

# Airport Information Systems—Landside Management Information Systems

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## Abstract

Research on the intersection of the areas of aviation and management information systems is sparse. Just as within other economic sectors, members of the aviation sector must incorporate new and existing technologies as they grow to maintain their competitive edge whether in aircraft systems, airports or other aerospace and aviation related industries. A proper classification is a prerequisite to systems alignment. This paper reviews landside airport information management systems, and their connections and interoperability with other systems and who the key airport users are. The information presented in this paper is based on interviews and data collection at a number of representative airports across the United States. Airport size and function are key considerations in the acquisition of information management system airside or land side. The implication is that not all airports are equipped in the same manner and therefore these systems can only be considered as representative of what exists “on the ground”. This paper represents a point of departure or a reference for those researchers interested in a more in-depth study of airport information systems on the landside.

## Keywords

Airport, Aviation, Management Information Systems, Landside

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## 1. Introduction

As airports are becoming increasingly important to cities and regional economic viability, they are also becoming global business hubs. In some parts of the world, entire cities or fully-functioning suburbs are being developed around airports to include residential, retail and other commercial entities. As centers of not only air travel,

but other types of commercial activity as well, airport infrastructure management has come to include the coordination and management of a myriad of systems and services designed to support an increasingly complex constellation of airport operations. This may include everything from airport parking and ground transportation, security and logistics of landside operations, custodial services, transportation systems integrated with those outside the perimeter of the airport, and interfacing with governmental and industry agencies. Typically these operations involve the movement, analysis and use of data and information processed by information systems that support convenience and comfort within the airport environment. These systems are operated either by airport employees or by contractors on behalf of the airport.

Not only is research into the landside management scarce, but basic descriptions of landside components of airport management are not generally available. The purpose of this paper is to contribute to the body of knowledge by providing descriptions of airport landside management information systems, their interoperability with other systems, and the key uses and users of each system. There are many types of management information systems and they can be organized or classified in a number of different ways [1] [2]. Furthermore, each system may or may not be necessary for a particular airport depending on the business goals and objectives and the certificate the airport is operating under. Consequently, the system classification schema presented in this paper is neither all-inclusive nor exclusive; however, a number of leading aviation practitioners, business professionals, and educators in the industry are instrumental in both proposing and validating the schema. The study used interviews, documentations, and observations as the primary sources of data. This paper is concerned with key Airside Management Information Systems.

The landside management information systems discussed in this paper include: Asset Management System, Computerized Maintenance Management System (CMMS), Vertical Transportation Monitoring System, Building Management System (BMS), Electrical Monitoring System and Environmental Management System [1].

## 2. Methodology

This study uses qualitative methods to elicit data related to the classification and use of Landside Management Information Systems. The study collected data using observations, interviews, and document analysis. Twenty-one extensive interviews were conducted with senior airport officials and IT directors from four US international airports and aviation faculty in Embry-Riddle Aeronautical University. A systematic search for the entire data corpus was conducted and data categories were created. Constant comparative method of data analysis was used (Merriam, 2001). The constant comparative method is a technique often used in the grounded theory tradition of qualitative research. It involves systematic search and arrangement of field notes and other data accumulated into categories in order to increase the understanding of the situation. In reviewing the field notes, the researchers generated and tested assertions by looking for key linkages and conducting member checks.

## 3. Asset Management System

The Asset Management System encompasses the software-based applications used to schedule and manage airport assets and resources. An airport is a complex dynamic system constantly interacting with internal and external forces. This necessitates efficient management of airport assets and resources 24 hours a day, 365 days a year. To meet this challenge, airport operations managers depend on automated systems to track and manage assets and resources. These software systems also may provide the tools to view resources from life-cycle perspectives, an invaluable function in achieving a high level of operational efficiency. Tracking resources from the purchase date or implementation date until the disposal or decommission date provides cost visibility, a vital aspect often overlooked or miscalculated in operational budgeting.

Airport assets are both widespread and diverse due to their varying nature, mission, and role within the airport organization. An Asset Management System allows an airport operator to create an asset management plan describing the long-term strategy for the best use of each asset; thus, defining the value of the asset throughout its life-cycle. This information allows an operations manager to act proactively, as opposed to reactively, in maintenance decision making.

