þÿAsset and Infrastructure Management for Airports Primer and Guidebook

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GHD Inc.

AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP REPORT 69

Asset and Infrastructure Management for Airports—Primer and Guidebook

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AIRPORT COOPERATIVE RESEARCH PROGRAM

Airports are vital national resources. They serve a key role in transportation of people and goods and in regional, national, and international commerce. They are where the nation's aviation system connects with other modes of transportation and where federal responsibility for managing and regulating air traffic operations intersects with the role of state and local governments that own and operate most airports. Research is necessary to solve common operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the airport industry. The Airport Cooperative Research Program (ACRP) serves as one of the principal means by which the airport industry can develop innovative near-term solutions to meet demands placed on it.

The need for ACRP was identified in *TRB Special Report 272: Airport Research Needs: Cooperative Solutions* in 2003, based on a study sponsored by the Federal Aviation Administration (FAA). The ACRP carries out applied research on problems that are shared by airport operating agencies and are not being adequately addressed by existing federal research programs. It is modeled after the successful National Cooperative Highway Research Program and Transit Cooperative Research Program. The ACRP undertakes research and other technical activities in a variety of airport subject areas, including design, construction, maintenance, operations, safety, security, policy, planning, human resources, and administration. The ACRP provides a forum where airport operators can cooperatively address common operational problems.

The ACRP was authorized in December 2003 as part of the Vision 100-Century of Aviation Reauthorization Act. The primary participants in the ACRP are (1) an independent governing board, the ACRP Oversight Committee (AOC), appointed by the Secretary of the U.S. Department of Transportation with representation from airport operating agencies, other stakeholders, and relevant industry organizations such as the Airports Council International-North America (ACI-NA), the American Association of Airport Executives (AAAE), the National Association of State Aviation Officials (NASAO), Airlines for America (A4A), and the Airport Consultants Council (ACC) as vital links to the airport community; (2) the TRB as program manager and secretariat for the governing board; and (3) the FAA as program sponsor. In October 2005, the FAA executed a contract with the National Academies formally initiating the program.

The ACRP benefits from the cooperation and participation of airport professionals, air carriers, shippers, state and local government officials, equipment and service suppliers, other airport users, and research organizations. Each of these participants has different interests and responsibilities, and each is an integral part of this cooperative research effort.

Research problem statements for the ACRP are solicited periodically but may be submitted to the TRB by anyone at any time. It is the responsibility of the AOC to formulate the research program by identifying the highest priority projects and defining funding levels and expected products.

Once selected, each ACRP project is assigned to an expert panel, appointed by the TRB. Panels include experienced practitioners and research specialists; heavy emphasis is placed on including airport professionals, the intended users of the research products. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, ACRP project panels serve voluntarily without compensation.

Primary emphasis is placed on disseminating ACRP results to the intended end-users of the research: airport operating agencies, service providers, and suppliers. The ACRP produces a series of research reports for use by airport operators, local agencies, the FAA, and other interested parties, and industry associations may arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by airport-industry practitioners.

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FOREWORD

By Marci A. Greenberger
Staff Officer
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This report provides a primer and guidebook for airport managers and staff on asset and infrastructure management applicable to all areas of the operation of an airport. The report begins with a primer for executive-level staff. The primer offers an overview of an asset and infrastructure management program and the benefits and costs of implementation. The guidebook provides examples from various airports and is designed to be a reference for integrating proven asset and infrastructure management practices and techniques, at airports of all sizes. The guidebook defines an asset and infrastructure management program and its components and how a program relates to daily operations and longer term planning. In addition, a PowerPoint presentation, which can be used to present the benefits of a program to stakeholders, is available on the TRB website and can be found by searching on the title of the report.

Asset and infrastructure management is commonly used by organizations around the world to coordinate the safe, secure, and environmentally sound lifecycle management of assets in a cost-effective manner. With the limited resources that airports are typically facing, airport managers are constantly looking for more efficient and effective ways to manage infrastructure over time. Asset and infrastructure management can be one such tool—this type of systematic management approach promotes the efficient use of resources in a proactive rather than reactive decision-making process and provides data and information in an integrated manner. Some airports have at least one or a few asset management systems. Typically, the systems operate independently of one another and are sometimes in different departments. If the departments operate in silos, they do not necessarily configure systems to capture asset performance information using the same guidelines. This deprives senior management of the opportunity to use centralized information to make strategic, capital planning, and financial decisions.

Asset management has evolved over the past several decades from a maintenance management focus, to include renewal planning, and on to the current holistic approaches described in current specifications and manuals. This approach requires the integration of processes across airport departments to align decision making in a common direction toward the achievement of the airport strategic objectives and key performance targets.

GHD's research included speaking with personnel from and obtaining information on asset and infrastructure management programs at airports, domestically and internationally, as well as from organizations outside of the aviation industry. Readers will find many different and practical examples illustrated in the guidebook applicable to their airports and the guidance provided will help users put together an enterprise-wide asset and infrastructure management program, regardless of the size of the airport and/or their resources.

CONTENTS

Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the Web at www.trb.org) retains the color versions.

PART 1

Asset and Infrastructure Management for Airports—Primer

PRIMER CONTENTS

Asset and Infrastructure Management for Airports—Primer

Why Asset Management for Airports?

Evidence from other industries shows that an asset management way of doing business allows us **to do more with less** and to

- Make better investment decisions,
- Align managers, decisionmakers, and workers to a common purpose to seek solutions and make decisions that result in the best economic, service level, and risk exposure outcomes,
- Improve flexibility to respond to changes in the regulatory and commercial environment.

The following significant benefits have been achieved:

- A 13.5 percent increase in pavement life (Hudson et al., 2001) and
- Pavement levels of service maintained with a 30 percent cut in budget (Falls et al., 1994).

Port Authority of New York and New Jersey, "To provide the consistently high levels of service that the region requires, the Port Authority spends nearly $1 billion annually to maintain the region's ports and airports bi-state bridges, tunnels, and rail facilities in a state of good repair. . . ."

". . . using systematic asset management to ensure cost-effective use of capital resources, replacing aging facilities based upon economic lifecycle analysis to avoid failures of operational facilities while minimizing unnecessary maintenance costs . . ."

What Can Asset Management Do for You?

CEO and Board—Better understanding of future needs to service customers competitively.

Budget and Finance—Reduce unforeseen post-budget capital needs; provide 10-year and beyond forecast of capital, operations, and maintenance needs; allow establishment of price paths to address changing infrastructure investment needs.

Planning Manager—Incorporation of planning requirements for infrastructure and assets in airport asset management plans.

