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SUMMARY

Decisions requiring passenger comfort technology are shown to depend on: the relationship between comfort and other factors (e.g. cost, urgency, alternate modes) in traveler acceptance of the system; and which of two types of markets is being addressed. Profit-making systems, serving a selected market, require technology to quantify effects of comfort versus offsetting factors in system acceptance. Public service systems, serving the broadest practical market, require technology to predict the maximum percentage of travelers who willingly accept the overall comfort of any trip ride. One or the other of these technology requirements apply to decisions on system design, operation and maintenance.

INTRODUCTION

The objective of this paper is to review the subject of vehicle passenger comfort from the perspective of the transportation system organizations which have need for the technology. These organizations must make complex decisions in diverse areas (e.g. marketing, vehicle design, maintenance) to achieve and maintain traveler acceptability and use of their particular modal systems. Appreciation and understanding of the users' requirements are needed by the human factors community to better provide appropriate technology in a form directly usable by those making decisions (ref. 1).

Users' decisions regarding comfort are critically dependent on two major factors: the relationship between passenger comfort and traveler acceptance of the system; and the breadth and nature of the particular travel market intended to be served by the system. The paper will address these two factors to show the dependency, the relationship between the various physical factors which affect the ride environment, and the resulting comfort technology needed for decisions concerning the system.

SYSTEM ACCEPTABILITY

The relationship between passenger comfort and travel acceptance of the vehicle system is illustrated in the block diagram of figure 1 as reported in reference 2. Passenger ride reaction to a given ride environment is just one of a number of inputs upon which travelers' decisions on acceptability are based. Included are other factors of the system such as safety, frequency of service and cost.

Traveler-unique factors are also very important such as degree of susceptibility to motion sickness, fear of using a particular mode of travel, and urgency of the trip. Finally, the availability and attributes of alternate travel modes are considered by the traveler. In the overall process of decision making on acceptability of a particular system, the specific role played by ride comfort is, therefore, of great importance in establishing the level of severity which needs to be specified in the design criteria and/or standards which help govern the ride environment.

If the system acceptance factors are uncoupled, an expression could be developed to quantitatively relate travel acceptance to level of comfort, as illustrated in figure 2 by a first-cut relation developed from correlations made of passenger response surveys and ride environment measurements carried out on numerous commercial airline flights in the United States (ref. 3). Queries were made of 861 passengers at the conclusion of their flight regarding their willingness to take another flight having a similar ride, at least without hesitation. The resulting relation was then incorporated into a generalized method for predicting total trip ride characteristics and passenger satisfaction (ref. 2). In subsequent validation studies carried out on commercial airline flights, good agreement between prediction and passenger surveys were obtained from U.S. carriers (fig. 3). The results for the Canadian Airtransit STOL Demonstrator operation, however, showed poor agreement for the end-point situation where the ride was least comfortable and passenger acceptance would be expected to decrease drastically. For the end-point, the survey indicated over 60 percent of the Airtransit passengers would be willing to take another trip as compared with less than 10 percent for U.S. commuter passengers. Obviously, Airtransit's unique tailoring of other system factors (e.g. high-frequency schedule, downtown-to-downtown time savings, total-trip service) to enhance acceptance by the business travelers (over 90 percent of Airtransit users) was significant in offsetting lack of ride comfort. Interactions must therefore exist between the various factors entering into systems acceptance, but these effects are not yet understood or quantified.

TRAVEL MARKETS AND DECISIONS

The Airtransit experience cited above, is a good example of marketing strategy for competitive profit-making systems where decisions regarding passenger comfort are involved. The marketing objective is to provide a system whose advantages over competing modes outweigh any disadvantages for the travel market towards which it is directed. System viability sometimes requires a fine balance to be made in tradeoffs between the types and levels of advantages and disadvantages. Each upgrading of the system must be cost effective. For example, adding an active control system to provide a very comfortable ride and attract extra customers could, in fact, require a trip-price increase which would discourage ridership sufficiently to yield a net loss rather than a gain in profit. To aid in profit-making systems decisions, methodology is required to quantify, from a set of pertinent inputs, the effects of passenger comfort versus offsetting factors in the acceptance decision process of the particular set of travelers of interest.