Labor-intensive work must be scheduled, tracked, documented, and reported. An Asset Management System facilitates these tasks by allowing airport staff to schedule and track authorized jobs and projects by individual maintenance activities, location, and assigned crew. The system is also capable of accounting for contractor activities and total cost associated with each function or activity.

Some common commercial-off-the-shelf (COTS) Asset Management Systems include the American Association of Airport Executive (AAAE) Spatial Airport Asset Management System, IBM's Maximo System, and AxisFM Facilities Asset Management software. These types of COTS systems aid accurate forecasting of future needs for capital-planning projects and expansion planning for accommodating larger aircraft and similar strategic decision making.

The software interface allows the user to log into the system and select the desired operational function. Based on this selection, the user can work in any area such as preventative maintenance, capital planning, facility-asset life-cycle management, or project management. From there, the software allows the user to update assets, start the planning process for a new capital project, or create reports on asset usage and resource status.

Asset management software tools are used to help identify avenues for cutting costs, conserving energy, and using equipment and resources more efficiency. Their use is critical to the success of all dynamic business organizations, especially airports, because improved capital planning and decision making leads to savings by reducing operational and maintenance costs and increasing equipment longevity.

The primary users of the airport Asset Management System are airport facility managers and maintenance and operations personnel who schedule the use of assets and service jobs. Additional users include airport operations and financial accounting personnel who access the system to produce daily reports for billing completed jobs and using resources. Secondary users include airport tenants, such as the airlines leasing space and using airport facilities, as well as passengers and visitors who use airport and airline resources.

The management information connections and interfaces for asset management systems encompass the computer systems used to manage airport resources. The software may consist of independent applications with either direct connections or software modules that integrate with airport applications, such as a module from a larger airport operations program (e.g., Enterprise Resource Planning [ERP] package, CMMS, Business Management System [BMS] application). Key functions include adding new assets and tracking asset locations, associated values, and similar activities or uses of resources.

Common hardware for the Asset Management System includes servers to host the application and workstations for user interface. Additional equipment could include scanners and bar code readers for asset tracking, RFID tags, and other inventory tracking devices.

The Asset Management System may be run on the airport's existing network or may be hosted by the software vendor contracted by the facility operator to maintain and run the system. In this latter case, the facility operator usually provides a connection to the airport's network or provides workstations that allow system users to log in to update and monitor their assets.

The asset management program may be attached to an ERP when both share an existing database or it may be attached to a separate database such as SQL<sup>®</sup> or Oracle<sup>®</sup>. Data stored in the database include information on the airport's assets, personnel, equipments, facilities, systems, utilities, financials, and management plans. Data input into the system are used for scheduling, planning, forecasting, and budgeting.

Airport IT employees maintain the network and equipment that operate the Asset Management System. They also manage the installed software application and they serve as IT administrators providing access rights and performing preliminary or basic system troubleshooting.

#### **4. Computerized Maintenance Management System (CMMS)**

The Computerized Maintenance Management System (CMMS) is the software-based system used to enhance efficiency of operations in areas such as inventory management by maintaining a database of maintenance information related to an organization's operations.

In general, having the ability to operate efficiently at peak capacity over time is how many organizations gain a competitive edge over their competitors. Airports are large facilities with hundreds of complex systems that must operate in the most efficient manner possible to minimize costs while providing the high level of service expected by passengers and visitors. A CMMS enables an airport of any size and category to provide the degree of comfort and convenience expected by its customers. As with the Asset Management System, the CMMS facilitates greater efficiency in operating procedures, improves inventory management, and reduces costs associated with maintenance labor and operations.

The CMMS is capable of integrating considerations of facility maintenance into a single software package. However, to be most effective, the CMMS must include all resources that will interact with the system. There-

fore, the CMMS operator must account for all systems, equipment, and inventory owned or operated by the airport. The software provides the flexibility for tracking not only equipment but also facility assets such as electrical outlets, network drops, building lighting, HVAC controls, and much more.