Engineering Manager—Greater lead time on project work load, processes for continuous improvement in design and construction standards, improved engineering records, data and knowledge management.

Operations Manager—Support for, and focus on, achieving operating efficiency and effectiveness, and service level outcomes.

Maintenance Manager—Increased support for improved maintenance processes and practices.

Environmental Manager—Awareness of the environmental consequences of infrastructure failures and ability to pre-plan mitigations.

Information Technology Manager—Greater awareness and understanding of the specific system functionalities needed to support the business.

Primer Overview

A confluence of changes in the aviation industry is driving U.S. airports to look to a range of strategies to maintain safety and customer service levels in the future. These changes include restriction on the availability of funding from federal, state, and local government for capital and other projects, the reduction in fuel tax income for general aviation airports due to growth in low-cost airlines, and the forecast increase in passengers and air cargo over the next decade.

This primer results from the investigation of the holistic integration of asset management processes, practices, and tools across the airport organization (public and private), as a means to improve the return on investment in airport assets and infrastructure, in terms of financial sustainability, risk exposure, and levels of service to customers and stakeholders.

The research findings, which include the review of standards and approaches, form the basis for the recommended approaches in this primer and the associated *Asset and Infrastructure Management for Airports Guidebook.* Additionally, best practices from sectors outside of aviation were identified.

Refer to Appendix A for best practice information for other infrastructure sectors including electricity, water, rail, and gas.

Primer Objectives

This primer outlines what asset management is and its relevance to airport executives. It summarizes what the airport executive needs to know and do to achieve ongoing value realization from investment in infrastructure management improvements within an airport organization, including

- Systems requirements;
- Governance and organization;
- Roles, skills, and competency requirements;
- Change leadership roles;
- Identification of value-adding improvement opportunities; and
- Benefits from the adoption of comprehensive asset management principles.

The distinction between the primer and the guidebook is best described as follows:

- The primer outlines the "what" and the "why" of asset management and is directed at executive staff.
- The guidebook summarizes the "how" and is directed at implementers.

Julieanne Alroe, CEO of Brisbane Airport, Australia, "One of the greatest benefits of asset management has been the ability to provide information to the Board on infrastructure capabilities and future needs—this type of knowledge is invaluable and is essential for making the best, justified investment decisions."

Intended Audience

Holistic approaches to asset management include the strategic, tactical, and operational functions of an airport. As such, the intended audience for this primer includes executives responsible for

- Strategic planning and master planning,
- Finance and capital planning,
- Airport planning,
- Asset management,
- Risk mitigation,
- Operations and maintenance, and
- Information technology.
- (Note: Airlines Advisory Board—Airlines approve Capital Funding/Projects—MII—Majority—In Interest)

The Asset Management Challenge

Infrastructure asset management has been evolving steadily as an approach to managing the whole-of-life-costs and performance of infrastructure for the last 20 years.

During this period, water, wastewater, gas, electricity, municipal, and road transportation asset owners began to recognize that infrastructure built during the post-World War II boom would be due for renewal in the near future, and would significantly increase the renewal rates that customers and rate payers were accustomed to funding. They recognized a shift from construction to a renewal and rehabilitation focus for infrastructure investment, coupled with a need to operate more cost-effectively, and to consider long-term financial sustainability, and intergenerational equity in investment decisions. This shift required new skills and competencies to integrate financial and technical strategic planning 20 years ago, to holistic approaches that are heavily driven toward realizing organizational strategic objectives today.

Airports and Asset Management Today

There have been sweeping changes in the ownership and management of airports over the past decade. A move to private ownership and regulatory monitoring of price and service levels has resulted in reorganization and a focus on the optimization of the management of physical assets at airports in the United Kingdom, Australia, and New Zealand. In the United States, airports have continued to be predominantly publicly owned during this period, with funding support from the federal government in the form of Airport Improvement Program (AIP) grants under FAA reauthorization acts, and Passenger Facility Charges (PFCs).

The forecast continued growth in passenger and cargo traffic indicates a continued long-term need for capacity expansion. Compounding this with the ongoing need to meet standards and manage aging infrastructure, there is an ongoing challenge for airport executives to secure funding and ensure financial and service-level sustainability in the long term. This challenge is leading airports to focus on

- How to do more with less and
- How to focus the business on customers and the cost-effective delivery of services.

Document Structure and Content Overview

After the primer's introduction, the primer is structured in the following two major sections:

From Asset Management Policy through Implementation of Asset Management Plans outlines the current standards and resources for asset management, the concept of a holistic strategy and objective-driven asset decision making, and the necessary process and activity linkages into existing strategic business planning processes and governance required to make it work. These sections outline the key enablers that the airport executives need to provide.

From Performance Assessment and Improvement through Putting It All Together deals with implementation needs and the concepts of continuous improvement, as part of a Plan–Do–Check–Act (PDCA) approach.

Introduction to Asset Management

Standards and Resources for Asset Management

Currently, there is no single standard in the United States to guide infrastructure businesses in the implementation and application of asset management.

There is an internationally recognized documented approach for infrastructure asset management called Publicly Available Specification (PAS) 55 2008. At the time of this writing, PAS 55 is being used as the basis for the development of an ISO standard, supported by the American National Standards Institute (ANSI), and the International Infrastructure Management Manual (IIMM), 7th edition (2011).

The ISO Project Committee 251 Asset Management (ISO PC251) has developed three ISO draft documents to date. The full process to a final ISO asset management standard is expected to take up to 2 years. The three ISO draft documents are

- ISO 55000 Asset Management—Overview, Principles, and Terminology;
- ISO 55001 Asset Management—Management System Requirements; and
- ISO 55002 Asset Management—Application Guidelines.

Several primers and guidelines have been written for U.S. transportation agencies based on the IIMM, including the AASHTO *Transportation Asset Management Guide,* and the FHWA *Asset Management Primer.*

Fundamentals of Asset Management

Since the PAS 55 specification is forming the basis of an ISO standard for asset management, the PAS 55 definition for asset management is used for this primer. The definition states that asset management is defined as follows:

> Systematic and coordinated activities and practices through which an organization optimally and sustainably manages its assets and asset systems, their associated performance, risks and expenditures over their lifecycles for the purposes of achieving its organizational strategic plan.

An organizational strategic plan is defined as

> Overall long-term plan for the organization that is derived from, and embodies, its vision, mission, values, business policies, stakeholder requirements, objectives and the management of its risks.

