relatively straightforward example. As innovations become more extreme it becomes increasingly difficult to determine what must be included in the descriptive scenarios. For example, if the new concept involved a mass-produced, relatively inexpensive personal airplane for intercity travel, it would be almost impossible to recognize all the aspects and implications of the changes which would be introduced by the large-scale acceptance of this concept, unless some form of guidance were provided. Thus, one of the uses of the descriptors determined by this study is to provide just such guidance. In effect, they can be used as a check list in preparing scenarios for both the new concept and the NORM. It is essential that any descriptor judged applicable to the new concept be included in the NORM, and vice versa.

Figure 1 presents a schematic representation of what is believed to be an appropriate process for the evaluation of unconstrained transportation systems. In the conceptual design stage the scenarios referred to above must be constructed. The objective of the process is then to determine which of these scenarios is "best" (in an overall sense) for implementation. This leads to the natural question of what must be considered in determining "best." The natural questions involved relative to a transportation system are:

- Will it be used?
- Will it be acceptable to the general public (non-users or users when in a non-user mode)?

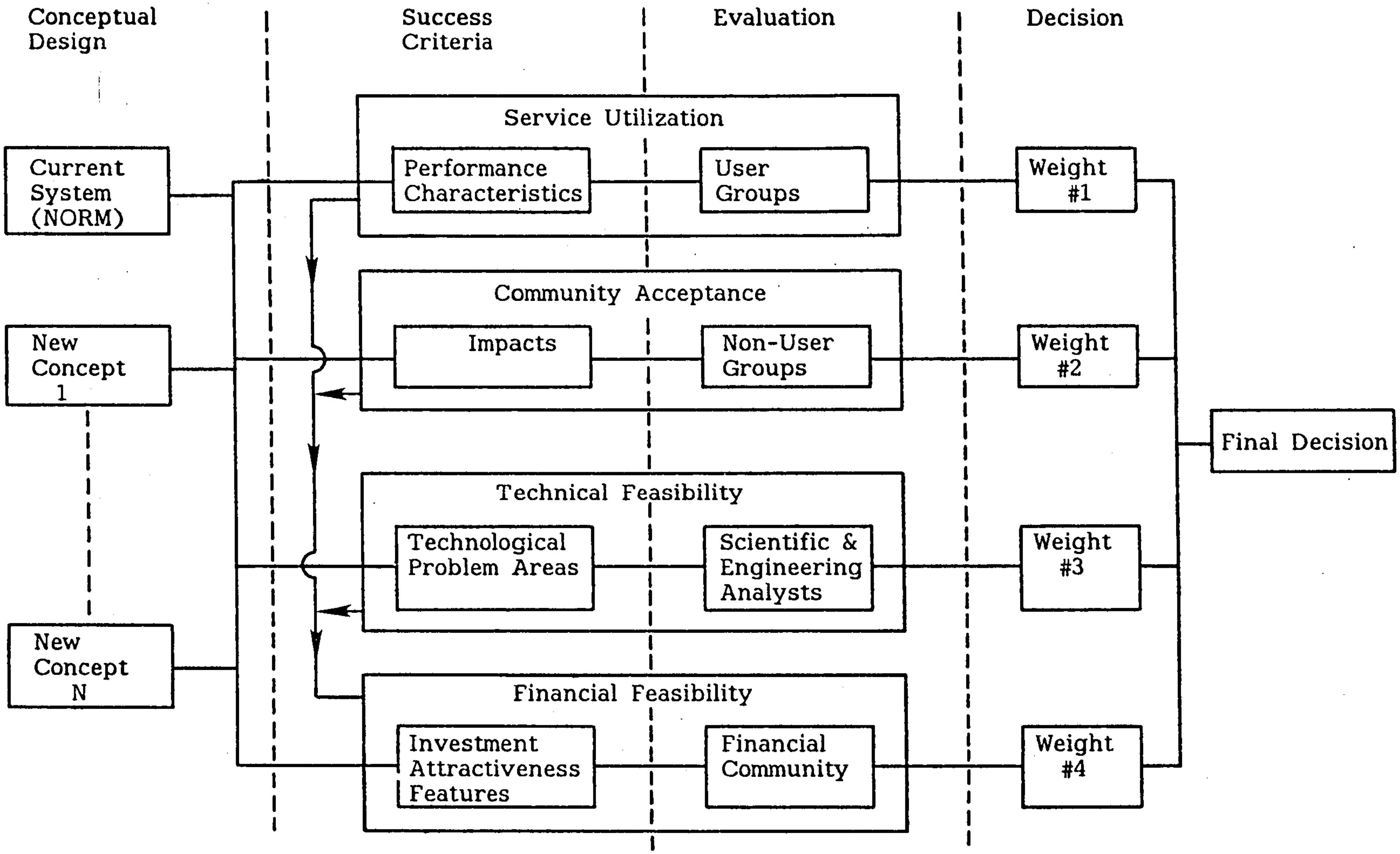

Figure 1. Schematic of Evaluation Process for Innovations in Transportation System Design.

- Is it technically possible to achieve the system goals?
- Can the concept be made sufficiently attractive to obtain the financing required for its implementation?

These four questions give rise to the four paths or "TRACKS" which compose the evaluation process. These TRACKS are of quite different nature, and each requires its own set of descriptors and its own selection of evaluators. The descriptors, the determination of which is the objective of this study, are shown in the figure as "Success Criteria," and the terminology indicates the general nature of the descriptors required in each TRACK. It follows that it is probably advantageous to prepare separate scenarios, based on the different descriptors, for each TRACK. This is because, within a given TRACK, the evaluations made should be based only on considerations appropriate to that TRACK.

At the conclusion of the evaluation phase, the decision makers should have in hand a judgment, or set of judgments, as to the relative merit of each concept for each TRACK. The decision makers must then weight them properly and combine them into a final decision. As indicated earlier, in this work we will be concerned only with the generation of the descriptors and the structure of the evaluation groups. A little consideration will indicate that these two are interrelated, i.e., the particular nature and phrasing of the descriptors will depend upon the choice of by whom they will be addressed.

Let us examine each of the TRACKS in more detail.

TRACK 1. Service Utilization

This measures the satisfaction and willingness to patronize the system of the potential users, which in turn are based on operating performance characteristics such as fares, schedules, type of equipment, dependability, etc. Traditionally this area has been handled through demand studies and market share forecasts. In unconstrained systems these traditional models will have to be abandoned and a more general scheme adopted, since incremental changes are now giving way to rather gross changes in the system. For example, we are not concerned only with a fare or schedule change, or the substitution of a slightly different piece of equipment; rather, we are introducing entirely new vehicular or system concepts whose characteristics are unfamiliar to the public.

TRACK 2. Community Acceptance

This represents the impacts, good or bad, caused by the intrusion of all parts of the system and their operations into specific neighborhoods as well as into the community in general. This intrusion will be into the lives of individuals, businesses, and institutions, who may or may not use the system directly, or who may or may not realize that they are being affected by it indirectly. Although community acceptance is becoming a visible issue in current systems in terms of noise and congestion at new or existing facilities, the unconstrained system may well pose many other serious issues of a political or societal nature which must be addressed.