Definitions of resources vary according to the type of system. Generally speaking, airport resources refer to any equipment or assets that provide value whether the value is realized now or sometime in the future. Therefore, airport resources include equipment, hardware and software systems, personnel, and physical buildings and areas. The resources in the CMMS also include human capital that can be allocated to perform scheduled and unscheduled projects or jobs. The CMMS provides the ability for facility operators to track human resources by trade and skill level, which aids in tracking labor costs against the particular work order and equipment used.

Inventory control is defined simply as knowing what is currently readily available and what needs to be available for unplanned events. As such it is an important aspect of any effective maintenance facility program.

The CMMS allows facility managers to track inventory levels and set alerts and notifications for replenishment when stocks fall to predefined levels—all in real time. The system also allows facility operators to link inventory to assets, ensuring that spare parts are available when needed to prevent or minimize asset downtime. Some software packages even allow inventory records to be linked with external parts vendors and equipment suppliers for automated ordering of scheduled projects to ensure parts and equipment are available until the project or job is completed.

Since planning is essential for maximum efficiency, and a plan allows for the proper scheduling of resources, equipment, inventory, and time, the CMMS allows airport facility operators to schedule preventative maintenance days, months, and even years in advance. This is invaluable for efficient allocation of resources.

Consider, for example, the addition of a new terminal building in an airport. The airport facility manager enters information related to new systems into the CMMS along with the manufacturer's recommended preventative maintenance tasks and schedule. The manager uses the CMMS planning tool to determine what resources will be needed in the future and then the tool determines what those resources will cost going forward. The manager uses this information to project budgets, staffing levels, and other needs for contracted work.

Work flow management is important for all airport systems requiring maintenance, whether scheduled or unscheduled. Parts wear out, systems fail, and preventative maintenance tasks are ongoing. It is simple to assign a repair task when a system fails by notifying maintenance crews of the problem and directing them to make needed any repairs. However, this kind of reactive maintenance process is usually inefficient, costly, and time consuming. As mentioned, efficiency is paramount to running a high-performing airport focused on ensuring its customers and visitors are safe and satisfied with the facilities and services. The CMMS allows facility operators to plan and track both scheduled and unscheduled work-flow tasks with minimum effort. It provides access portals for the entry of system failures and requests by authorized users. Based on the requests entered into the system, the CMMS generates a work schedule that includes assets, inventory, equipment, projected job times, and qualified work crews and it provides important job-flow status updates to primary users and maintenance management personnel.

System reporting is probably the most valuable tool of any CMMS, because it provides analytical reports to airport facility managers. The various CMMS tracking and reporting tools provide facility managers data on operational costs, productivity, asset repair history, equipment downtime, and safety compliance from a systemic perspective. These data are the key performance indicators that enable the airport facility manager to determine if adjustments need to be made in resource allocations, equipment, or processes to improve efficiency.

Reports help the airport facility manager justify repair-or-replace decisions with downtime analysis and cause-of-failure tracking information that can guide the setup of preventive and predictive maintenance programs to optimize asset and labor performance. The CMMS can also help the facility manager schedule, track, and record equipment inspections for safety and environmental compliance. Federal or state regulations often specify how systems must operate and the CMMS can provide the documentation to support compliance with any and all regulations.

It is important to note that a CMMS may be comprised of software modules purchased and implemented separately or purchased and implemented as an entire suite of applications. The software provides a number of tools that automate processes and provide data on performance, reporting parameters, resources, and assets for multiple systems. Data analysis capability allows the airport facility manager to instantly see performance levels and create life-cycle analysis processes for airport systems and assets. The facility manager is able to improve decision-making processes with real-time data and provide valid justification in budgets and other reports for needed

expenditures. Together these CMMS functionalities improve efficiencies and reduce costs.

The primary user of the CMMS is the airport facility manager, relying on the CMMS to run the environmental systems, track equipment, schedule maintenance and repair work, and facilitate maintenance operations. Additional users include the airport maintenance workers.

The CMMS information management connections require computer software to control processes and provide performance indicators for improving processes and decision making. CMMS software applications are similar to asset management software in that they allow tracking and support of separate maintenance functions, but they differ in that the CMMS software modules are proprietary. The vendor performs any needed software modifications and updates, but the system users set the permissions for daily access and perform updates to the system database (*i.e.* input information on assets).