Figure 1 illustrates the integration of processes and systems for undertaking holistic asset management. The figure shows the relationship between the organizational strategic plan and the development of asset management policy and asset management strategies, objectives, and plans for realizing the organizational strategic plan. The structure illustrated in Figure 1 is commonly known as the *asset management framework.*

Note that asset management strategies are the approaches to operations, maintenance, and the timing and type of capital investments required to achieve the level of service, cost and risk exposure inferred by the organizational strategic plan.

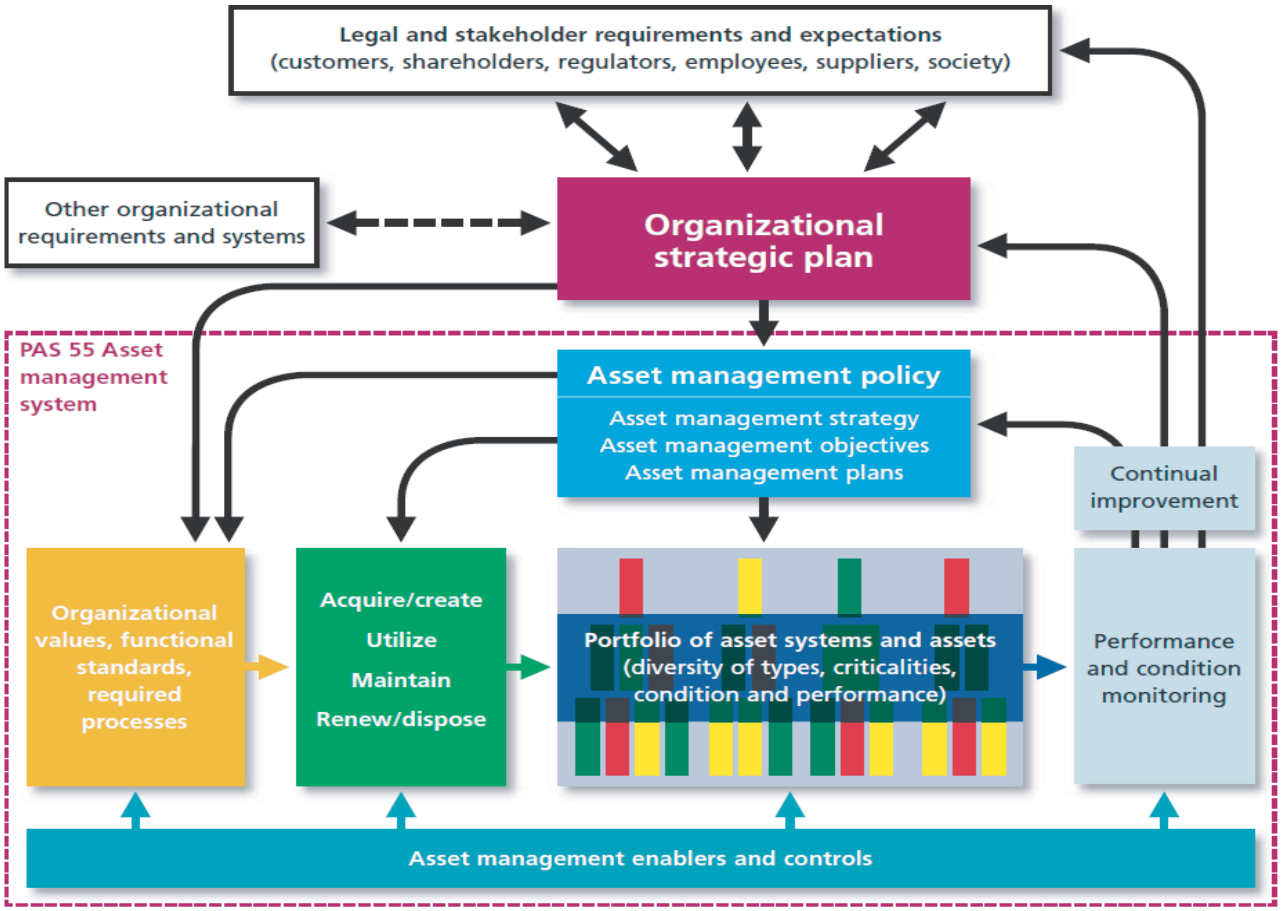
Airport executives have a crucial role in providing the asset management enablers and controls required to achieve a functioning asset management framework. Typical responsibilities are to

- Establish and maintain an organization structure that facilitates asset management processes, with clear direction and leadership;
- Ensure staff awareness, competency, commitment, and cross-functional consultation; and
- Enable the retention of information and knowledge of asset condition, performance, risks and costs, and the interrelationships between the organization's asset management policy and the organization's strategic plan.

Benefits

PAS 55 identifies principal benefits of asset management as

- Enhanced customer satisfaction from improved performance and control of product or service;
- Delivery to the required standards;
- Improved health, safety, and environmental performance;



Source: PAS 55.

Figure 1. Holistic integration of processes and systems for asset management.

- Optimized return on investment and/or growth;
- Long-term planning, confidence, and performance sustainability;
- The ability to demonstrate best value for money within a constrained funding regime;
- Evidence, in the form of controlled and systematic processes, to demonstrate legal, regulatory, and statutory compliance;
- Improved risk management and corporate governance and a clear audit trail for the appropriateness of decisions taken and their associated risks;
- Improved corporate reputation, the benefits of which may include enhanced shareholder value, improved marketability of product/service, greater staff satisfaction, and more efficient and effective procurement from the supply chain; and
- The ability to demonstrate that sustainable development is actively considered within the management of the assets over their lifecycles.

Asset Management Development Continuum—Looking into the Future

Over the past 20 years, there have been significant changes in the strategies adopted by utilities, manufacturers, and process industries to plan, design, construct, run, monitor, renew, and dispose of assets, for the purposes of efficient and effective delivery of quality, sustainable services to customers. Table 1 summarizes this evolution.

Refer to Appendix A for best practice information for other infrastructure sectors including electricity, water, rail, and gas.

Table 1. Evolution of asset management practices.