TRACK 3. Technical Feasibility

This is basically a comparison of the new concept vis-a-vis the current state-of-the-art, and an evaluation of the likelihood of achieving what must be done beyond this current state. Approaches which will be required, such as technological forecasting, R & D critical path planning, etc., are generally well developed. However, their application to the overall evaluation of unconstrained systems must be couched in terms compatible with the overall methodology involving all the TRACKS. Also, since the steps forward from the present state may be expected to be both large in a given area and closely intertwined within the system with advances in other areas, the level of uncertainty involved in predicting futures will be increased.

TRACK 4. Financial Feasibility

Here we are concerned with the willingness of financial institutions to commit funds to the system, i.e., the investment attractiveness features of the proposed system. The extent of this commitment will be a major factor in determining whether or not the concept is ever implemented. It would appear at first glance as though this TRACK would be reasonably amenable to the traditional standard techniques of financial attractiveness, although it must be realized that the results in this TRACK will be heavily dependent on the results of the other three TRACKS, as shown in Figure 1. (It should be noted, however, that the other three TRACKS operate essentially independent of each other.)

SECTION III

RESULTS

In this section the descriptors which should be considered in the evaluation of any unconstrained transportation system are presented. As indicated earlier, these descriptors are independent of the method of evaluation used. No matter what procedure is used (e.g., benefit/cost, ranking techniques, direct economic analysis, etc.) attention should be paid to every descriptor; each one should be included in some way in the analysis, or a justification should be made to allow it to be neglected or combined in some way with another descriptor. Thus, in a sense, the descriptors serve as a check list for the analyst. But they represent far more than a simple list. Each entry is carefully structured and phrased to properly relate it to the context in which it applies. Consequently, a given word or phase used as a descriptor can have different significance to different types of evaluators, or to the same evaluator under different circumstances.

Because of this complexity it was decided to present the descriptor list in a tabular form in which the descriptors are identified, various definitions are presented for each descriptor, depending upon the context in which it is used (or may be perceived), measures are given appropriate to each definition, and the evaluator groups likely to use each definition are identified.

Since each of the TRACKS require an entirely different set of descriptors and the best approach for generating them varied considerably, this section is divided into four subsections, one for each TRACK.

A. TRACK 1: Service Utilization

Service utilization reflects the user acceptance of the system that can be anticipated based on the design and operational characteristics of the system. The success criteria, or descriptors, must account for all of those features of the concept or system under study that might influence the attitude of the users toward it, i.e., the descriptor must reflect the perceptions of the users as they identify the system features which are important to them in making their decision whether or not to use it.

The first step is to identify the users who might be involved, as their perceptions will be governed by their motivations for using the system. Certainly the Patrons of the system are one of the primary user groups involved. This group is solely responsible for providing the revenue for the system. However, the Patrons Group represents too great a diversity of motivations to be of much value for generating descriptors unless it is fruther subdivided. At the initial level it can be subdivided as follows:

Patrons

Passengers - transport of persons

Cargo Users - transport of goods

Government - subsidy to provide for public good, and subsequent control

Even at his level a great diversity of motivation can still be sensed when considering possible descriptors, and so a second level of motivational subdivision leads to the situation as represented in Table 1.

Certainly motivations are quite different at these subdivided levels. Travel paid for as a corporate expense gives rise to a markedly different reaction to certain descriptors than does an individual on a pleasure

Table 1

Subdivision of Patron Group - 2nd Level

Passengers

- Business and Commercial Travel
- Personal Travel for Business
- Personal Travel for Pleasure

Cargo Users

- Shippers
- Receivers

Government

- Federal
- Regional
- State
- Local

trip. Likewise, the motivation for a shipper deciding to use air transportation to transport his product may be quite different from that which governs the same choice by the customer. In the case of governments, the Federal Government is more likely to be involved with subsidy issues or the basis of social concern, while the other sectors would probably be motivated more by the concern for economic development.

Depending upon the nature of the system/concept under study, it may advisable to go to even a third level of stratification. For example, each of the passenger categories can be further subdivided into:

- Sex
- Age
- Education
- Etc.,

Likewise, the shipper and receiver categories naturally breakdown into:

Perishables
High value goods
Routine shipments
Special objects (caskets, animals, etc.)

Finally, an analysis of the Federal Government role yields:

Military
Commerce
Social
Mail and dispatches
Regulatory

With the exception of military and mail, the same breakdown would also apply to the other goverment groups.

The other major categories of users are Operators and Manufacturers. These two groups have similar motivations: to produce a product that will sell. In the case of the Manufacturers, they sell to the Operators, and offer primarily physical entities for sale. The Operators sell to the Patrons and market services. In a sense it may seem strange to classify the Manufacturers as a user. This is felt desirable in this case because the policies and design decisions of the manufacturers must be attuned to bridge the gap between what the customers want and what they believe is feasible to provide. There is also a direct image association from the ultimate user to the manufacturer. Thus, it is essential that manufacturer representation be included in the service acceptance evaluator groups, and that these relationships be kept in mind during the formation of the descriptors.

A first cut of the breakdown of the Operators and Manufacturers Groups is given in Table 2. In this case it is felt that further subdivisions may not be very fruitful.

Table 2

Subdivisions of Operators and Manufacturers Groups

Operators	
	Large airline systems
	National airlines
	Regional airlines
	General aviation--corporate
	General aviation--personal
Manufacturers	
	Main frame assemblers
	Component suppliers
	Service industries

Thus, in summary, evaluation groups for the Service Utilization TRACK should be selected from the Groups listed in Tables 1 and 2, with thought being given to the need for further expansion of the Patron Group as discussed in the text.

Now that the evaluation groups have been identified, the next step is to determine the factors involved in the decision as to whether or not the users will indeed use the system. This matter has been the subject of much analysis, both by the authors and by other researchers. The list of parameters upon which decisions are based regarding the acceptability of air transportation service can be stated with a high degree of confidence, and data concerning the relative importance of most of these to the Patron Group are available [1]. The list is given in Table 3.

In formulating this table, an effort was made to reduce each possible parameter to its most fundamental level. Hence, some commonly used terms do not appear on the list, but their components do. For example, productivity is a commonly used measure by operators and

Perishables
High value goods
Routine shipments
Special objects (caskets, animals, etc.)

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Table 3

Parameters Affecting Service Acceptance

- safety
- dependability
- time to certify
- time to implement
- degree of automation
- efficiency in terms of energy
- efficiency in terms of space
- maintainability
- repairability
- weight
- cost
- comfort
- convenience

manufacturers in air transportation (it has no significance to the patron), but in Table 3 it has been reduced to its elements, viz., weight and time to implement, and in some cases cost.

