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AND SHORT COURSE ON THE PAVEMENT CONDITION INDEX (PCI) METHOD

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PAVEMENT MANAGEMENT SYSTEMS (PMS) AS: SYSTEM APPROACH, PERFORMANCE, EFFICIENCY, SAFETY AND ECONOMY

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PRELIMINARY CONSIDERATIONS

Airfield pavement a highly complex situation. The first step in establishing an innovative approach to this complex engineering problem is to focus attention on those needs of the potential user which properly drive a pavement design process.

The Terms Systems approach, Performance, Efficiency, Safety and Economy, have been widely proposed as the general requirements of a transportation system or even as the measure of success of a system or its component parts.

These terms must be stated in a manner that is technically meaningful to the various disciplines involved. This is particularly true at the interface point where several disciplines may be involved in meeting a single requirement. For example, the qualification of roughness is of importance for different reasons to the landing gear designer, the pavement designer, the contractor, the airport operator, and potentially the pilot. It should be remembered that the pavement is to serve the USER. The designer must reflect the actual needs and desires of the USER.

SOME FACTS

•Topological Characteristics of runway surface is of concern during all phases of aircraft ground operation, taxiing, take-off and landing.

•The direct deleterious effect of runway and taxiway unevenness on operational safety of aircraft range from failure due to structural overload, fatigue damage, interference with instrument readability decrease in ground control to crew and traveler discomfort.

•Unevenness is caused by construction inaccuracies in grade profiles, differential sub grade settlements, and pavement failures.

•The severity of the problem is ever growing as airplane gross weights and ground speeds increase.

•In view of the plan to develop 1.500.000 lb plus gross weight aircrafts, new criteria are being developed for runway smoothness specifications, and to study more efficient and reliable analytical methods for airplane response predictions and also a better understanding of the behavior and performance of both aircraft and the pavement.

To accommodate the increasing demand of ever-increasing heavy aircraft loads, the question often arises whether it is more economical to increase the number of wheels in a gear assembly or to increase the thickness of the airfield pavement. Hence the question of "**Optimum Design**" to achieve greater level of performance.

The problem is not how to design and build new pavement systems for greater frequency and magnitude of loadings, but rather how to upgrade and provide remedial measures for existing pavement systems to meet current and future traffic demands.

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1-*INTRODUCTION*

1.1- No one can say when exactly the notion “Pavement Management Systems” was introduced in the vocabulary of the airport pavement designer. But what mainly influenced the systems approach to pavement design and research in the early 1970 were the more rigorous demands of these large, heavy wide body, high performance aircraft. To meet those demands, a new and more comprehensive look at the pavement’s role was needed. The systems approach holds today the key to an integrated plan for design, construction, operation and maintenance of airfield pavements, which we summarize as “Pavement Management System”.

1.2- ANALYSIS

- Structural strength was considered the single dominant feature by the aircraft pavement designer. For example, high performance aircraft ground operations can be constrained by runway roughness: hence, roughness control becomes a dominant element of the pavement design.
- For the designer the need for a hard look at what an airfield pavement is and is supposed to do becomes compelling.
- Airfield pavement a highly, complex situation

  a) Provides a host of properties to the user (i.e.the aircraft, its operator, the passengers)

  b) It is beset by many forces that would destroy it

  c) Provides a proper operational surface for the airplane

  d) It is subjected to substantial destructive forces by the environment

1.3- PURPOSE OF AN AIRPORT PAVEMENT:

Provision of safe, efficient, high performance and economical method of transportation of goods and people.

1.4-PAVEMENT SYSTEM

It is often convenient to regard the “Black Box”