1980s	Assessments performed to understand the future investment requirements in renewal, growth, operations, and maintenance.
1990s	Organizational restructuring accomplished to establish a strategic planning function, service delivery functions, and service-level agreement structures. Asset management process and practice maturity assessment and auditing tools emerged during this period.
2000s	Enterprise Asset Management Systems (EAMS), Enterprise Resource Planning (ERP) systems, and Geographical Information System (GIS) integration begins to integrate the financial and technical management of infrastructure across organizations. Asset management courses available as post-graduate certificates and advanced degrees. Vice president and director of asset management roles emerging.
2010s	Full cost of service transparency, customer/stakeholder negotiation to establish price and service level trade-offs, and increased use of level of service, risk and cost optimization models for decision making.
In the Future	An ISO standard for asset management will specify the requirements for asset management and begin formulating a common basis for infrastructure management. This may lead to commercially available support tools that support a common standard, simplifying the process for organizations implementing change. For U.S. airports, expect to see an increasing uptake of holistic asset management principles along the lines of other industries in the U.S. such as water and power (Appendix A). The next 10 years is likely to bring continued and increased pressure on cost, service levels, and sustainability, and require a greater awareness and management of asset performance and future liabilities. This ACRP project is intended to start the process.

Asset Management Policy

Purpose of an Asset Management Policy

Asset management policy sets the framework for the management of airport infrastructure and assets. Each policy statement is endorsed and upheld by all executive staff. The statements are intended to guide the airport organization by specifying the minimum set of considerations and actions to be undertaken by staff in the execution of asset management analysis and decision making and the development of asset strategies as illustrated in Figure 2. PAS 55 describes the asset management policy as defining the mandated requirements, overall intentions/principles, and framework for the control of asset management.

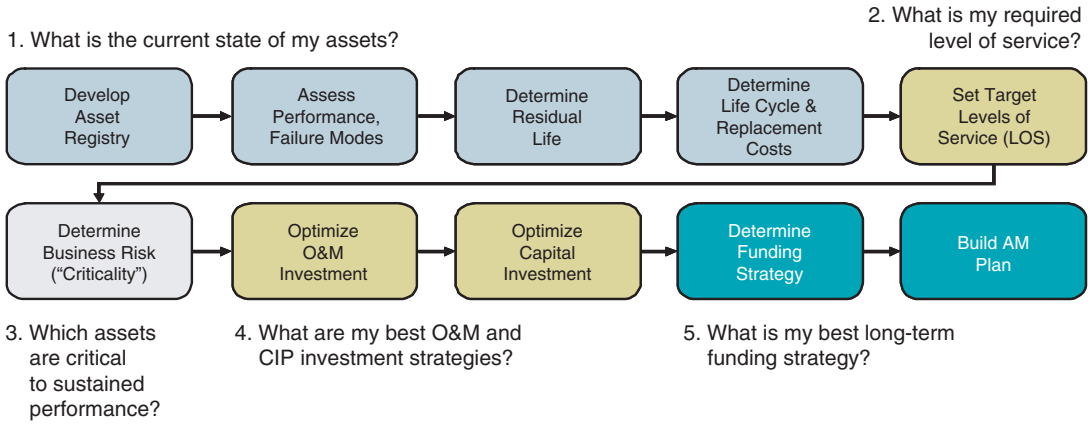


Figure 2. EPA's 5 core questions in a 10-step approach to developing asset management plans.

Asset Management Policy Contents

The International Infrastructure Management Manual (IIMM) and ACRP 01-16 research suggest that the typical content of an asset management policy includes the following:

- Organizational context and importance of asset management,
- Overall vision and goals of the organization and supporting asset management vision and goals such as
  - Sustainable management of infrastructure with respect to economic, social, and environmental impacts,
  - Commitment to capturing and maintaining quality asset data and information, and
  - Optimization of asset management decisions to achieve sustainable desired cost, service level, and risk outcomes,
- Executive and key position roles and responsibilities, and
- Audit and review procedures.

Asset Management Objectives, Strategies, and Plans

Asset Management Objectives and Airport Master Plans

The Airport Master Plan or strategic plan outlines the 5- to 20-year plan for airport development and investment required to meet forecast demand, and strategic goals. The outputs of this process are inputs to the process for determining the objectives for asset management in terms of meeting strategic objectives and customer and stakeholder needs.

According to PAS 55 Part 1 (BSI 2008), asset management objectives should be

- Specific and measurable outcomes or achievements required of the asset system(s) in order to implement the asset management policy and asset management strategy that are needed to meet the objectives of the airport master or strategic plan,
- Detailed and measurable levels of performance or condition required of assets, and
- Specific and measurable outcomes or achievements required of the asset management framework or system.

An example of a link between airport master plan implementation and asset management objectives is the decision to defer capital investment in terminal expansion to accommodate increased operating demand accomplished instead by operational changes that decrease aircraft turnaround and processing times for arrivals. This may require

- Use of process improvement techniques such as LEAN 6 Sigma (a quality management and statistical analysis approach to eliminate defects and reduce the variability in business processes) to improve the capacity of terminals both for passenger throughput, and aircraft turnaround and
- Review of maintenance strategies for jet bridges to ensure that operational downtimes are limited, to meet arrival processing and aircraft turnaround time targets.

Asset Management Plans, Content, and Development

Airport asset management plans describe the activities and investments in infrastructure and assets required to achieve and maintain service outcome standards in the short and long term according to the airport's master or strategic plan for servicing customers, the community, and other stakeholders. More importantly, the plan process facilitates a transparent and systematic evaluation of the trade-offs among feasible management options in terms of levels of service, investment/intervention costs, and risk.

For example, an integrated plan to manage major runway rehabilitation or upgrade would form a part of a 10-year asset management plan. The business case for the optimal timing of renewal would be justified such that minimal disruption to services and income generation is achieved, and that the risk exposure associated with continued use is managed.

The 5-question, 10-step approach to developing an asset management plan (U.S. EPA) shown in Figure 2 describes the essential steps involved.

Asset management plans typically include variants of the following content:

- Overview of the facility/system or network of assets included in the plan,
- Levels of service—current performance and targets,
- Strategies and investments to close performance gaps,
- Risk assessment and mitigations,
- Renewal plan,
- Demand and growth forecasts,
- Capital plan (new assets),
- Ten-year infrastructure investment plan,
- Ten-year funding plan,
- Business improvement plan (improve efficiency and effectiveness of business processes and data and information),
- Challenges for implementing the plan and actions for addressing the challenges, and
- Human resource requirements to implement the plan.

Asset management's five governance questions are as follows:

1. Do you know what the required service function is for each asset you own, how that service requirement is changing over the life of the asset, and how each asset is performing in that context?
2. Do you know what assets you have, what condition they are in, and whether they are enabling you to perform efficiently and effectively in the context of the current strategic business drivers?
3. Are you actively managing risk in order to prioritize and optimize investments in your assets and infrastructure, and to identify the relative importance from a business/financial perspective of your assets?
4. Do you have documented operations, maintenance, and capital investment plans that reflect what you know about your assets?
5. Are you balancing the business risk associated with your assets with long-term funding and management improvement strategies to sustain your current business model?