The particular hardware components composing the CMMS are designed based on the how the airport chooses to host the CMMS application. In-house applications are installed on traditional network servers that run the software applications on airport workstations. Additional hardware may include mobile devices and similar hand-held devices, bar code readers, and printers that interface with the CMMS software.

The CMMS can operate on the airport's LANS or WLANS with connectivity to other systems such as the Restricted Access Control System, BMS, CCTV System, Fire System, Revenue Management System, and other airport systems. It can also be hosted online through a SaaS provider. In this latter case, the airport pays a fee to use the CMMS as a Web application, but in so doing avoids the expense of purchasing and installing CMMS hardware and software.

The CMMS application usually requires a relational database management system (RDBMS) database. The type of stored information varies by airport and the data deemed relevant to airport operations. In most configurations, the database includes object tables for storing information on equipment, tools, facilities, vehicles, employees, schedules, utilities, systems, schedules, maintenance plans, schematics, inventories, customers, vendors, assets, and work orders.

Airport IT employees maintain the CMMS when it is hosted by the IT department. Their duties as system administrators include granting access rights, installing updates, performing database administrator duties, and ensuring the system runs efficiency over the network. If the system is Web hosted, they provide firewall access to the vendor hosting the site in addition to their other system responsibilities.

## 5. Vertical Transportation Monitoring System

An airport's Vertical Transportation Monitoring System assists the movements of passengers, visitors, employees, equipment, and supplies between the various levels and areas of an airport. It includes the software applications or modules used to monitor the status and performance of all elevators, escalators, and moving sidewalks in airport terminal facilities.

Elevators and escalators require monitoring for both safety and security because of the possible endangerment from mechanical malfunctions or security breaches involving unauthorized access to integrated airport control systems.

Many airports integrate elevator monitoring into their Building Maintenance System (BMS). Primary monitoring of elevators, especially newer elevator systems, is usually contracted to companies specializing in elevator installations and repairs. These companies provide elevator system status to the airport's facility monitoring system through data reporting and direct connections to the airport's BMS. They provide status-monitoring points that allow detection of elevators that are out of tolerance when halted (perched between floors). The monitoring system provides the operational status of all monitored elevators and provides alerts when any elevator makes an inappropriate stop or experiences an unexpected delay (Elevator cabs have panels with buttons that enable emergency calls for assistance and notification of mechanical problems via the monitoring system.).

Elevator and escalator monitoring systems are mechanical devices capable of reporting status and performance efficiency to facility managers. Generated data allows managers to track the hours of usage to determine the most appropriate and the cost effective preventative maintenance schedules to maintain peak operational efficiency. However, because of the specialized maintenance and repair requirements of elevator systems, airport facility managers contract with qualified outside vendors to maintain and monitor this system.

Primary users of the Vertical Transportation Monitoring System are airport maintenance employees and contracted service technicians. Secondary users include passengers, airport employees, and airport visitors. The

management information connections for the system include the electrical connections that relay the operational status of each mechanical system to the Vertical Transportation Monitoring System. Software from other integrated airport systems (e.g., Restricted Access Control System, BMS, and Fire System) receives status conditions and is also capable of controlling system operations.

There is no hardware equipment in terms of the airport's landside management information connections. Computer hardware such as servers and workstations are located at the company contracted to monitor and service the system; nor are there any networking components or database software applications installed landside. Consequently, the airport's IT department is not involved with the software installation, operation, or maintenance of the Vertical Transportation Monitoring System.

## 6. Building Management Systems (BMS)

The Building Management System (BMS) includes interoperable intelligent systems, devices, and points that monitor and control an airport's electromechanical systems for automatic doors, facility lighting, power, smoke and fire detection, and environmental conditions. The BMS connects to the mechanical systems that monitor and control the operating status and performance of certain airport systems such as the Electrical Monitoring System, Environmental Management System (e.g., carbon dioxide sensors), and the HVAC System (*i.e.*, heating, ventilation, air cooling/conditioning). It is configured to control the airport heating, cooling, and ventilation systems for multiple areas of the facility. Each of the component systems is programmed to automatically control (turn on and off remotely) system fans and heating elements and open and close vents and dampers to maintain the programmed facility temperature and airflow. The system also controls the Facility Lighting System, activating lighting in specified areas based on programmed utilization schedules.