In contrast to the Airtransit system, which was attractive to a selected set of travelers, some systems are aimed at serving the broadest practical public travel market in an acceptable manner. The basic public service objective is to provide a system whose attributes shall be sufficient for systems acceptance by essentially all travelers, insofar as technologically practical and economically reasonable. Service effectiveness is emphasized rather than cost effectiveness, and profit is not of paramount importance. In fact, many, if not the majority, of public service systems require financial subsidy. In regards to passenger comfort technology, methodology is required to accurately predict, from a set of pertinent inputs, the maximum percentage of all potential travelers who will willingly accept (but not necessarily enjoy) the integrated ride environment for any particular trip of any candidate transit system. Such methodology can then be used in making cost/acceptability tradeoffs to assess economic reasonableness, and if required, to establish realistic comfort standards for a practical maximum set of travelers.

For some public service systems, the objective may be to achieve not only traveler acceptance but also traveler use of the system (e.g. provide congestion relief or fuel saving by minimizing use of automobiles). This situation could be regarded as a competitive public service system where tradeoffs would be required between advantages and disadvantages but where a profit is not necessary. The comfort level will likely have to be sufficient for the passengers not only to accept but also to enjoy the ride. The methodology required would then be a combination of that required for the profit-making systems and that required for the basic public service systems.

SYSTEM RIDE FACTORS AND DECISIONS

In the studies reported in reference 2, the role played by the various physical factors which contribute to the integrated ride environment of a vehicle were identified as was methodology to predict total-trip ride comfort and satisfaction (acceptance). The method is outlined in figure 4, using an airplane trip as an illustrative example. During the course of the trip, the vehicle experiences a variety of events which affect the ride. Some of the event inputs are natural (e.g., air turbulence), some are operational (e.g. piloting), and some are associated with the system components (e.g. runway roughness). Each event must be individually addressed and then integrated in an appropriate manner. Integration over the course of the trip involves use of a memory decay weighting relation, which for the subject method, was developed in experimental studies of test subjects. Memory decay between trips is also a significant factor, particularly in systems acceptance, and a need exists for predicting its effects.

An expansion of the first three elements of the block diagram of figure 1 is presented in figure 5 to better point out the input factors and the vehicle response-function factors which affect the ride environment to which passengers are subjected. Aside from the external natural inputs, the factors ultimately depend on decisions made regarding the design, operation and maintenance of the transportation system components. For many transportation systems responsibility for these decisions is divided among several organizations, often with little coordination, in: the design and manufacture of the vehicles; the design and installation of guideways; the operation and maintenance of the vehicles; and the maintenance of the guideways. Decisions which are cost effective for the overall system can involve tradeoff studies which cross organizational lines. A wheeled-vehicle/guideway system provides an example: the degree of sophistication required of the vehicle suspension system versus the degree of smoothness required of the guideway surface. It should be pointed out that the ride comfort relations referred to in figure 4 exist in the form of a mathematical model of the ride environment and are suitable for use by designers in making tradeoffs between the various environmental factors (e.g. accelerations, temperature, seating) to provide a specified level of passenger comfort. Meaningful models have not yet been developed, however, for making tradeoffs between passenger comfort and offsetting factors (e.g. other system factors, traveler-unique factors, alternate travel modes), needed for decisions regarding competitive systems.

In the physical design of a system, the overall objective is to meet performance and economic requirements to satisfy a specified set of travelers, established either by profit-making marketing objectives or by public service objectives/standards. Also required is the identification of any operational constraints. The ride comfort technology required for decisions on system design and operations, therefore, would be the appropriate one of the marketing decision methodologies described earlier: that for profit-making systems, that for acceptable public service systems, or that for enjoyable public service systems.

Maintenance of guideways (including highways, runways and taxiways) has technology requirements closely related to those for system design and operation. The objective is to provide adequate maintenance to avoid vehicle capability constraints, with minimum interference in system operations and at reasonable cost. Ride comfort technology required would be the methodology to rapidly identify specific surface irregularities and discontinuities which must be upgraded to achieve a ride comfort level which meets the system design objective.