Asset Management Enablers

Organization Function, Leadership, and Change Management

Improvements in asset management often require a change in organization structure and roles and responsibilities of staff to instill the required level of focus on asset management processes, procedures, and decision making.

To achieve the best results, airport executives must be prepared to

- Review how the airport is currently managing infrastructure to identify poor performing areas relative to appropriate practices, and develop improvement programs that will deliver the greatest value to the airport financially, and to the customers in terms of level of service;

- Support a vision for asset management and provide the leadership required to get the best results out of an asset management improvement plan or initiative;
- Assign an executive staff member as the champion for the asset management implementation program, which is a IIMM [NAMS Steering Group, 2006] recommendation; furthermore, a cross-functional asset management steering committee of executive staff and relevant support staff can be used to integrate asset management decision making across silos; and
- Appoint or assign the equivalent of asset owners, service providers, and asset managers, and provide the necessary systems and change management support to implement supportive processes and procedures.

The asset owner, service provider, and asset manager roles are defined as follows:

- Asset owner—short- and long-term corporate governance, sets investment objectives;
- Asset manager—determines what needs to be done to achieve investment objectives; and
- Asset service provider—delivers services to meet the objectives (design, construct, operate, maintain, renew/decommission).

Asset Management Information and Decision Support Systems

The quality of asset management decision making is dependent on the quality of the data and information captured and maintained for all infrastructure across the airport. The ongoing maintenance of a complete inventory of assets owned by the airport is a fundamental first step to improving asset management practices. Asset performance information (both cost and technical) needs to be associated with the asset inventory. Analysis and indexing tools also are required to use the data and information for decision making and planning, design and operations, and maintenance. At a minimum, key systems include

- Enterprise Resource Planning (ERP),
- Maintenance management,
- Geographic Information Systems (GIS),
- Renewal analysis tools, and
- Capital project evaluation and prioritization tools.

The airport executive needs to support investment in

- Change management and training for the implementation of new systems, or improved use of existing systems to support the preferred asset management processes and procedures for the airport; and
- Establishing the tools and management structure to ensure data and information management happens—document management, engineering records management, training, and quality assurance and control over asset data records.

Staff Competencies and Training

Implementation of an asset management framework usually requires increased scrutiny of investments to consider economic, social, and environmental impacts, and risk reduction and levels of service assessment. This indicates that additional skill sets may be required by airport management, including

- Engineering economics and investment modeling,
- Reliability analysis and risk assessment, and
- Maintenance management.

Figure 3 illustrates the roles and competency units for an asset management organization as defined by the Institute of Asset Management Competencies Framework.

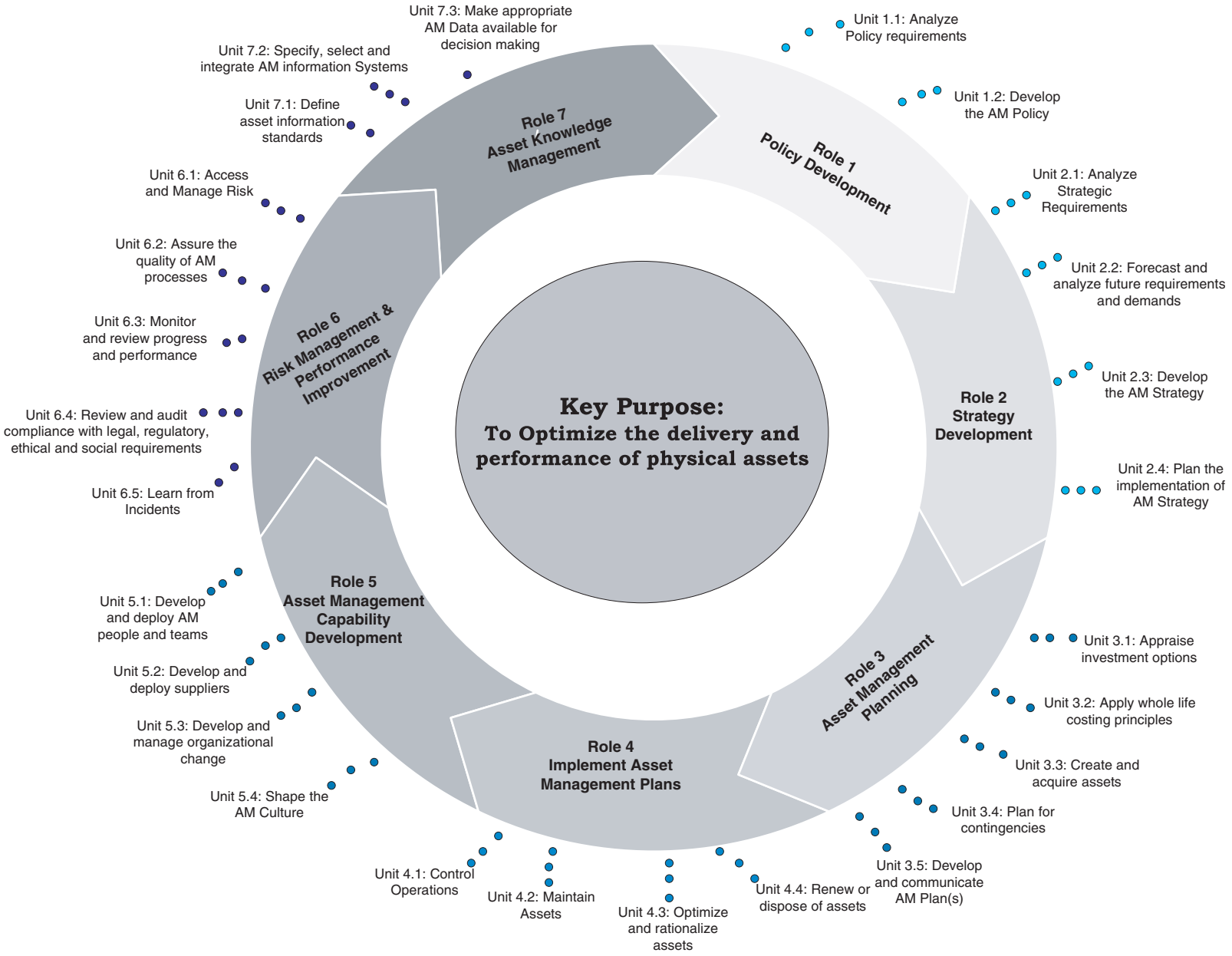


Figure 3. Roles and competencies for an Asset Management Organization.