The BMS employs Programmable Logic Controllers (PLC) configured for each monitored system. Controllers are computer units that have input and output capabilities. The PLC units are installed between the host BMS and the systems to be monitored and controlled. The input and output capabilities allow a PLC to transmit and receive instructions from the BMS host computer to the monitored system based on facility conditions or changes in conditions of the monitored system. A PLC also receives information from the monitored system and transmits it back to the host computer for status updates.

The BMS provides operating status to key users, keeping them informed of current performance levels, and alerting them to system outages. Once logged into the system, a user interfaces with the GUI to adjust the settings for the lighting, HVAC, or ventilation systems. Users are also able to monitor these interoperable systems through a dashboard that presents real-time system status and performance. The BMS can also be connected to the Vertical Transportation Monitoring System (e.g., elevators and escalators) for monitoring performance, detecting outages, and providing data for calculating reliability percentages and downtime statistics when analyzing system performance. In addition, the BMS can be connected to the Restricted Access Control System, CCTV System, and Fire Alarm System. Some of these systems also allow airport operators to submit work orders for repair and service calls; thus, reducing labor requirements by automating job functions and reducing costs by maintaining optimal efficiency levels of these systems.

Primary users of the BMS are airport maintenance employees and contracted service technicians. These individuals ensure the component systems operate efficiently based on preprogrammed parameters.

The BMS controls airport facility systems that provide a safe and comfortable environment for everyone inside airport buildings and facilities. Therefore, secondary users include employees, passengers, and visitors occupying the airport facility.

The BMS management information connections require software applications that integrate numerous facility control and monitoring systems. Software applications such as COGZ and Manager Plus allow users to work within different functional areas or modules of the application. The modules may be dedicated to work order requests, equipment assets, inventory control, purchasing, or other functions depending on the interoperable systems and their particular configurations. The software application may be hosted on the airport's central control server or can be a Web application hosted by the software vendor that provides access to key airport users via Internet connections to the web.

Hardware required for the BMS includes configured workstations, control modules, status monitors, system servers, and processors. A series of integration computers are installed between the various systems' host computers and the BMS server to allow the system to monitor and control all connected systems. The BMS can be

set up to use either the LANS provided by the airport or the LANS provided by the facility operator who is contracted to manage the BMS. In both cases, systems connected to the BMS communicate over the LANS for instructions and status reporting. The BMS includes a database such as SQL<sup>®</sup> server to store asset information, program configuration, and work schedules. The BMS receives data from the monitored systems and transmits instructions to those systems based on preprogrammed instructions and changes in conditions of the facility or system. Reporting from the system allows for adjustments in system operating levels based on the settings stored in the BMS database. Reports also provide historical information that can be used for system life-cycle analysis, which is essential for determining replacement priorities. The BMS also can be integrated with the CMMS and the Asset Management System for allocating airport resources and equipment for systems in need of maintenance or repair.

Airport IT employees may serve as system administrators for the BMS, ensuring the system stays operational and accessible to maintenance employees. These personnel update and maintain the BMS database after the vendor installs the system. The BMS relies on connectivity to field devices that may run on the airport's LANS maintained by the IT department. In some cases, the vendor or outside contractor provides the system administration.

## 7. Electrical Monitoring System

The Electrical Monitoring System, an interoperable system with the BMS, encompasses the devices that monitor and record the current and voltage levels of powered systems. Energy expenses are roughly 10% to 15% of annual total operating budgets for airports [3]. So it is no surprise that airports consume an enormous amount of electrical power on a daily basis. Electrical power is required for every building, all runways and taxiways, access-controlled gates, parking lots, and all other areas on and in an airport. Indeed, airports are one of the largest consumers of electrical power in most cities and, in many cases, entire states. Visiting an airport at night or during inclement weather provides obvious visual evidence of this fact.

An airport must meet FAA requirements for maintaining adequate airfield lighting even if a small percentage of lights are not operating for some limited time. Several monitoring systems are vital to keeping this lighting system operating as required on a continuous basis.

