Airport Pavement Management Systems

Characterization and Applicability

Extended Abstract

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1. Introduction

The air transport performance and efficiency depends, among many things, of the proper functioning of airport system that in turn, necessary depends of the proper infrastructure operation condition related to the movement of aircraft on ground, especially runway pavements that may make impractical the aircraft operation and the airport equipment support.

Given this reality, the airfield pavement M&R practices should be treated with priority and responsibility by the board, since this is not an easy task and the financial resources involved, in most cases, are high and/or insufficient.

The need for implementation a rational management method, both from the global perspective network monitoring, either in defining needs associated with project preparation and works execution arising from them, is a subject of undeniable importance and timeliness. For this reason, and like the road system, airport pavement management system have been developed and implemented as maintenance and management pavement fundamental tools, with the aim of reducing costs, increasing time operating and improve the quality of operation of managed infrastructure.

Progress in hardware and software used for collection and processing data, has contributed to more and more administrations enjoy of "smart" systems that not only rely on specialist’s knowledge and experience but are cut across several significant users in decision making.

This work has the aim of gathering and systematizing a set of information about the “state of the art” in relation to airfield pavements and applied methodologies, showing the importance of the use of management systems in conservation and maintenance of complex infrastructures such as airfield pavements. Describes the importance of airport pavement management system, highlighting its objectives, listing their main characteristics and rules in which they have been and should be developed.

It is also focused the importance and value of using geographic information systems – GIS in management, maintenance and rehabilitation of aeronautical infrastructures, since its integration with SGPA allows coordinate more efficient operations and available resources.

Finally, considering the example of the Lisbon Airport and its experience in airfield pavement maintenance, are presented the main criteria taken into account in the planning of M&R actions focused on the contribution made by the existing pavement management system and the advantages of its integration with geographic information systems.
2. Airport Pavement Management System

Historically, most of airport managing teams take decisions on pavement maintenance and rehabilitation supported by immediate needs or experience, rather than long-term planning or based on documented data. This approach didn’t allow them to evaluate the cost and effectiveness of other alternatives for repair and maintenance strategies, leading to inefficient use of existing resources (TRB, 2008). The obvious notion that decisions taken in this would be reflected in pavement future condition and the availability of resources, has brought the need to develop and implement supporting tools, as are the airport pavement management systems - APMS.

The role of an APMS is to assist decision makers in developing economically viable strategies to maintain the pavement in a serviceable condition over a given period of time. APMS provides a consistent, objective and systematic procedure for determining priorities, schedules and allocating resources. It can also quantify information and provide specific recommendations to maintain a pavement network at an acceptable level of service while minimizing pavement-related expenditures.

There are numerous benefits that may be realized through the use of an APMS. First of all, an APMS can be used to provide improved documentation of the inventory and condition data available for the pavements in a given system. Also, because the information pertinent to the pavements is stored in a single database, it becomes significantly easier to access. Thus, a major benefit is that an APMS can provide a more efficient way to monitor the condition of the pavement system and to also outline any plans for M&R.

Another benefit of an APMS is that it can be used to examine deterioration trends of various pavement branches within the system, leading to the ability of predict future pavement conditions. With this in mind, an APMS can assist an airport in making cost-effective decisions about specific M&R treatments and their optimal timing while also understanding the long term impacts of the decisions being made leading, eventually, to improvements of the condition of the pavement system due to a more efficient method of allocating available funding.

The costs associated with an APMS include the costs to collect inventory data, to assess the condition of the pavements, to establish a pavement management database and to analyze the collected data. These aren’t one-time costs since the database must be updated to remain current. There are also costs associated with computer hardware and software as well as labor costs associated with those operating and maintaining the APMS. Training, both initial and refresher is another cost associated with an APMS.
The general structure of an APMS includes the following modules:

- **Airport pavement condition survey**
- **Pavement network inventory**
- **Database (airport pavement)**
- **Quality evaluation**
- **Strategies evaluation**
- **Conservation program**
- **Deterioration models**
  - **Economic analysis (Cost and sensitivity analysis)**
  - **Priorities optimization (Financing)**

**Figure 1 – Airport pavement management system general structure.**

Data acquisition and processing are essential components of an APMS. During this step, it is necessary to obtain objective, reliable, updated and organized by category data: inventory, traffic, pavement conditions and costs. The information required for each data category must be considered taking into account management needs for the optimal use of network infrastructures.