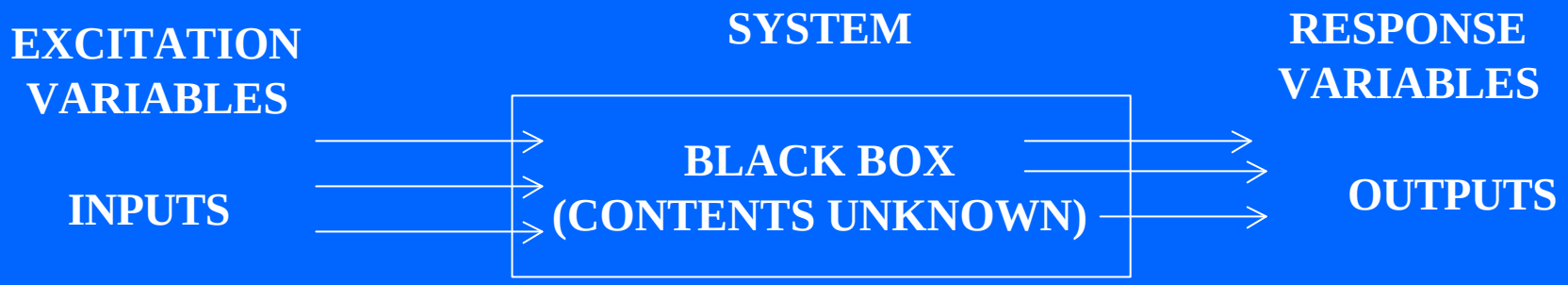


Fig. 1- BLACK BOX SYSTEM CONTENTS NOT DISCERNABLE

1.5- THE BOX:

- Accepts certain inputs in the form of traffic and environmental variables.
- Responds by developing within its structure a mechanical state which, in the case of a successful design, sustains the input variables over a certain lifetime.

1.6- THE BASIC DESIGN INVOLVES SEVERAL DISTINCT OPERATIONS:

1) Appropriate input and responses variables must be identified and described quantitatively.
2) Methods of selection of both construction materials and construction techniques must be adopted.
3) Response of the system to all types of inputs expected to occur in service must be measured, either directly in the system itself.
4) Quality of the response or measure of performance of the system to be judged by an approximate criterion.
5) Modification of the system be permitted to attain as near an optimum condition as possible.

1.7- THE INPUTS TO THE SYSTEM CONSIST OF:

- Traffic: (To impress through wheel loads and certain stresses)
- Environment: consists of, among other things, diffusion of heat and moisture into the system.

Note: The environmental input may influence strongly the response to traffic input.

It should be observed that for a particular system, it is possible, to look no further into the “black box”. The alternative would be to carry out a series of experiments in which expected traffic and environmental inputs are fed into the system and the responses measured.

A number of alternatives “boxes” could be used and their responses compared, and, based upon evaluation of these responses, a measure of the performance of the system could be set up.