The final step in formulating descriptors is to analyze the context in which these parameters will be applied to reach decisions. The first observation to be made is that the parameters will be evaluated throughout the operation of the system, although their interpretation may change from time to time. Assuming that the unconstrained air transportation system is considered to be a door-to-door experience, then what is required is an arbitrary but appropriate definition of all the activities involved in this door-to-door trip. They are defined in Table 4. If limited components or operating procedures are being studied, it may be necessary to break down some of these major activity categories further.

Table 4

Definition of Activities Comprising an Air Trip

Access:	getting from the point of origin to the initial transport vehicle
Intermodal Transfer:	actions involved in getting from one mode to another, if required to get to the terminal.
Ticketing:	action to purchase contract for the flight or for the access portions.
Activities in the Terminal:	luggage, checkin, concessions, waiting areas, etc.
Flight:	All activities directly related to the aircraft.
Transfer:	Activities involved in changing from one aircraft to another at a connecting point.
Activities in the Terminal:	luggage, pickup, personal services, waiting, etc.
Intermodal Transfer:	actions involved to go from the terminal through an intermediary mode to the final egress mode, if required.
Egress:	getting to the point of destination from the final transport vehicle.

For example, the flight activity can be broken down as follows:

- boarding
- taxiing
- take-off
- climb
- cruise
- descent
- landing
- taxiing
- deplaning

It has also been necessary to include a list of technology elements to be considered in formulating descriptors, since several of the evaluator groups have their perceptions of the parameters influenced by changes in high performance technology characteristics. Although these apply primarily to the Operators and Manufacturers, there are some associations that are made directly with some members of the patrons group. The list is given in Table 5.

Table 5

Technology Subsystems Affecting Performance

Navigation:	hardware and mechanism by which vehicles are directed from one point to another.
Propulsion/Energy:	design, performance and fuel efficiency of propulsion system; power loading of prop system.
Interior Design:	includes layout and furnishing of cockpit, galley, passenger area, cargo area, bathrooms and waste storage.
Configuration:	fuselage, wings, tail; how they fit together; overall vehicle appearance.
Structure and Materials:	design; reinforcement required; common and/or special materials.
Avionics:	electrical systems and electronic devices.
Landing Gear:	retraction mechanism; brakes, tires, and wheels.
HVAC:	air vents, ducts, air conditioning/heating unit; temperature control.
Hydraulics:	water storage facilities, pumps, supply to galley and toilets; fuel distribution.
Software:	associated with avionics, automatic control, etc.
Auxiliary systems:	any system not an integral part of the plane.
Communication Equipment:	radio, intercom.
Emergency Back-up:	redundant hydraulic and electrical devices.
Automatic controls:	self regulating steering device.
Ground Support:	passenger and aircraft servicing equipment.
Pollution Controls:	devices for reducing air and noise pollution.

Using all the factors discussed above, the material in Table 6 was assembled. To use this table, each definition under each descriptive parameter is considered individually. In preparing for evaluations by the groups indicated (or otherwise selected as appropriate for that definition), any changes between the candidate system and the NORM for any of the measures cited must be identified and used some way in the evaluation. If there is no change, then this fact should in some way be included.

In this table the evaluation groups have been used only at the highest level of aggregation. In general it was felt that this would be satisfactory for the purpose of preparing the definitions and measures. Although additional detail can be achieved with a more sophisticated breakdown of each evaluator group, the benefit does not seem to outweigh the difficulty, provided that the evaluation process recognizes that at least the second tier of disaggregation should be included in some appropriate fashion. It is difficult to be more specific about this point without addressing it from the perspective of a particular evaluation process. Additional comments will be made concerning the matter in Section IV.

TABLE 6

Summary of Descriptors for the Service Utilization Track

PARAMETER	DEFINITION	MEASURE(S)*	GROUP**
Safety	Risk as sensed by passengers, cargo owner. Being/feeling safe.	Passenger fatalities per 100 million passengers.	1
		Passenger injuries per 100 million passengers.	1
		Number of fatalities in previous year.	1
		Number of aircraft accidents per year.	1
		Number of aircraft accidents during previous year.	1
		Size of aircraft (number of seats).	1
		Crew size.	1
		Propulsion system (jet?, other?).	1
		Ratio of freight loss and damage claims paid to freight revenue (by carrier).	1
		Runway conditions (paved?, lighted?).	1
	Risk of fatality, serious injury, or loss as a result of an occurance (accident) associated with the operation of an aircraft.	Passenger fatalities per 100 million pass-miles.	1, 2, and 3
		Passenger injuries per 100 million pass-miles.	1, 2, and 3
		Cargo losses (tons) per 100 million ton-miles.	1, 2, and 3
	Risk of fatality, serious injury, or loss during access and egress portions of the trip and within the airport (security).	Ground traffic accident data (accidents per year in highway that provides access to and egress from airport).	1 and 2
		Number of thefts per year in airport (including parking areas).	1 and 2
	Aircraft mechanical reliability: any device for preventing an accident, training of crew for emergency operations. Can be based on certification of operations.	Type of certificate held.	2
		Is crew trained?	2
		Accident rate per million aircraft miles flown: total accidents, fatal accidents.	2 and 3
	Aircraft design reliability. Can be based on certification of airworthiness.	Type of certificate held.	3

* Parameters can be measured as a number (value), as a percent improvement over actual performance, or as a specific answer to a question.

** Group [1 - patrons; 2 - operator; or 3 - manufacturer] to which each measure applies.

TABLE 6 (continued)

PARAMETER	DEFINITION	MEASURE(S)*	GROUP**
Dependability	Schedule reliability. Can it be trusted?	% scheduled aircraft miles completed (by carrier).	1 and 2
		% of flights completed within 15 minutes of scheduled time.	1 and 2
	Effects of weather.	% cancellations.	1 and 2
		% scheduled completed aircraft departures.	1 and 2
	Mechanical reliability. Aircraft instrumentation.	Type of certification held.	1 and 2
	Production schedule reliability.	% completion.	3
Time to Certify	Ticket and baggage certification: queuing time from beginning of line for tickets to end of line for baggage.	Minutes, hours.	1 and 2
	Elapsed time to accomplish certification of operations.	Years, months.	2 and 3
	Elapsed time to accomplish certification of airworthiness.	Years, months.	3 and 2
Time to Implement	Scheduled flight time and connection time (if applicable).	Hours, minutes (per mile, overall).	1 and 2
	Time to ready the aircraft for takeoff: cleaning, fueling, catering, etc.	Hours, minutes.	2
	Time to ready the aircraft for flying: wind tunnel tests, flight tests, etc.	Years, months.	3

* Parameters can be measured as a number (value), as a percent improvement over actual performance, or as a specific answer to a question.