CONCLUDING REMARKS

Passenger comfort has been identified as only one of a number of factors which influence traveler decisions on acceptance and use of a transportation system. Study results have been presented for one situation which indicate that interactions exist between comfort and other acceptance factors. Tradeoffs are therefore possible in providing a transportation system whose advantages over competing modes outweigh disadvantages for the travel market toward which it is directed. Decisions concerning the design and operation of transportation systems for competitive market situations require technology to quantify the effects of passenger comfort versus offsetting factors such as trip cost, trip urgency and the availability and character of alternate modes. The state-of-the-art of such technology is considered to be not too well advanced at the present time.

Public service systems which do not operate in a competitive environment, are generally aimed at serving the greatest number of people in an acceptable manner. Decisions concerning their design and operation, therefore, require technology to predict the maximum percentage of travelers who willingly accept, (but not necessarily enjoy) the overall comfort of trip ride. Considerable technology has been generated in this area and its state-of-the-art is considered to be greatly advanced over that required to address competitive market situations.

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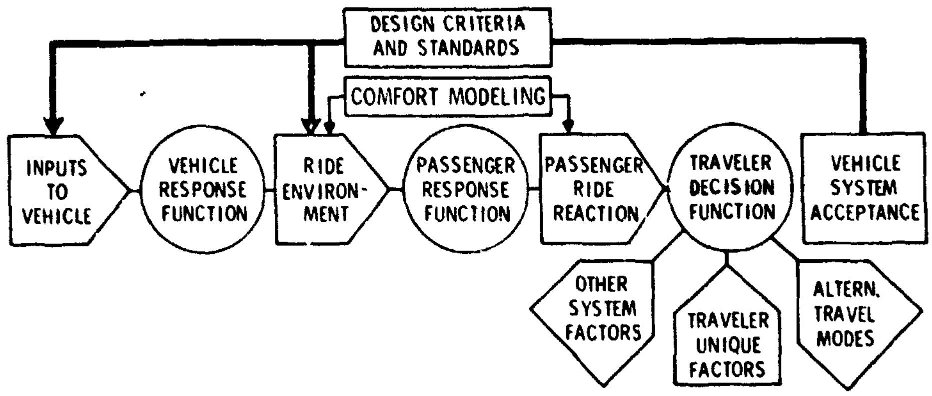

Figure 1. - Block diagram model of ride environment, passenger ride reaction and system acceptance.

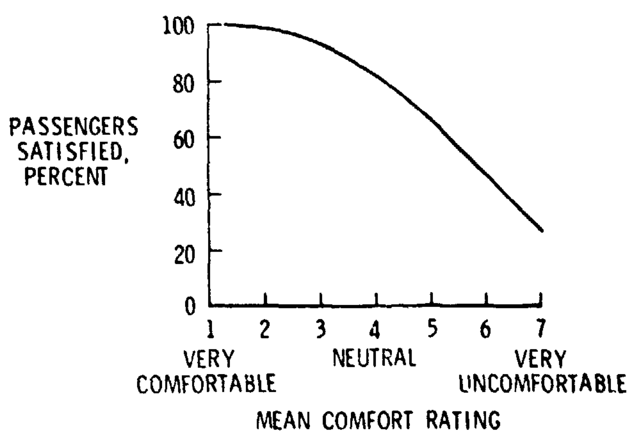

Figure 2. - Illustrative ride comfort decision function for system acceptance.