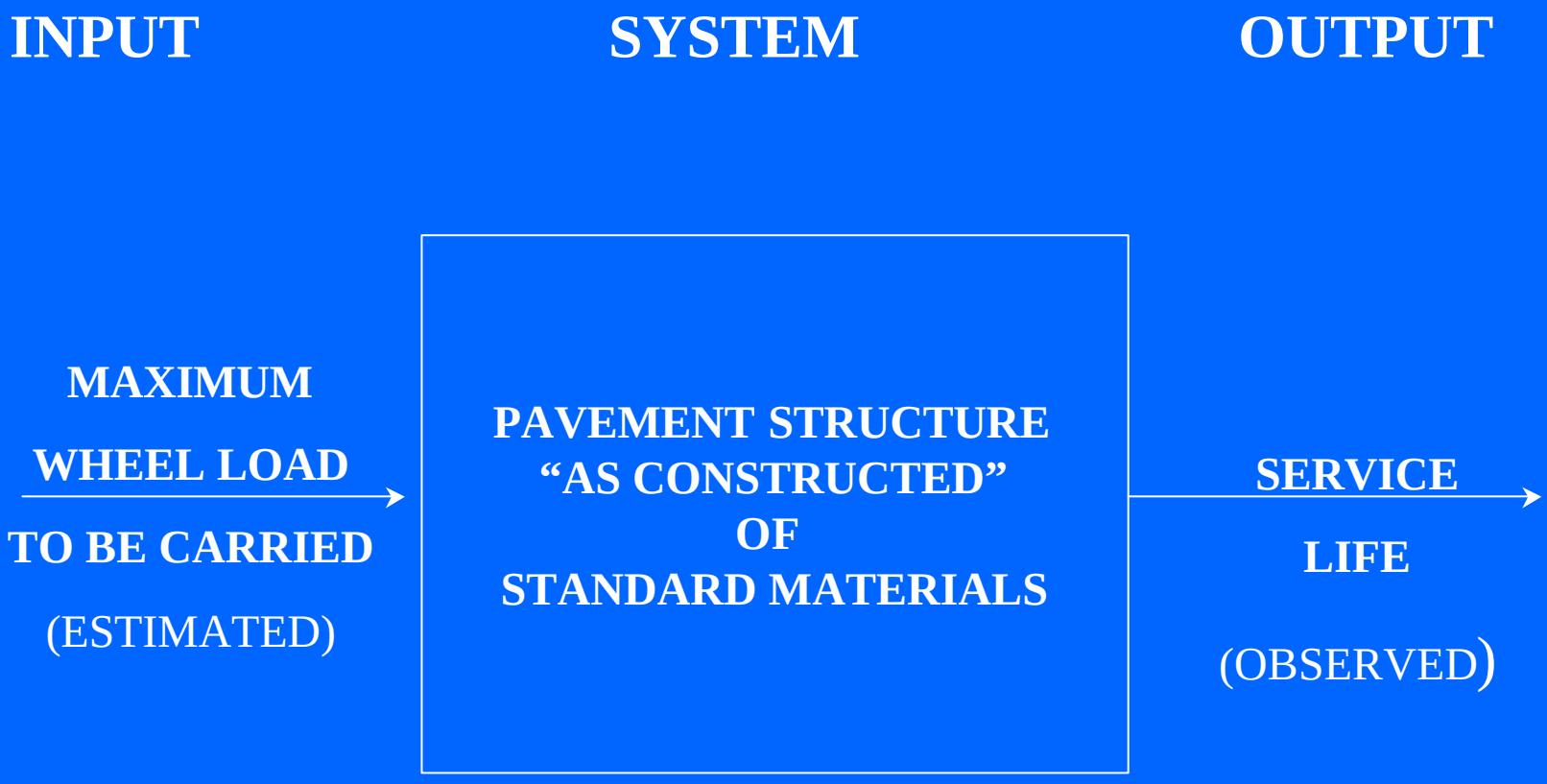


Fig. 2- DIAGRAM OF EARLY PAVEMENT DESIGN METHODS*

*Sketch provided by Ronald Hudson, B. F. Collough and Fred N. Finn (Members ASCE)