** Group [1 - patrons; 2 - operator; or 3 - manufacturer] to which each measure applies.

TABLE 6 (continued)

PARAMETER	DEFINITION	MEASURE(S)*	GROUP**
Degree of Automation	Contact with and passenger perception of automated systems and services: ticketing, baggage, food, etc.	% of satisfied passengers.	1
	Type of hardware and software utilized and its functions.	% improvement as compared to norm (actual, other).	2
	Design of aircraft automatic systems: hardware and software design; its reliability.	% improvement as compared to norm (actual, other).	2 and 3
Efficiency in Energy	Maximum Performance with minimum amount of fuel.	Fuel cost per passenger mile.	1 and 2
	Fuel saved by more energy efficient engines and aircraft design and weight.	Fuel cost per seat-mile.	2
		Fuel cost per gallon.	2
		% change of fuel cost over prior month, over same month in prior year.	2
		Gallons of fuel consumed per block hour.	2
	Ground support equipment fuel consumption, terminal energy use (lighting, etc.).	Fuel cost per gallon.	2
		Cost of electric power consumed per month.	2
	Design and production of an energy efficient aircraft and engines with a minimum of expense or waste.	% of savings in fuel.	2 and 3
		Expected average fuel consumption per block-hour.	2 and 3
Efficiency in Space	Appropriate distances/areas between or within things: counters, gates, baggage area, services, lounges, work areas, hangar space.	Feet, meters, square feet, square meters.	1 and 2
		% improvement as compared to actual/other.	1 and 2

* Parameters can be measured as a number (value), as a percent improvement over actual performance, or as a specific answer to a question.

** Group [1 - patrons; 2 - operator; or 3 - manufacturer] to which each measure applies.

TABLE 6 (continued)

PARAMETER	DEFINITION	MEASURE(S)*	GROUP**
	Appropriate areas inside the aircraft.	Square feet, square meters.	1, 2, and 3
Maintainability	Ability to maintain in good condition, functioning properly, and in continuous use all aircraft, equipment, facilities, and services. Perventive maintenance programs.	% of necessary equipment available. % of personnel with required certification. % of improvement as compared to actual (norm/other).	2 2 2
	Ability to support good maintenance by supplying necessary equipment.	% of necessary extra equipment in stock.	3
Repairability	Ability to put damaged aircraft/equipment/facilities/services back in good condition or replace them.	Number of certified employees.	2
	Ability to support repairs by supplying spare/replacement parts needed.	% of spare/replacement parts in stock.	3
Weight	Gross take off weight. Empy weight.	Pounds, tons, killograms.	2 and 3
Cost	Of fares, insurance, services, (access, food, etc.).	Dollars	1
	Of moving freight/cargo per pound, ton.	Dollars	1
	Of purchase of aircraft/equipment, operations and maintenance, services to passengers, insurance, landing fees, slots, etc.	Dollars	2

* Parameters can be measured as a number (value), as a percent improvement over actual performance, or as a specific answer to a question.

** Group [1 - patrons; 2 - operator; or 3 - manufacturer] to which each measure applies.

TABLE 6 (continued)

PARAMETER	DEFINITION	MEASURE(S)*	GROUP**
Cost (continued)	Of general and administrative operations, advertising and publicity, depreciation and amortization, etc.	Dollars	2
	Of producing the aircraft: research and development, testing, mockups, production, marketing, labor, materials, equipment, etc.	Dollars	3
Comfort	Degree of satisfaction with environment based on: provision of ease and quiet enjoyment, relief from distress, seat space, food and beverages, restrooms, attendants' service, lounges, reading material/entertainment, motion, noise, temperature, pressure.	Average comfort rating.	1
		% passengers satisfied with ride.	1 and 2
		% passengers satisfied with seating.	1 and 2
		dB, degrees, psi.	1, 2, and 3
Convenience	The quality of being convenient, at a time and place suitable to the user, flight scheduled at favorable time of day, convenient routes, connections with good timing, reasonable walking distances, etc.	Frequency of service (# of flights per day).	1 and 2
		# of destinations served.	1 and 2
		# of favorable flights offered.	1 and 2
		# of points with favorable connections.	1 and 2
		Total cities with round trip service.	1 and 2
		Total connections available.	1 and 2
		Average (or maximum distance walked).	1
		Available seat-miles/ton-miles.	1 and 2
		Load factors.	2
		Thru-ticketing?	1
		Joint fares?	1
		Thru-baggage check?	1
		24-hr. reservation service?	1

* Parameters can be measured as a number (value), as a percent improvement over actual performance, or as a specific answer to a question.

** Group [1 - patrons; 2 - operator; or 3 - manufacturer] to which each measure applies.

B. TRACK 2: Community Impacts

The objective of this TRACK is to measure the extent to which the system is likely to be acceptable to the non-user public. There is no question but that any system will affect the citizens of the communities in which it operates in a variety of ways. The results may be both beneficial and detrimental, and in fact, they may actually differ from the way they are perceived by the individuals and groups who react to the impacts. The situation is quite complex, since what might be perceived as a negative impact by a small group of individuals may actually be a distinct benefit to some other group or when viewed from a larger perspective.

Based on past experience with these types of issues, it seems apparent that as new systems become more unconstrained, i.e., innovative or containing unfamiliar concepts or activities, they are likely to meet increasing public resistance, unless the impact analysis phase is handled thoroughly and carefully. Thus, it is a very important component of the overall analysis, and should probably be emphasized in the feasibility study phase. The community impacts and the probable reaction to those impacts should be well understood before a decision is made to begin the prototype development.

TRACK 2 is similar to TRACK 1 in that it is also based on perceptions. Thus, the requirements for evaluation are also similar. Basically, the steps are as follows:

- Identify the impact areas.
- Define them properly.
- Identify the evaluators concerned with each area.

- Attach a relative importance to the evaluations of each group.
- Combine all factors and make final decision.

Since this report addresses the pre-evaluation phases of the problem, it is concerned with the first three items in the process. As before, motivation is the key to the proper selection and use of evaluators. Unlike TRACK 1 there is no fundamental individual decision involved, as was the previous case in the basic matter of whether or not to patronize the service. In TRACK 2 the motivation is likely to be based on issues of

- invasion or privacy,
- degradation of environment,
- change in role of land use,
- economic benefit,
- alteration of standard of living,
- etc.

As is usually the case in real-life situations, a new system will affect most of these issues in some way, and the overall result must reflect the inevitable trade-offs between benefits and disbenefits.

The nature of these issues is such that public reaction rarely surfaces on an individual level. In fact, it is inherent in democratic principles that decisions should be made to benefit the majority. However, since current trends indicate that an informed and vocal minority can indeed influence public policy, the tendency is for those concerned about a particular issue to group together to make their desires or fears heard. Unfortunately, the motivations involved do not have the universality that is associated with the users of a tansportation system. Thus, the selection of the groups to be involved in the evaluation of the community impacts of an unconstrained transportation system are quite dependent on the nature of the system. Since normally, upon the introduction of a new concept, a pressure group exists (or soon will exist) for almost any kind of impact, the important aspect in the evaluation process is to be able to identify and describe accurately all of the impacts. In the nature of providing guidance to the analyst in a checklist format, considerations should be given to each of the following societal segments when forming evaluator groups for community impacts.

- Industry
- Business
- Patrons (users)
- Community and neighborhood residents
- Special interest groups of all kinds (at national, state and local level)
- System employees
- Professional groups
- Government (particularly if the system is being privately evaluated).