Implementation of Asset Management Plans

Lifecycle Processes

Asset management plans outline the short- and long-term investments and strategies needed to meet service levels and achieve the objectives of the airport master plan or strategic plan. The asset management plan is not intended to be a shelf document. It is intended to be implemented and audited, with flexibility to be able to address changes in the commercial environment or airport priorities, to ensure that the plan is being followed so that the intended outcomes are achieved.

The airport executive must be prepared to review existing capabilities and capacity in order to implement the asset management plan. Review of the following enabling processes is often required, and plans for improvement or change identified and put into action:

- Asset planning and delivery;
  - Project initiation and planning,
  - Project delivery,
  - Asset commissioning and hand over, and
  - Continual auditing or monitoring of airport commercial environment shifts,
- Operations and maintenance; and
- Renewal and decommissioning.

Identification and Management of Resources

An asset management plan may recommend an increase in capital projects, in planning activities, and changes to maintenance strategy, or that a significant number of assets require decommissioning. There are often human resources, outsourcing, or systems-related needs for implementing an asset management plan. Asset management plans should include an estimate of the additional resources that may be required for implementation.

The airport executive must be prepared to evaluate the need for improvement in systems or the addition of staff, or outsourcing of activities required to implement asset management plans. In turn, the asset management planning processes need to be sufficiently robust so that estimates of both additional resources and the benefits of the asset management plan in terms of cost, levels of service, and risk can be adequately relied upon to justify its implementation.

Managing Hurdles and Impediments to Implementation

Hurdles and impediments can be external to the airport—such as regulatory or economic concerns, or they can be internal to the airport—such as airport policy, airline service changes, or procedure-related issues (e.g., procurement rules or contracting terms).

Identification of the issues, possible actions, and responsibilities for resolving or managing the hurdles and impediments typically lies with the executive team.

Performance Assessment and Improvement

Monitoring and Management Performance to Achieve Objectives

The monitoring and management of performance relies on the existence of a performance management framework that links performance goals, through appropriate performance measures, to activities to monitor and improve performance where monitoring indicates a need.

In terms of customer service levels and asset response, executive management is concerned with the controllable aspects of a small set of key performance indicators (KPIs) such as

- Percentage of delayed flights due to the efficiency of airport configuration and layout.
- Connecting times related to the organization of the airport and efficiency of airport operations such as airport-operated baggage handling systems and automated people movers.
- Baggage delivery (timeliness and lost bags) due to the efficiency of airport-operated baggage handling.

Combining these with business KPIs, and lower-level KPIs associated with facility management (e.g., cleanliness of restrooms), there are a range of performance issues to manage from an asset management viewpoint that directly impact maintenance tactics (what maintenance is performed and how often) and renewal and new capital investment decisions.

A performance management framework that maintains its relevancy through regular strategic reviews by executive management provides the link between stakeholder needs and the airport's ability to realize them through asset management responses.

Managing Risk

Business risks are risks to the organization. Asset risks are risks posed by the asset, mostly through its failure, or inability, to continue to provide the function required of it.

Identification and management of business risks that impact the airport financially, such as regulatory change or route changes made by airlines, and asset risk associated with physical mortality or stranding of investments, form a part of an asset management framework.

A SWOT (strengths, weaknesses, opportunities, threats) analysis used during the strategic planning activity identifies business risks that are then incorporated into the asset management strategy and planning processes.

For example, a SWOT activity undertaken during the master planning process will identify the level of uncertainty in master planning alternatives for airport development, and form a basis for identifying trigger conditions and actions to manage changes (e.g., in demand or stakeholder support).

Asset risks should be identified and monitored to ensure that investments are made to reduce risk (change in design, change in operations and/or maintenance strategies).

The key role for executives in managing risk is to ensure that a risk analysis and management process is in place, and that the appropriate procedures are in place to enable flexibility in planning and delivery of services.

Management Review

Strategic Priority Review and Adjustments

Changes in strategic direction or priorities usually impact infrastructure services, with an associated short-term and long-term cost and service-level implication. Therefore, the asset management plan requires an ongoing review, usually as part of the business planning process, to ensure that the long- and short-term impact of changing priorities and the associated asset response is well understood.

This requires integrated planning and decision making between airport planners, finance and budget, asset management, and operations and maintenance staff. Some airports have airline representation or standing committees providing input.

Putting It All Together: Implementing an Asset Management Framework

Asset Management Maturity Assessment

The IIMM and PAS 55 both recommend the evaluation of the current approach to asset management used by an organization as a first step in evaluating where an organization can improve asset management and deliver value for the investment. The industry refers to this evaluation as both a maturity assessment (used in PAS 55) or gap analysis (used by the Water Environment Research Federation).

A maturity/gap assessment should evaluate the level of asset management practice and integration of process and practices across the airport in terms of the following areas:

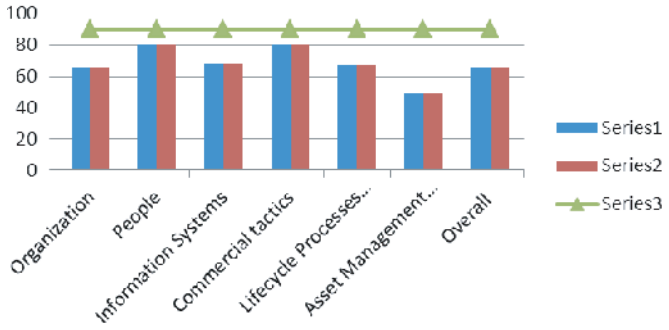
- Organization,
- People,
- Information systems,
- Commercial tactics,
- Lifecycle processes and practices,
- Asset management plans, and
- Overall.

Figure 4 shows an example of output from a gap assessment. Note that for the airport, the areas for improvement include the availability, completeness, and accuracy of asset data and knowledge, the function of the organization itself, and better use of asset management planning. A maturity assessment is a powerful communication and continuous improvement tool.

Implementation Roadmaps: Delivering Value

The maturity/gap assessment forms the basis for the development of an asset management improvement plan or roadmap. Important aspects to consider in the development of an improvement plan are

- The role of the assets and their configuration in the achievement of airport performance goals;
- The human aspect of processes, and which processes have the greatest impact on the improvement of airport performance; and
- The level of practice beyond which the airport will receive little value (e.g., the use of a spreadsheet versus the use of an integrated maintenance management system for a small airport).



Series 1 = Your assessment
Series 2 = Top 10 percent of airports in the United States
Series 3 = Best appropriate practice

Figure 4. Gap analysis for large hub airport in the United States.