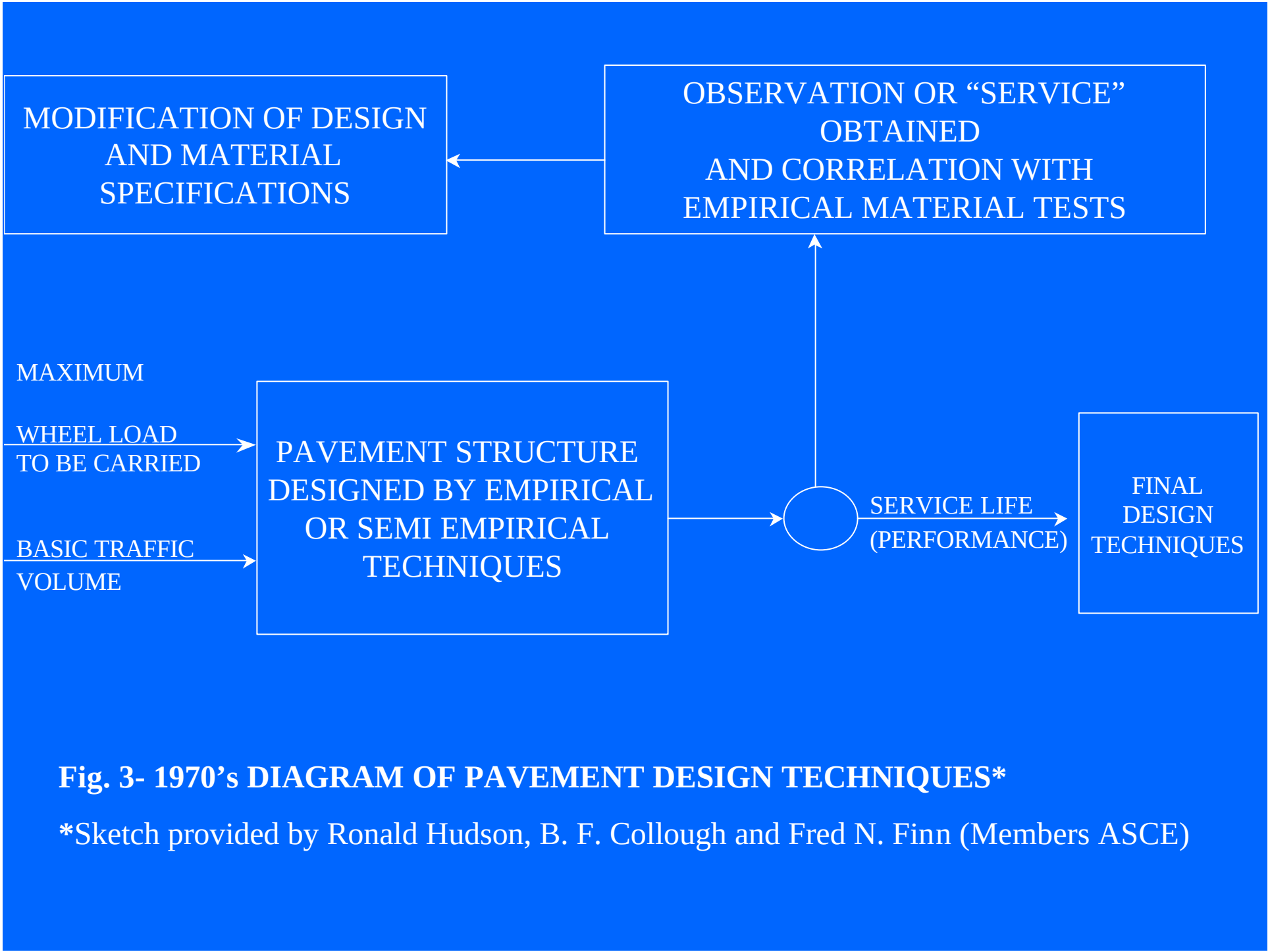


Fig. 3- 1970's DIAGRAM OF PAVEMENT DESIGN TECHNIQUES*

*Sketch provided by Ronald Hudson, B. F. Collough and Fred N. Finn (Members ASCE)

The pavement engineer observes the performance of these pavements and repeat the construction of those which perform well. Those designs which perform poorly are either discontinued or modified for future use. In successive phases, the design is refined in greater detail. This has certainly been the case in the development structural system.

Fig. 3- shows a block diagram of the evolution of many existing pavement design techniques. These techniques have evolved and used to modify materials specifications and testing procedures. The resulting methods are empirical, the designs may be expressed as equations; the materials test values are sometimes related to a mathematical theory such as the “Young’s Modules of elasticity”.

SYSTEMS APPROACH

- A systems approach requires a good description of the problem.
- A systems approach and description will provide a background and structure for coordinating and utilizing research from many sources.
- A system description will rapidly point out the areas of weakness and consequently, areas of urgently needed research.
- The systems approach emphasizes the need for a coordinated solution to the problem.
- The systems approach develops techniques in optimization and operations research. Proper formulation of the pavement problems will permit the use of these techniques to help solve them.
- The concepts used to formulate the system output function from behavior and performance information can lead to specification of this portion of the problem.

2.- PMS AND PERFORMANCE

2.1-Overall efficiency of a pavement structure is dependant on the performance of its component parts indicative of good performance.

How do we define Performance?

Performance is a measure of the quality of response e.g., whether or not:

- ❖Breakdown (distress) of the system during the response;
- ❖Excessive permanent deformation occurs and;
- ❖Performance is attained for reasonable cost.

The purpose of an airport pavement is to provide safe, efficient, comfortable, economical method of transportation of goods and people.

One objective of measure of performance will involve concepts concerning the mechanical and economical life of the system.

- To obtain an optimum systems design, it is necessary to alter the structure of the system until a maximum mechanical-economic life is achieved for a given range of inputs.

Performance is a measure of the accumulated service provided by a facility, i.e., the adequacy with which a pavement fulfills its purpose. Performance is often specified with a performance index, as suggested by Carey and Irick (refer to "The Pavement Serviceability Performance Concept" by the authors). As such, it is a direct function of the present serviceability history of the pavement.

2.- PERFORMANCE

2.2- The safe operation of today's aircraft involves three primary factors and these are: the aircraft, the pilot and the pavement.

This constitutes a very complex and do not lend to a simple engineering solution, but rather are often dependent upon the interaction between man and the machine which we will call, for the purpose of our discussion, Performance of both Man and Machine.

- Achieve the desired pavement surface characteristics in keeping with the service demands of such surfaces. This call for a good understanding between the designer and the user.