These groups have different perceptions of the new concept/ system, and different motivations, thus providing a sufficiently broad base for evaluation. They can also reflect psychological impacts of the new concept/system on individuals, revealing individual needs and values as well as the collective position of their special groups.

While it may be possible for an experienced system analyst to make the proper impact identifications and descriptions, past experience does seem to indicate that it is almost impossible to do so without early involvement of the public. The nature of this early involvement is also difficult to specify independent of the actual system. It will probably include a combination of techniques ranging from simple communication of ideas in the most elemental public relations sense, or the formation of an advisory committee to the designers, or perhaps public hearings. For complex projects or advanced concepts it may be necessary to utilize more sophisticated techniques such as the Delphi method to determine the probable specific issues of concern, and the probable reactions to them. Whatever the method used, the most important thing is that a carefully planned approach be adopted in the pre-evaluation phases.

The best that can be done in this report, which addresses the problem on a general scale, is to indicate the types of input areas and issues that should be examined for any concept. As before, it consists of a sort of a checklist, the use of which in the context of a specific system, should guide the analyst to particular areas which may be neglected or which may require considerable additional depth of insight for that project.

The general categories of community impact may be taken as the following.

- Social
- Environmental
- Economic
- Political/Institutional
- Natural resources.

These categories are not mutually exclusive. For example, when considering components of each, land use will be included under environmental since it is usually the environmental considerations which affect the use of the land. However, any relocation of people or facilities which result from environmental causes is certainly of a social, and probably economic concern.

It is appropriate to consider each of the categories in more detail.

1. Social Impacts

First of all, the impacted entities must be identified: individuals, communities, regional areas, and special interest groups. Then the interaction with each must be established. Demographic impacts also need to be explored: e.g., changes in population by migration or by age, sex, or class mix. Effects on community cohesion is another area to be studied. Will the community be divided? How deep will the division run?

Changes in individual life style and their psychological effects, and changes in values due to the implementation of an innovative technique must be considered. Displacement and relocation of people is probably the most widely treated social impact, and always results in psychological and social stress.

2. Environmental Impacts

These are somewhat easier to identify than the social impacts due to a more direct cause and effect which can be visualized. It is also simple to use a scanning technique or checklist from one of the numerous lists available from the literature. Land use impacts can be subdivided or defined in two different ways: as part of the physical environment or as a cultural factor. As part of the physical environment, land use impact may include the effects of solid waste accumulation, erosion, pollutants, etc. As a cultural factor it may include changes in land values, and the encroachment of commercial development into the area. These changes may be among the few environmental changes which often are beneficial. Air, noise and water pollution effects must be explored, since there are federal maximum levels specified for each. It is also necessary to look at potential hazards and a number of aesthetic areas, as well as intrusion into wildlife habits.

3. Economic Impacts

Any technological development brought on by especially innovative concepts/systems will have economic consequences, either plus or minus, on society. We can classify these consequences or impacts as labor (employment directly generated and related industrial and commercial growth); commerce (improved operations); public subsidy (public funds made available); and private financing.

4. Political/Institutional Impacts

Institutions and politics are vital factors in the implementation of a new technology. Institutions are large organized groups of individuals, while politics can be considered as the domain of power relationships. There are also a large number of public responsibilities which must be taken into consideration on the political side. In general the impacts in both areas can be classified as due to implementation (effects on other projects and institutions), legal (relationship to existing codes and laws), and liability (jeopardy of being sued).

5. Natural Resources

The issue here is the extent to which irreversible and irretrievable resources are committed. In transportation systems energy is of major concern and all possible energy sources have to be looked at, especially in terms of the fuel consumption of new vehicular concepts or systems, and/or the required terminal utilities: electricity, gas, and water.

As in the case of TRACK 1 the impacts as defined under these five different categories should be evaluated in terms of the user activities, as defined in Table 4. It is quite possible that there will be different interpretations for each of these activities. The same may be true for the technology subsystems of Table 5.

Table 7 represents and attempt to summarize the above discussion in tabular form, and includes some of the measures which might be appropriate for each of the subjects.

TABLE 7

Summary of Descriptors for TRACK 2 - Community Impacts

CATEGORY	IMPACTS	DEFINITION	MEASURES
Social	Population density	Changes in composition or number caused by migration to or from the area	% change
	Community characteristics	Severence of close associations Land use patterns Needs or requirements Congestion	qualitative
	Individual effects	Lifestyles Psychological needs Physiological needs	qualitative
	Displacement of people	Involuntary and irreversible movement	# affected % of population involved
	Recreational areas	Changes in recreation facilities	quantity type # of people served
	Areas of historical interest or scenic beauty.	Elimination or impairment	# involved % of what is available to the area
Environmental	Land	Solid waste accumulation Erosion	amount per acre
	Air Pollution	Particulates Sulfur Oxides Hydrocarbons Nitrogen oxide Carbon monoxide Photochemical oxidants Hazardous toxicants	parts per million lbs/m emission rate

TABLE 7 (continued)

CATEGORY	IMPACTS	DEFINITION	MEASURES
Environmental (continued)	Air Pollution (continued)	Diffusion Factor (winds, topography) Odor	qualitative
	Noise	Proximity to various land use activities	ft. or meter
		Intensity, frequency spectrum exposure, duration	any standard indication based on dB scale (e.g., dBA, EPNdB, NEF, etc.)
		Psychological effects Physiological effects Communication effects Performance effects Social behavior effects	qualitative
	Water Pollution	Ground water pollution by Oil Radioactivity Suspended Solids Thermal Acid and alkali Biochemical oxygen domain Dissolved oxygen Dissolved solids Nutrients Toxic compounds Fecal coliform	ppm or lbs.
		Flow variations	gal/min
		Aquifer Safe Yield	gal/min
		Effect on Aquatic Life	local species affected

TABLE 7 (continued)

CATEGORY	IMPACTS	DEFINITION	MEASURES
Environmental (continued)	Hazards	Risk as sensed by the community due to fire, explosions, spills.	Historical trends in industry
	Aesthetics	Changes in neighborhood physical characteristics	qualitative
	Ecology	Large animals Predatory birds Small game Fish, shellfish and waterfoul Field crops Threatened species Natural land vegetation Aquatic plants	% of population affected
Economic	Business and commerce (includes govt. and institutions	Development affected by required or stimulated changes in land use patterns	Tax base, Dollars
		Migration in or out of area	# of entities involved # of entities involved
	Labor	Employment opportunity	# of jobs job classification wage scales
	Public subsidy	Requirements for public funding	% change in bonded indebtness % change in tax rate
	Financial community	Private funding required Normal business activities	amount; % change
	Competition	Relative to existing systems performing the same function	market share expected

TABLE 7 (continued)

CATEGORY	IMPACTS	DEFINITION	MEASURES
Political/ Institutional	Implementation (competition)	Effect on community plans for other projects	# of projects affected benefit/cost
	Legal	Compatibility with existing laws, ordinances and codes	# affected reasonaliteness of change likelihood of change cost of changes
		Special concessions required	# and time extent
	Liability	The jeopardy of being sued for trespass, negligence, abnormally dangerous activity, or nuisance.	degree of risk gravity of harm extent of typical liability
Natural Resources	Energy	Vehicle fuel consumption	miles/gallon payload/gallon
		Terminal utilities	kwh, ft^3, or gals. per unit of productivity (ft^2, passengers processed,
	Water	Change in availability (consumed or created)	gallons
	Timber	Consumed or displaced	acres board feet

C. TRACK 3: Technical Feasibility

The technical feasibility track accounts for the potential for achieving a design which will provide the essential characteristics of safety, economy, acceptability and operating performance as planned. Can the concept/system be made with available resources, techniques, and technology? If not, what are the unknowns or refinements which need to be addressed? What will it cost and how long will it take? Other factors which need to be considered are the influences on the new development by existing technologies, and the impacts which the new development will have on existing technology.