An understanding of these aspects allows improvement plan tasks to be prioritized in a way that results in a positive return on the investment in terms of cost, risk, or service levels.

Managing Change

Improvements in management processes always involve change, whether that change is at the operational level only through the implementation of a new system, or a more sweeping organizational change.

The role of airport executive staff in implementing change requires the following:

- Chief operating officer (COO), or above, level of leadership;
- Use of a governance structure, such as an implementation steering committee, of executive staff;
- Regular progress reporting to the COO, other executives, and involved staff;
- Training and change management activities; and
- Celebration of improvement outcomes.

Concluding Observations

Evidence shows that holistic asset management, or a systems approach to management and decision making, can deliver significant benefits. These benefits are not always reflected in lower costs or improved service levels—there are a number less tangible benefits, as follows:

- Alignment of purpose,
- Enhanced flexibility, and
- Better control over budgets and performance.

Tips for new adopters include the following:

- Be clear about what the airport is endeavoring to achieve,
- Undertake a maturity assessment,
- Establish a leadership and a governance structure early,
- Regularly review progress and performance,
- Since information systems support processes, understand your process and procedure requirements and drive the configuration of systems to support them, rather than the reverse,
- Do not underestimate the role of change management, and
- Have key staff review the guidebook of this ACRP and hold an open meeting to identify problem areas for implementation.

Consultation and visits to similar airports that have successfully adopted asset management plans, even if for selected assets (i.e., a new terminal or concourse) can be extremely helpful. There are several sources of information sharing among airports and these types of contacts can be reassuring to a newly formed airport asset management team. Airport management may be new to this evolving asset management business but challenge and innovation is synonymous with aviation.

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Glossary

AASHTO Transportation Asset Management Guide—analyzed the DOT business processes and strategic approach to managing transportation infrastructure assets.

Airport Improvement Program (AIP)—provides grants to public agencies and, in some cases, to private owners and entities for the planning and development of public-use airports that are included in the National Plan of Integrated Airport Systems (NPIAS).

Airport Asset Management Plans—describe the activities and investments in infrastructure and assets required to achieve and maintain service outcome standards in the short and long term, according to the airport's master plan or strategic plan for servicing customers, the community, and other stakeholders.

Airport Master Plan—provides a road map for efficiently meeting aviation demand through the foreseeable future while preserving the flexibility necessary to respond to changing industry conditions. The following are general goals and objectives addressed by the plan:

- To provide a framework for long-range planning,
- To graphically present preferred airport development concepts,
- To define the purpose and need for development projects,
- To comply with all applicable FAA requirements,
- To enable the airport to achieve its mission,
- To assure compatible land-use development,
- To support the financial health of one of a city's most powerful economic engines, and
- To identify facility requirements for all airport users.

The master plan process provides a blueprint for the future. The future plan recommendations are contingent upon further environmental studies and must be financially feasible (www.airportsites.net).

American National Standards Institute—oversees guidelines and standards that affect the marketplace and the means in which business is carried out

Asset—an item that holds value within the setting it is used.

Asset Management (AM) as defined by NAMS—A systematic approach to the procurement, maintenance, operation, rehabilitation, and disposal of one or more assets. AM integrates the utilization of assets and their performance with the business requirements of asset owners or users. AM is all about the continuous alignment of asset performance to meet service delivery outputs to deliver the desired outcomes.

AM also is defined as a management paradigm and a body of management practices that is applied to the entire portfolio of infrastructure assets at all levels of the organization that seeks to minimize the total cost of acquiring, operating, maintaining, and renewing the organization's assets within an environment of limited resources while continuously delivering the service levels customers desire and regulators require at an acceptable level of business risk to the organization.

Asset Management (AM) as defined by PAS 55—systematic and coordinated activities and practices through which an organization optimally and sustainably manages its assets and asset systems, their associated performance, risks, and expenditures over their lifecycles for the purposes of achieving its organizational strategic plan.

Asset Management Framework—system of processes, procedures, practices, support systems, organizational roles and responsibilities, and policies used to enable sound management decisions for the optimal management of physical assets.

Asset Management Information System (AMIS)—computer-based software system for collecting and analyzing data, and extracting meaningful information on the performance of existing assets and their operating costs to aid in asset management decision making. AMIS is often also referred to as an enterprise asset management system or EAMS.

Asset Management Plan (AMP)—document that identifies the short- and long-term service delivery requirements of the portfolio of assets belonging to an organization. It provides a framework for managing an asset, or group of assets, from within the asset portfolio.

Asset Management Policy—sets the framework for the management of airport infrastructure and assets. Most policies include the following:

- Organizational context and importance of asset management,
- Overall vision and goals of the organization and supporting asset management vision and goals,
- Executive and key position roles and responsibilities, and
- Audit and review procedures.

Asset Management Strategy—a high-level, long-term action plan for the assets and/or asset systems, that asset portfolios or the asset management system. A preferred strategy outlining the minimum acceptable asset performance criteria needed to support service delivery including resource levels for human, fiscal, and IT for the required functionality.

Asset Performance—measurement of the achievement of pre-determined outputs arising from the existence and operation of assets using a range of performance targets that measure the individual and collective contribution an asset makes toward service delivery and/or business outputs.

Asset Strategic Planning—process of developing management strategies that will contribute to the best utilization of assets in the delivery of services to the community in line with corporate plans and service delivery strategies, and that will ensure ongoing compatibility between the composition of an asset portfolio and the changing environment within which it operates.

Business Improvement Plan—review and documentation of current business processes carried out in an organization. Specific recommendations are then documented as future actions for the organization.

Business Plans—Annual department or business unit operating plans that specify the outputs to be provided, and their input resource costs for a defined period of time.

Capital Investment Strategic Plan (CISP)—strategic planning process for capital investment in physical assets through the acquisition of new physical assets and the material improvement of existing physical assets.

Capital Project Evaluation and Prioritization Tool—methodology used in determining the timing of when a capital project should be requested and how much funding is available to complete the needed work.

Change Management—aids in the evolution, composition, and policy management of the organization.

Economic Life—period from the acquisition of the asset to the time when the asset, while physically able to provide a service, ceases to be the lowest cost alternative to satisfy a particular need. The economic life is at the maximum equal to the physical life but obsolescence will often ensure that the economic life is less than the physical life.

Enterprise Asset Management Systems—maintenance management system that operates across the enterprise to include the management of all physical assets owned by the enterprise.

Enterprise Resource Planning—a means of applying external and internal procedures to an organization to carry out means of business.