2.3- Aircraft pavements have long been the metaphorical meeting point of the aircraft manufacturer, aircraft operator, airport management, and the civil maintenance engineer. Each is concerned with utilizing the facility to the full while preserving it against indiscriminate damage.

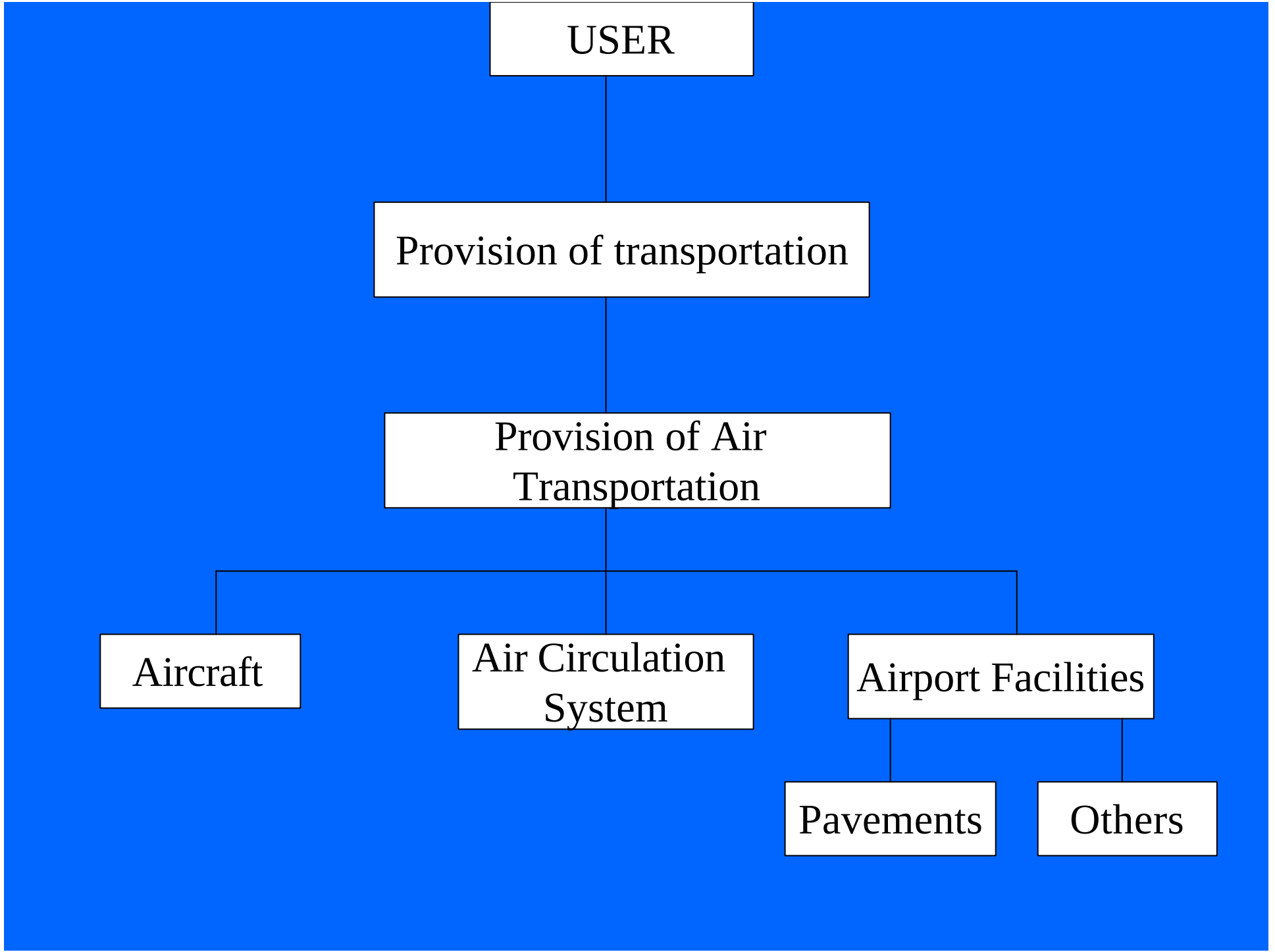
2.4- The problem of material characterization and pavement performance is so complicated, a coordinated framework for solution of the overall problem is needed. Examination of available techniques indicates that the concepts of system engineering, which evolved in the electronics, communications and aerospace industries, are appropriate to the examination of pavement structures.