The database is the core management system, where data from various sectors are recorded and processed while it receives and provides information of various system components. The data include the values of several variables and factors that influence the behaviour of pavements as well as information on the network operation (maintenance, operation, accident and social costs).

After analyzing data from infrastructure condition survey at any given time, a quality evaluation is made, involving the analysis of various performance indicators and thus status parameters. The selection of these indicators may vary depending on the aerodrome characteristics and its size, type and flow of traffic it receives, weather conditions, etc.
Pavement deterioration models can predict its time evolution and allowed us to simulate various conservation strategies with the aim of achieving the "optimal" conservation strategy.

The cost analysis can prove to be quite complex so often, as a matter of simplicity, the cost analysis used in the road sector is frequently used in airport scenery. In this context, is common to consider two major groups: administration costs and user’s costs.

Administration costs include project cost, construction costs (initial costs), maintenance costs and residual value. The user’s costs can be more difficult to determine and are associated to aircraft operation costs, delay costs, accident costs, among others.

When intended to select one alternative among several resulting from economic evaluation, it is advisable to understand the effects produced by variation in cost factors. The identification of critical and very little relevant factors may be essential to distinguish between two similar alternatives.

Generally, one of the problems with which those responsible for airport administration is facing a shortage of financial resources to maintain the entire pavement network (or networks) with the desirable level quality, is often necessary make decisions about the branches to be benefited at the expense of other. Thus, is necessary to prioritize conservation interventions by the available resources and the benefits achieved.

Knowing pavement condition at each stage of life and it likely future development (from deterioration models), can be defined a number of types of conservation actions to apply in a given sequence and pavement life stage, according to the adopted conservation strategy. For the same pavement branch, alternative strategies are compared, leading to determining by the system the optimal strategy.

With the setting of conservation program, APMS cycle is completed. The conservation program defines the type of intervention, properly located in space and time, for each network branch and implementation details. Proper referencing along the network of conservation actions performed over time is essential for further studies as to evaluate performance.
Geographic Information System – GIS integrated with APMS

One of the major challenges organizations face today, including aviation organizations, is the ability to manage, share and update the available data efficiently and safely.

The use of GIS in airports has increased in the last years and a new management practice in aeronautical infrastructure is the combination of GPS with GIS technology in maintenance, enabling better coordination and management of aeronautical activities (McNerney, et al., 1995).

The integration of GIS with APMS subsystems can provide a variety of advantages, including:

- graphical display of maps containing the pavements network and pavement condition evaluation (for example, in terms of pavement condition index – PCI), for selected branches;
- graphical display of maps containing other important networks for pavement management such as: drainage networks, lighting and signs, markings, etc., and its characterization;
- graphical display and characterization of externalities (pollution, noise);
- generation of input files for APMS analysis modules, extracting relevant data from pavement evaluation;
- creating an interface between a GIS and APMS program, where GIS is used as a apron for the construction and operation of analytical models;
- graphical display of APMS analysis modules results and production of graphical output that can be included in APMS reports.

3. Case Study

The preparation of this work would not be complete if not properly supported by a case study. The choice fell on the national scene, particularly on Lisbon International Airport, the largest and oldest Portuguese airport for civil aviation.

Throughout this chapter is made is made a general description of the airport and presents relevant data to understanding the infrastructure and its operation. Focus also necessary aspects required for APMS operation in an airport with Lisbon characteristics, whenever possible, supported and documented by airport provided data.
The Lisbon International Airport is located 7 km north of central Lisbon and comprises a total of 516 hectares, of which 412 hectares belong to the municipality of Lisbon and the remaining 104 hectares to the municipality of Loures. The “Air Side” has approximately 1 500 000 m$^2$ of paved area which includes the tracks 03-21 and 17-35, with real magnetic orientation of 028° / 208° and 174° / 354° respectively, 42 taxiways and 16 aprons.