Technical feasibility studies always involve some sort of projection, with a factor of uncertainty that increases with time span, i.e., the longer the time span of the development project, the lower the changes for success. Technological forecasting and a thorough and detailed description of the innovative concepts under study are very important as well as highly interrelated.

Forecasting can be based on three rationales or bases. The first one can be identified as continuity of growth. This applies even for very advanced, unproven technologies because they generally incorporate some concepts from the past. The second rationale is that technological development responds to opportunity and need. A third common basis can be provided by an understanding of the process of technological innovation which aids in a successful prediction of technological development. This process can be described in terms of levels of emergence, i.e., development of the innovative technology based on opportunities and needs as they are identified.

In the process of identifying the appropriate parameters for evaluation, we need to consider not only the time and cost involved in the project, but also the risk and probability of failure in the new development. Other parameters which need to be considered as factors which influence an evaluation of the innovative process are:

- Technological readiness - refers to the influence and support of existing technologies on the new technology.
- Competing technologies - reflects influences on the new technology.
- Impacts of the new technology - defined as technology transfer and change.
- Legal problems - implications of the law on the new technology.
- Corporate image - Is this the type of technology for which the corporation enjoys a good reputaton, or is desirous of achieving one.

These parameters need to be evaluated for the different concepts/systems/technologies under study in terms of some definite activities related to the technology development process. The following are among the most important:

- Acquisition of materials

  Have they been developed?
  Have they been thoroughly tested?
  Are they available in sufficient quantity?

- Acquisition of facilities and machinery

  Are they available?
  Compatibility with production?
  Do they blend with existing facilities?

- Acquisition of Technology

  State-of-the-art?
  Infringement on other technology?

- Design feasibility

  Is it implementable?
  Can it perform the intended function?

- Availability of labor and skills

  Are they available?
  Extent of training required?

- Infusion into current market mix

  Compatible with complimentary supporting technologies?
  Relation to competitive technologies?

In the final analysis, each parameter (e.g., risk, time, cost, etc.) must be considered from the point of view of each activity (materials, facilities, labor, etc.) for each of the areas of technological performance found in Table 5 (propulsion, avionics, structures, etc.). A variety of evaluators must be used at this point, as the expert judgment of the scientists and engineers active in the related research and development is necessary in this TRACK. Thus, essential groups may be identified as:

(1) technology experts from the company performing the study (including research, engineering, and production representation),

(2) corporate sales and public relations,

(3) corporate management,

(4) specialized technical consultants (recognized experts in a particular area,

(5) operators, and

(6) financial community.

Of course, the representatives from the various groups would only address matters where they had reasonable technical competence.

These groups, if used properly, can provide value judgments as to the likelihood of success of the development of innovative technology, the benefits to the company performing the study, and the potential preliminary interest of the financial community. In this latter respect, this does not imply any committment of funding. This comes through TRACK 4. The use of the financial community in TRACK 3 simply provides interaction between the two tracks.

As in the previous tracks, the picture for TRACK 3 is summarized in tabular form, this time in Table 8.

TABLE 8

Summary of Descriptors for TRACK 3 - Technological Feasibility

PARAMETER	DEFINITION	MEASURE	GROUPS*
Risk	Possibility of loss or failure in the venture of a new development	% chance of success or risk	1, 3, 4
Time	Time for development of the new technology	years	1, 2, 3, 4
Cost	Expenditures in developing the new technology	dollars	1, 2, 3, 6
Technological readiness	Support by available technology	extent of departure from existing technology	1, 4
Competing technologies	Conventional systems in use or other new systems being developed	status of potential competition	all
Technology transfer and change	Impacts on other developments and on future technological change	yes or no impact expected (ranking scale)	all
Legal problems	Effects of regulations on new development Effects of approved patents on new development	yes or no impact expected (ranking scale)	2, 3, 5, 6
Corporate image	Recognition of innovation Possibility of future contracts	yes or no	2, 3, 5, 6

* Number refers to list on page 39.

D. TRACK 4: Financial Feasibility

Financial feasibility consists of two basic factors: whether or not the total amount of capital required can be obtained, and the terms and conditions under which the money is available. Actually, two separate decisions on financial feasibility may be required: one by the corporation, and another by some type of financial institution approached by the company for funding over and above immediate corporate resources. Each will make its own evaluation based on techniques which are well established, tried and tested within the company or institution involved. There is, however, a definite time sequence involved. The corporation desiring to produce the new concept must make two decisions. The first is the extent to which corporate resources can be allocated to the project. The second is whether to proceed with external financing if the first decision indicates that this is required. Related to the second decision is an additional question of the form(s) of financing to be pursued. Whether or not financial institutions become involved in the evaluation process for a given concept depends upon the results of the corporate decisions.

In general, the corporate decisions will be based upon a variety of criteria, some of which are interrelated. These are listed in Table 9, and are essentially the same ones as will be used by the financial institutions when their turn comes.

The criteria of marketability and risk involve inputs from TRACKS 1, 2, and 3, and thus, sequentially, these evaluations must be made prior to the TRACK 4 evaluation. Also the timing of the financial decisions within the product development steps (see page 4) is important to the type and extent of feasibility analysis used. As a general

Table 9

Criteria for Financial Feasibility Analysis

Capital Intensity:	What is the total investment required?
Cash Flow:	When is the money needed as a function of time, and how long will it take to get it back?
Marketability:	Will the product be acceptable and salable, and how much of the product will be required?
Risk:	What is the likelihood that once the project is started the product can be produced within the initial time and cost constraints?
Profitability:	What will be the rate of return on the investment?
Competition for Funding:	Is this a reasonable use for the resources and line of credit of the company at this time, i.e., how does the rate of return compare with other possible uses for the resources and credit?

rule, financial questions must be settled by the conclusion of the second stage of the product development process, viz. the feasibility study. In large projects such as normally occur in the aviation industry the next phase, prototype development, is usually very expensive and often requires external financing of some sort. It is rare that a company would undertake an endeavor of this scope without a clear indication of ultimate success in the production phase. Usually the side benefits which accrue to the company from a prototype construction are far to small to balance the cost.