Internal electrical systems are commonly monitored by the airport BMS. After load requirements are calculated through planning efforts, the Electrical Monitoring System ensures necessary load factors are met and the correct voltage is supplied based on the systems being powered by electrical circuits. Typically, electrical systems, especially critical systems such as the Restricted Access Control System, Airfield Lighting System, Fire Alarm Monitoring System, and their emergency backup systems are monitored by multiple software systems to ensure the correct voltage is constantly being supplied.

The Electrical Monitoring System has point connections between electrical substations and the electrical-monitoring software. Most of the connections contain some type of metering device, transmission medium, and interface software. Data are transmitted from the metering device to the software interface that displays current and voltage levels of the system. The Electrical Monitoring System increases efficiency by (a) minimizing wasted energy; (b) improving system performance by improving reliability percentages; and (c) providing data analysis for planning system usages and accommodating high-use periods. Furthermore, it improves safety by ensuring systems are shutdown prior to scheduled and unscheduled maintenance work.

The software application allows users to monitor the real-time status of electrical circuits and load levels as graphical representations. The software also allows users to monitor electrical-related accounting functions such as cost allocations, consumption costs, energy audits, and unit allocations. Primary users depend on such data to (a) ensure correct power loads in the system; (b) make adjustments to improve operating efficiencies; and (c) forecast future electrical needs based on the projected energy consumption of the different systems reporting to the system. Rising electrical utility prices are beyond the control of airport operators; consequently, finding more efficient means to reduce electrical power consumption is the primary component to reducing operating costs of electrical systems. Airport operators also use the data collected by the Electrical Monitoring System to pinpoint when and where electrical power is being used so appropriate charges can be applied and to ensure the correct power loads are supplied based on projected needs.

Primary users of the Electrical Monitoring System are airport maintenance employees and contracted service technicians. These individuals review data output from the system to ensure electrical requirements are met on a

continuous basis. Secondary users include accounting personnel, facility operators, and the IT employees monitoring system loads for voltages to the airport IT systems.

EMS management information connections require connection to the electrical provider's electrical power network. Airport electrical power is supplied by utility substations and is then distributed to the airport facilities to support the various electrical systems. Airport facility managers, engineers, and electricians monitor computer-based systems installed by the electrical provider to ensure the correct voltages are maintained at all times. Software applications such as Power Xpert Energy Viewer by EATON show energy consumption from all of the airport systems in a summary report. The Electrical Monitoring System may also include a Web-based application allowing key users to monitor system status via an Internet Web browser.

The EMS management information connections also include computer servers and workstations used for data acquisition and system monitoring. Other hardware includes the various field devices that regulate power coming into those systems. These systems can be connected directly to the airport LANS for distributed monitoring, or connected to a separate LANS for the electrical power system, or delivered via Web-based connections. Electrical systems use network equipment designed specifically for each system. Additional connections include gateways, Ethernet switches, addressable relays, network translators, power UPS cards, and other devices necessary to connect the various field devices to the system.

The system databases store information on the connected equipment and the power consumed. The relational database GUI has object tables and fields for the substation equipment and reference tables for the Institute of Electrical and Electronic Engineer (IEEE) standards for voltages and circuit addresses. Data are displayed as histograms for voltage usage to graphically depict irregularities in electrical currents.

Airport IT employees have monitoring capabilities for the purposes of monitoring power for IT related systems. This is especially important for monitoring power to the Network Operations Center, computer server rooms, and UPS systems. The IT personnel grant access to airport's networks for data delivery from the electrical utility systems to all of the integrated airport systems.

## 8. Environmental Management System

The Environmental Management System, an interoperable system with the BMS, encompasses the network of sensors and monitoring and control systems that record and report environmental conditions in the airport environment.