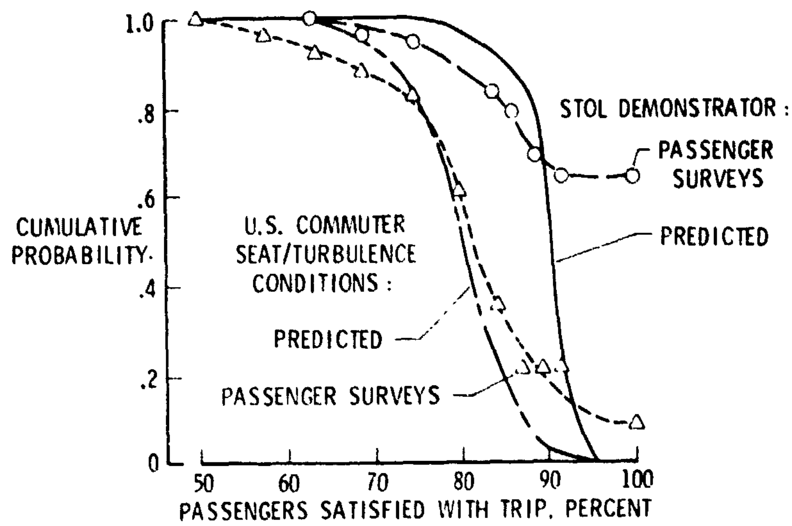

Figure 3. - Total trip satisfaction for Airtransit STOL Demonstrator system and for U.S. commuter system.

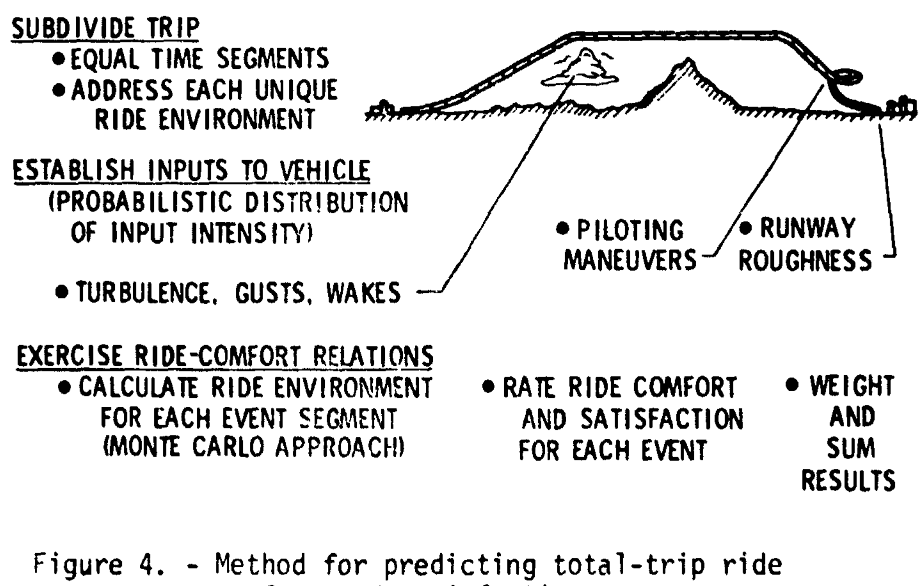

Figure 4. - Method for predicting total-trip ride comfort and satisfaction.

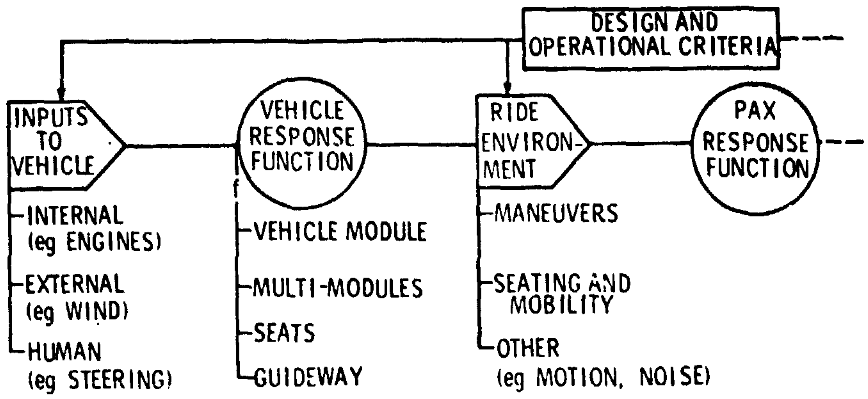

Figure 5. - Input factors and vehicle response function factors which affect ride environment.