This is not necessarily true in the feasibility phase. In the first place, the scope of this phase is often sufficiently limited that there is little question about the ability to do the analysis with internal funding. The most costly part of this phase is probably the research necessary to allow a final evaluation to be made in the technology TRACK. This may be basic research, or it may be related to the design or production processes involved. In either case the company will probably obtain results which will be useful in many applications other than the particular project which served to generate the research. More often than not, the company will consider such information as proprietary and of great competitive advantage, and will wish to keep it closely guarded. Also, since it is difficult to establish a direct relationship between such information and profitability, financial institutions generally avoid placing funds directly into this type of work. Thus, the feasibility analysis is generally funded with internal resources.

In the aviation industry the principal exception to this is an involvement with government sponsored R & D, which is often of a military nature, and sometimes of a scope incompatible with corporate resources. However, in these instances the industrial participant is really not the principal entity involved in the four-phase development of a product. This role is now played by the government agency, and they, in fact, need the same kind of evaluation information to make their decisions.

Thus, as in the case of the other TRACKS, the major analysis of financial feasibility will be done in the product feasibility phase. The decisions made at this phase are the ones referred to in the initial paragraph of this section. They will be made at the highest levels of management and will be conducted by individuals well versed in the techniques of financial analysis which the company or agency has seen fit to select for use, based on past experience. There is no universal agreement on the best techniques for application to the financial aspects of project analysis, although the feeling is beginning to emerge that a method based on cash flow is desirable.

One reason that it is so difficult, if not impossible, to generalize regarding the decisions involved with financial feasibility is that they are so dependent on individual situations with respect to the particular company, as viewed from a company-wide basis. This includes such matters as:

- Equity
- Indebtedness
- Tax credits of various kinds
- Depreciation
- Cash Flow position
- Future earnings prospects
- Credit ratings
- Etc.

The decisions are also, of course, dependent upon the general economic climate prevailing at the time of decision, on the trends in the particular sector involved, and on the relative position of a company within that sector. Finally, the cost of money is important in the decision. With the exception of the latter, all these items apply to evaluations by both corporate management and the financial community. In the case of government these factors are replaced by what is essentially a cost/benefit approach, keeping in mind the responsibility of the agency to the taxpayer, and the intent of Congress.

It is clearly beyond the scope of this study to suggest ways to improve financial decision making at this top level. However, there is another place in the process where a financial feasibility decision will be important. This is at the conclusion of the concept evaluation phase, at which time a decision is made to abandon the concept or to pursue it, probably with a detailed feasibility study at an increased level of funding. At this point all the decisions are likely to be of an in-house nature, and unless the scope of the feasibility phase requires an unusually large commitment of funds, a recommendation made at a lower level in the management structure will probably receive top-management approval as a matter of course. In this setting it is important that the decision process be consistent with those to be used when making similar decisions for other projects. Thus, it may be of value to address some of the fundamental considerations for implementing a financial feasibility analysis at this stage of the development process.

The procedure will essentially involve the same factors as in the other TRACKS. First we must select the proper evaluators, and choose the criteria upon which the evaluation is to be made. It will be the responsibility of the supervisor of the person(s) in charge of the conceptual development to form this team. Although personnel at the division or department level will undoubtedly be involved, it is important to also involve representatives at a similar level from the corporate marketing, financial and legal divisions, and it may be desirable to have an outside financial consultant to bring a fresh perspective to the evaluation. This financial consultant will probably not be in any way involved with the financial institutions which might represent sources for major funding for the latter stages of the project, if it gets that far.

The criteria will be the same as those given in Table 9, and a procedure for conducting the analysis should generally include the following points.

(1) Define a set of mutually exclusive alternatives (or scenarios) relating to the concept which represent possible courses of

action that may be taken by the company. There may be several such scenarios which emerged from the conceptual study, each representing an option for achieving the objective(s) of the project. Actually, there may be two types of evaluations involved at this stage. One, as described above, is the competition among options for achieving a given project goal (objective). The other is the competition among possible projects (each having different objectives) for the funds available in the divisional budget. In either case, there is one automatic option which should always be considered the "do-nothing alternative." In other words, a project or option should not necessarily be undertaken simply because it is the "best" of all the ideas put forth. It must also stand the test of demonstrating that the anticipated financial return to the company meets its standard of minimum acceptable rate of return (MARR) on its investment of money. The "do-nothing" alternative provides this check since it says that at the least the funds could be invested at the going short-term rate of return for cash surplus.

(2) Select a time period for comparison. Since money has a definite time value, alternatives must be evaluated over a comparable time period. Such a time period is often called a Planning Horizon, and this represents the width of a window through which the financial attributes of all alternatives are viewed. If the alternatives do not naturally adjust to a common horizon, then appropriate corrections must be applied.

(3) Develop cash flow profiles for each alternative. It is recommended that the financial attribute that is to be viewed through the planning horizon "window" be the history of cash transactions as estimated for the various alternatives. Admittedly at this stage of development these estimates are very uncertain. But estimates of other possible attributes which have financial significance are equally uncertain at this early stage, and the cash flow approach does have the advantage of being the fundamental issue involved in a financial decision. The fact that estimates of financial indicators are uncertain at this stage is no excuse for not conducting the analysis. A decision to commit additional funds must be made, and all factors relating to that decision must be considered, using the best that is available. Adjustments can be made for this uncertainty, and these are discussed in step 7.

(4) Specify the time value of money to be used, i.e., the current interest (discount) rate.

(5) Specify the descriptors to be used to evaluate the system. This is the list of Table 9, but the following comments are in order.

- Cash flows - see discussion in step 3.
- Marketability indicators are obtained by appropriately combining the results of TRACKS 1 and 2.
- Risk is composed of two factors: the results given by the technological feasibility analysis of TRACK 3, and the uncertainty in the various estimates made in defining quantities for the previous steps, e.g., cash flow profiles, discount rates, etc. the use of both of these quantities is delayed until step 7.
- Profitability will be based on a straightforward economic analysis using one or more of the standard measures of return, such as:

- present worth: converts all cash flows to a single sum equivalent at time zero,

- annual worth: converts all cash flows to an equivalent uniform annual series of cash flows over the planning horizon,

- future worth: converts all cash flows to a single sum equivalent at the end of the planning horizon,

- rate of return: determines the interest rate that yields a future worth of zero, and

- savings/investment ratio: determines the ratio of the present worth of savings to the present worth of the investment.

In some cases it may be necessary to use incremental (or differential) forms of these indicators.

- Competition for Funding - This is, in general, a management decision; the results of the profitability analysis constitute one input to the decision, but other factors also need to be considered, e.g., compatibility with long or short range plans, and ancillary benefits and costs of a marketing, public relations, or political nature; in short the investment proposal must be related to the total well-being of the company. In decisions made at this point in the total development process (i.e., should a feasibility study be done?), this factor is often not taken into consideration.

(6) Compare the alternatives using the descriptors specified in step 5. This requires the selection of a comparison method to blend the evaluators, descriptors and context in the proper manner. Consideration of this step is beyond the scope of this study.