Airports pose major concerns for the environment. Because they operate as small self-sustaining cities, they create environmental waste and air pollution that has the potential to affect the public health and safety of the inhabitants of the surrounding communities and businesses. Airports receiving Federal grant monies are required to implement programs to reduce noise levels and relocate non-airport properties exposed to unavoidable unsafe noise levels. Title 14 C.F.R. Part 150 requires commercial airlines to comply with these criteria to be eligible for grant funding.

a) The noise at an airport and surrounding areas covered by a noise exposure map must be measured in a weighted sound pressure level (LA) in units of decibels (dBA) in accordance with the specifications and methods prescribed under Appendix A of this Part.

b) The exposure of individuals to noise resulting from the operation of an airport must be established in terms of yearly day-night average sound level (YDNL) calculated in accordance with the specifications and methods prescribed under Appendix A of this Part.

c) Use of computer models to create noise contours must be in accordance with the criteria prescribed under Appendix A of this Part.

Many airports have programs and departmental units dedicated to noise abatement and environmental compliance. These units prepare or oversee the preparation of air quality, groundwater remediation, National Environmental Protection Agency (NEPA) requirements, and noise compatibility programs. They also handle environmental permits or documents and aircraft noise complaints, and serve as advocates of environmental friendly (*green*) programs such as materials recycling and water conservation. The unit administering the noise compatibility program handles property acquisition and resident relocations.

There are various sensor networks with microphones installed at distances specified in the airport's noise abatement map. These sensors record surrounding sounds in decibels to determine if the emissions from arriving and departing air traffic are within the acceptable exposure limits for nearby residents and businesses. Adminis-

trators use software applications to analyze the data collected from the field-sampling devices from the different environmental systems monitoring air and water quality and noise levels so they can adjust the mitigation programs and policies to limit unsafe exposures as necessary. For example, computer software applications such as the Brüel & Kjør Airport Noise and Operations Management System (ANOMS) identify and track active noise, patterns, and specific areas of unhealthy noise levels. Computer-based simulation models can be run to determine projected noise levels based on aircraft activity, wind direction, and distance from runways, taxiways, maintenance facilities, and terminal buildings. Information generated from simulations help airport administrators determine the potential need to purchase surrounding properties under the airport's noise abatement program to use for activities conducive to airport operations. Key users of the Environmental Management System include airport environmental engineers, noise abatement officers, airport property appraisers and real estate agents, airport airside employees, and FAA personnel. Indirect users include occupants of businesses and homes located around airport property, and especially those in the direct flight paths of takeoffs and landings. EMS management information connections utilize software modules for airport noise and environmental monitoring in addition to separate applications dedicated to specific systems. Software applications developed by various equipment manufacturers for monitoring environmental compliance include COTS programs as well as customized software specifically developed to suit a particular airport's needs. Some of these software programs allow the airport to run a complete suite of applications within the program while others target a single environmental issue such as air quality. For example, Adaptive Data Modular Systems (ADMS) measures air quality and emission levels around an airport and collects data on the different sources of air pollutants from aircraft, ground vehicles, and commercial industries surrounding the airport.

Hardware connections for the Environmental Management System include field-monitoring devices that measure noise, carbon emissions, and levels of certain chemicals originating from airport operations and any industries operating around airport property. Data recorded by these monitoring devices are imported into the computer servers and workstations running the airport's environmental engineering software.

Data from field devices are transmitted through portable connections or through wireless connections to the host computer. Some of the monitored systems may include field devices that communicate to SaaS vendors via wireless devices. In such cases, the vendor hosts the software application via a Web-based connection accessed over the airport's ISP. The vendor's relational database stores the data collected from the monitoring equipment deployed in the field along with information on GIS mapping locations, Federal standards, known sources of pollutants, key personnel, and all system users.

Depending on the installation setup, airport IT employees maintain the software program when it is loaded on the airport's servers or they maintain the Internet connectivity needed for Web-based applications. They also provide firewall access and system maintenance for most of the hardware equipment and software services. In some instances, they also maintain the database and provide database access to commercial vendors of the airport's environmental systems.

## 9. Conclusion

Airports use a myriad of systems to support their operations. Many of those systems incorporate software, database, and network components. They generate both on-demand and regular reports to assist airport management, improve operations and reduce cost at the same time. For airports, to become more effective and efficient in their operations, they need to understand the competitive advantage of these systems and how to align them together to better serve their stakeholders. This paper provides a possible classification for airport landside management information systems and describes some of their use.

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