The use of such techniques does not, per se, develop new and dramatic inputs to the solution of the problem, but it does provide the organization necessary for the overall solution.

3.- PAVEMENT PERFORMANCE AND BEHAVIOR

3.1- DEFINITION/ SUMMARY

- Performance is measure of the accumulated service provided by a facility.
- Performance of a pavement = the adequacy with which a pavement fulfills its purpose.
- Performance is a direct function of the present serviceability history of the pavement.
- Pavement serviceability and performance reflect an attempt to integrate user needs into the design and evaluation process.


USER
Provision of transportation
Provision of Air Transportation
Aircraft
Air Circulation System
Airport Facilities
Pavements
Others

EFFICIENCY

1- Behavior is the reaction of response of a pavement to a load, environment and other inputs. Such response is usually a function of the mechanical state of stress (i.e., the stress, strain, or deflection), which occurs in response to the input.

2- Factors affecting pavement structural behavior and efficiency have been characterized in different fashions by various individuals and groups (Carey, W. N., Jr., Harr, M.E. and Head, W.J., Irik, P.E., Mellinger, F.M., Monismith, C. L., Vallerga, B.A. etc). The reasons for these Characterizations vary, but the basic **motive** in all cases is to provide guidelines for design and/or evaluation.

These descriptions of pavement structural behavior are usually formulated either through associating factors that affect pavement efficiency or factors that affect failure of the pavement structure. However, a survey of the literature indicates that failure is difficult to specify, and meaningful definitions, of failure usually relate to some level of serviceability or performance.

ECONOMY

The systems approach as applied to airfield pavements has exposed several significant areas:

-Functional requirements and failure definition;

-Life cycle management of pavements; and

-Economic trade-off between the aircraft and the pavement.

1- All of the above have economic implications and thus become worthy of serious consideration for possible explicit inclusion in the design process. One should say that they must form in part of the design process.

2- The systems concept of the pavement problem is the vital framework for any meaningful solution. This view may appear too broad for any specific group to fully implement unaided. It should be noted that no traditional organization framework appears to exist which has the broad view.

3- Real economies are achieved when engineering designs are formulated to permit the selection of the optimal answers:

- To obtain an optimum system design, it is necessary to alter the structure of the system until a maximum mechanical-economic life is achieved for a given range of inputs.

-Economies of pavement structures versus aircraft interfacing systems.

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CONCLUSION

1- New Larger Aircraft (NLA) with wingspans and lengths approaching 350ft weighing over 1.500.000 lbs and capable of carrying over 1500 passengers may be in service by 2005.

-New airport pavements and modification of existing ones will be required.

-The systems approach applied to airfield pavement problem should be extended to achieve better results.

-Pavement design techniques will have to consider all the functional requirements of the user.

2- Standardization on functional requirements and failure criteria will have to be emphasized.

-Life time management of the pavement should be planned and controlled by way of the current modeling technology.

3- Airport pavements, runways and taxiways are becoming increasingly complex structural systems as aircraft sizes and traffic volumes continue to increase. Therefore, substantial effort are required both for improving present methods, materials and designs as well as for developing new interface concepts:

a) Interdisciplinary cooperation in tackling the question of airfield pavement management system approach.

b) The economic trade-off between the aircraft and the pavement.

c) Economic implementation worthy of serious consideration for possible explicit inclusion in the design process.

4- New concepts for serving people and more effective bases for assigning priorities to the use of resources will best be evolved from the knowledge that specific changes in service will produce specific improvements in the quality of life.

5- The quantitative consideration of environmental factors in the performance of an airfield pavement over time is a necessary part of any comprehensive pavement design procedure. Pavement Management techniques should give the status of the pavement at any time as well as guidance on optimal maintenance policies and upgrading actions, such as overlays etc. This management technique should also allow for aircraft pavement economic trade-offs.

Today several States are using the Integrated Airport Pavement Management System (IAPMS) which is a self contained software package designed to run on an 1986 class desktop computer.

It assists the engineer or planner to make the kinds of rational predictions of future pavement conditions and performance that are essential for accurate budget forecasting and sound management. The net effect is the preservation of infrastructure through improved pavement performance and reduced maintenance and rehabilitation cost.

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END

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