The commercial traffic is a large part of the existing movement numbers. From 1999 to 2009, it was found that commercial traffic on average represented 96% of all movements recorded, and only 4% of the traffic was not commercial. In 2009 accounted to 136,286 total movements.

Aircrafts A319 and A320 make up 60% of all movements recorded between landings and takeoffs in the various tracks.

In general, the runways and taxiways are in bituminous pavement. There are 16 aprons, most of which consists of concrete pavements, due to this material ability of withstand oil spills without degrading. Of these, only “80”apron, “versatile” apron and part of “70”apron, consisting of bituminous pavement.

**APMS Operation – Experience from Lisbon International Airport**

Because of the size and growing importance of Lisbon Airport in the international panorama, its administration felt the need to acquire an APMS with the aim of managing the relevant technical information to its responsibilities in this area.

The APMS *Airpave* allows storing data and assessing pavement condition based on gathered information from visual inspections. Through the registration of found degradation, is calculated the pavement service level from which is establish pavement degradation curves and identify the existing M&R needs.

The *Airpave* does not use an recognized international global index as PCI to assess the pavement condition (described in *ASTM D 5340*), however, like this, classifies pavements on qualitative and quantitative assessment of recorded surface degradation, even without resorting to any kind of measurement, but only based on visual perception.

The APMS works on a "base map" which are represented the airport operational areas. To facilitate maintenance and inspection activities, all pavements were cut into smaller analysis units in terms of their use (runways, taxiways, aprons, and peripheral pathways), class (flexible, rigid) and M & R activities that have been placed.
After obtaining and loading data from visual inspection can be seen the network status through color maps that express the condition of each section based on the F (functional), W (wearing) and S (structural) parameters. Maps give the immediate perception of branches / sections whose network level service is above or below the limit value indicated.

The software has a menu “M&R Strategies” where it’s made the selection of the more appropriate repair work in a particular situation, at the same time that are simulated theoretical condition (degradation) curves of pavements over time. These curves are affected by registered degradations during inspection and by M&R choices made by the user. An excel sheet shows the curves F, W e S (Figure 3.1). Default level service serves as a reference to the conservation strategy to be adopted.

Reach the optimal solution implies evaluate various financial scenarios and choose one that maximizes the investment compared to any restrictions imposed. This analysis, among many things, presuppose a database with all information related to materials commonly used in M & R works, the individual and total cost for each one of the techniques used in order to arrive at an estimate.

The financial module of Airpave has not been explored by the ALS maintenance department. The consumption of time and human resources required (currently involved in other projects) for meeting all the information and loading database has postponed its use.

![Airpave pavement condition (degradation) curves, expressed in terms of the parameters F, W and S.](image)

Figure 2 – Airpave pavement condition (degradation) curves, expressed in terms of the parameters F, W and S.
4. Conclusions

The growing volume of information in a pavement network leads to a necessity of having an efficient processing of data (alphanumeric and graphics) system and quick query speeding the making decision process.

In this field, APMS represents a concrete opportunity to move from a traditional maintenance system, almost based on problems correction, for a planned maintenance system that pavement actions covers, not only the solve of immediate problems, but also a preventive work that extends life-cycle and guarantee minimum standards of service throughout the network.

When a pavement management system is implemented gives up an objective and effective guidance to the various activities involved in maintenance, furthermore it is possible to monitor and promote planning and purchasing information, documentation required for each of the tasks scheduled making them formal and helping the feedback process between them.

It is understood that the contribution of an APMS in supporting decisions depends largely on the quantity and quality of information available in the database and should therefore be given special importance to the type and volume of data needed for its smooth functioning. Unless it is a strategic choice by the organization, it should be noted that an incomplete or outdated database can compromise the system, and even derail the investment made in its implementation.

As important is to get a APMS as objectively define the way in which it is implemented and operated by tracing out the requirements necessary for its proper functioning, the organization specific needs, cautioning the possibility of future development and ensuring its integration with other projects and existing systems. Furthermore, should not lead to the creation of information islands, but the necessary transversality within the organization. Not only is it important to increase the pavement life cycle as the life cycle of the APMS, enhancing the financial viability of both.
5. Bibliography


guilhemino-rodrigues/1154865-1728.html.