(7) Perform sensitivity analysis - This is the point at which the risk or uncertainty factors are introduced. The first matter to be addressed is the affect on the result from step 6 of the accuracy of the estimates of the various input variables (e.g., cash flow profiles, discount rate, results from TRACKS 1 and 2, etc.). This can be done in two ways. One is a sensitivity type analysis which can be done in a deterministic

manner by simply changing the value of the various parameters by a fixed percentage and recomputing the results. The changes in each variable should be tested independent of the others. The other method is to use a probabilistic approach. Typically, in this method probability distributions are assigned to each of the independent variables, and the laws of probability theory used to compute the resultant probability distribution for the figure of merit. With regard to the matter of introducing the results from TRACK 3 into the decision, this must be handled in a special manner. What is involved here is a factor which has an overriding influence on all other factors used in the evaluation. The possibility of not achieving the technological developments that are required for the successful implementation of the concept is vital to the result. In general it is recommended that this risk factor be used as a direct multiplier on the results obtained by setting the uncertainty in TRACK 3 to zero during step 6. This latter factor might be designated as the Financial Effectiveness, which, when multiplied by the technological risk factor gives the Financial Feasibility.

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

The four major types of information that are eseential for evaluating any type of transportation system have been defined. They are:

1. Service Utilization
2. Community Acceptance
3. Technical Feasibility
4. Financial Feasibility

These factors, or descriptors, which must be taken into consideration in an evaluation of an unconstrained transportation system were analyzed and listed for each of these tracks. The use of the descriptors is somewhat complex. In the first place, even though not every descriptor is involved in each system, it is important to examine each and every descriptor carefully to determine its applicability. This is not always an easy task, because the very nature of an unconstrained system implies that it will have many attributes which are unfamiliar to some groups of evaluators, and so the proper interpretation of these descriptors relative to the particular system attributes is very important.

Also, the specific descriptors which should be used and the precise interpretation of their meaning and significance is dependent on the stage of development of the unconstrained system. The development process is divided into four stages:

1. Conceptual Development,
2. Feasibility Analysis,
3. Prototype Development, and
4. Production

It would appear that the most precise requirements for good descriptor definition and delineation occur during a careful evaluation which should be made a part of the feasibility analysis. This is because the decision to proceed with prototype development usually involves the commitment of funds an order of magnitude or more greater than in any of the previous steps. Thus, all aspects of the four evaluation tracks must be examined carefully before these expenditures are made to determine whether the system is needed, whether it will be accepted and used, whether it can be produced and operated economically, reliably, and safely, and to understand the nature of the economic, social and political constraints under which the system will reach an equilibrium of productivity.

The specific choice and nature of the descriptors will also be dictated by the evaluation process itself. This can be divided into four steps.

1. Problem definition
2. Selection of evaluators
3. Evaluation procedure
4. Review and final decision

The key points in this process are

- the selection of appropriate and properly motivated evaluators for each evaluation track;
- the definition must place the system in its proper context, using all the essential descriptors, and phrasing them in such a way that they are interpreted properly by the evaluator group;
- an unconstrained system (or systems) must always be evaluated in comparison with a NORM, i.e. what exists at the present for achieving the same objective, since it is only through this approach that evaluators can have the opportunity to visualize the features and impacts of unfamiliar concepts;

- although it was beyond the scope of this study to analyze evaluation techniques, the selection of a particular technique can have a large affect on how the descriptors are phrased or used; nevertheless, the need to give consideration to a full set of descriptors during the problem definition phase is independent of the evaluation technique selected; and

- those who have the responsibility for making a final decision based on the result of the evaluation procedure must be thoroughly familiar with the interpretations of the descriptors as they were used in the various contexts throughout the evaluation.

In order to test the results of the study they were applied to a specific problem The Lockheed-Georgia Flatbed Aircraft concept [2] used as a freighter was taken as the unconstrained system. Although there may be other concepts which are more unconstrained, the Flatbed is certainly novel, and it offers an abundance of readily available data. The evaluation technique used was the Matrix Multiplication Method, developed by the authors for NASA [3]. Not only was this conveniently available, but it was designed to incorporate those characteristics, felt to be crucial for a good evaluation of a transportation system, which were discussed in the introduction of this report. A standard Boeing 747 freighter was taken as the NORM.

Since the objective of the exercise is not to actually attempt to determine the "best" concept, but rather to use the example to explore the problems which may be associated with the application of the descriptors in the setting and context in which they might be used, no attempt was made to use actual evaluators. Rather, the outlook, or posture, of the evaluators was defined, and then faculty and students at the University assumed these roles.

The results were very gratifying. The use of the descriptor sets and the evaluation tracks recommended in this report did not seem to cause any major problems, and in fact, went quite smoothly. One of the interesting results was the powerful influence exerted by the risk factor in the technology track. Since several aspects of the Flatbed Concept have never been reduced to practice, a relatively high risk factor assigned to some of these issues could easily change the Flatbed from a favorable concept compared with the NORM to an unfavorable position. This also illustrates the point that a good deal of information can be achieved from a careful sensitivity analysis involving the key descriptors.

Thus, it is our opinion, based on this exercise, that the general approach and descriptor sets contained in this report are appropriate for use in evaluating unconstrained air transportation systems.

Finally, a few general comments and words of advice may be of value to one interested in applying this approach.

- Technological development is considered highly sensitive to life style and consumer preference.
- Social and technical studies should be done simultaneously because of their interactive nature to assure that both represent feasible and mutually compatible future states.
- Community impacts evaluation is highly sensitive to the defined parameters. The categorization of potential impacts needs to be customized for each project under study.
- In instances where futuristic systems are involved, it may be difficult for individuals to anticipate the impacts that the innovative technology may produce.
- The characteristics of the concept/system under study will influence the selection of method, quantification, and resource personnel. The characteristics of the impacts themselves may shape strategy.
- The crucial problem in impact identification is frequently not the compilation of impacts, but rather the determination of which are most significant and of their relative importance.

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15. Supplementary Notes

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16. Abstract

The factors involved in the evaluation of unconstrained air transportation systems have been carefully analyzed. By definition an unconstrained system is taken to be one in which the design can employ innovative and advanced concepts no longer limited by present environmental, social, political or regulatory settings. It is found that four principal evaluation criteria are involved. (1) Service Utilization, based on the operating performance characteristics as viewed by potential patrons; (2) Community Impacts, reflecting decisions based on the perceived impacts of the system; (3) Technological Feasibility, estimating what is required to reduce the system to practice; (4) Financial Feasibility, predicting the ability of the concepts to attract financial support.

For each of these criteria, a set of terms or descriptors has been identified, which should be used in the evaluation to render it complete. It is also demonstrated that these descriptors have the following properties: (a) their interpretation may be made by different groups of evaluators; (b) their interpretations and the way they are used may depend on the stage of development of the system in which they are used; (c) in formulating the problem, all descriptors should be addressed independent of the evaluation technique selected.

Although the work is not concerned with evaluation techniques, the results of using the descriptor for the evaluation of a specific problem are discussed.

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