Gap Analysis—a process in which an organization reviews their existing processes, practices, and procedures and compares the findings to the expected delivery of these standards.

General Aviation Airports—general aviation (GA) airports are one of the two categories of civil aviation airports. GA airports cater to all flights other than military and scheduled airline and regular cargo flights, both private and commercial.

GIS (Geographic Information System)—a computer package that displays a map connected to a database. The package can typically combine features, such as roads and sewers, from different maps and overlay them on the same screen. To qualify as a GIS, such systems should also be able to reference a computer database for textual information, such as notes and dimensions, regarding features displayed on the map.

Hurdles and Impediments—obstacles or risk that may get in the way of the organization while implementing the principles of asset management.

Infrastructure Asset Management—is a focus of physical component/attributes of an asset and finding means of preventing those assets from failing.

Intergenerational Equity—ensuring that future generations are not burdened with the cost of the consumption of infrastructure by current generations.

International Infrastructure Management Manual—manual produced to give an understanding of asset management practices.

ISO (International Organization for Standards)—organization known for producing and publishing international standards for all subject areas in the world, and forming a network between both public and private sectors because it is not a government organization.

Key Performance Indicator (KPI)—quantitative or qualitative indicator of the quality of service, efficiency, productivity, or cost effectiveness of an agency, program, or activity that enables a comparison to be made for management purposes of performance against a standard target or norm; may be a quantitative measure or qualitative indicator of performance.

Lean 6 Sigma—a quality management and statistical analysis approach to eliminate defects and reduce variability in business processes.

Level of Service—level of asset service determined by both the quality and the quantity of services provided by an asset under consideration.

Maintenance Managed Item (MMI)—MMI level is that level for maintenance detail elected for the organization asset register. The MMI could be a whole building in some systems, whereas in more sophisticated systems it could be a shaft beading on an electric motor.

Best appropriate practice requires that the level of detail in the asset register should allow for the recording of data down to the MMI level. MMI refers to the lowest level of an asset's physical structure that is to be recognized within an asset register where the registry is structured as a nested hierarchy of physical assets. Typically, an MMI is set at that level of the hierarchy at which an asset is individually maintained or at which management decisions to repair, renew, or replace are made.

Maintenance Management—organization of maintenance activities within an agreed policy.

Maintenance Strategies—tactics and tools that will be used to deliver the maintenance plan, as well as defining the maintenance roles and responsibilities.

Maturity Assessment—evaluation of the degree to which an organization uses recognized best practices and the availability of information required to plan for and implement improvements. The ultimate value of maturity assessment can only be realized in the context of an overall process improvement and organizational change program.

Operations and Maintenance—activities related to the performance of routine, preventative, predictive, scheduled, and unscheduled actions aimed at preventing asset failure or decline with the goal of increasing efficiency, reliability, and safety.

Organizational Strategic Plan—overall long-term plan for the organization that is derived from and embodies its vision, mission, values, business policies, stakeholder requirements, objectives, and management of its risks.

PAS 55 2008 (Publicly Available Specification)—standards being used as the basis for development of ISO standard, which are supported by ANSI and the IIMM.

Passenger Facility Charges (PFC)—fee imposed by a facility owner, such as an airport, on those using the facility; typically added to the cost of a fare.

Plan, Business Plan—similar to corporate plan, but with a limited planning horizon (usually around 12 months), it addresses in significant detail how the organization intends to achieve objectives and handle issues. Although there is a single corporate plan, it is common practice for each business or functional unit in an organization to develop its own business plan. The collective business plans then need to be reviewed by the executive management team to remove duplication of effort and eliminate planning gaps.

Performance Management Framework—an ongoing, systematic approach to improving results through evidence-based decision making, continuous organizational learning, and a focus on accountability for performance; uses evidence from measurement to support planning, funding, and operations.

Rehabilitation—extensive work intended to bring an asset up to a new standard or to alter it for a new use.

Renewal Analysis Tool—spreadsheet or commercially available software used to analyze asset data and information to compare existing assets or facilities with assets or facilities of equivalent capacity or performance capacity.

Renewal—Project to upgrade, refurbish, or replace existing assets with assets of equivalent capacity or performance capability.

Risk Exposure—potential impact of economic, financial, or social loss or gain, physical damage or injury, or delay on the achievement of project objectives, delivery goals, or management effectiveness.

Risk Management—systematic way of identifying and analyzing potential risk and devising and implementing mitigation responses appropriate to their expected impact.

Risk Mitigation—recognition that, in general, it is neither financially feasible nor humanly possible to eliminate all risks associated with a project or program. The concept of mitigation accepts those risks it concedes lie within the organization's "risk appetite" framework—those identified risks where controls are already in place to monitor and manage them. The concept further develops detailed risk management strategies and/or plans to manage those risks beyond the parameters of its risk appetite, and by so doing, brings these risks within its risk awareness context and control parameters.

Strategic Asset Management (SAM)—planned alignment of physical asset input performance with an organization's service delivery output needs, to achieve desired outcomes. This is achieved by the systematic management of all decision making processes taken throughout the intended lifecycle of a physical asset.

SWOT (Strengths, Weaknesses, Opportunities, and Threats) Analysis—provides an assessment of an organization's strengths, weaknesses, opportunities, and threats to provide a snapshot of the present and a view of the future for that organization.

Whole-of-Life-Costs—all costs involved in a project including capital costs (planning, construction, land, and equipment) and operating costs (staffing, and the costs of maintenance and refurbishment).

APPENDIX A

Other Sectors and Asset Management

Examples of Other Sector Asset Management Application

1. U.S. Electricity Sector

Drivers: Deregulation of the electricity market in the United States introduced competition in the generation businesses, which resulted in the disaggregation of vertically integrated utilities and a change to an asset management business structure for many businesses, in order to deliver cost and service-level efficiencies.

- Organization Structure and Function
  - Separated the definition of the work required from the delivery of work.
    - Creation of an asset management function
    - Service delivery function
    - Service level agreements between asset management and other business units or organization functional groups (e.g., IT, finance, operations)
    - Performance-based remuneration for executive managers in charge of functional groups, based on service level agreement signed, performance measures, targets, rewards, and penalties
    - Emergence of VP asset management roles in electricity distribution organizations
- Lifecycle Processes and Practices
  - Reviews of maintenance and operations performance—cost and performance benchmarking
  - Capital spend reviews and justifications and prioritization based on strategic objectives, risk, revenue, service-level performance
  - Review of outsourcing strategies, development of more comprehensive contractor performance evaluation criteria and processes
  - Risk assessments, risk registers, risk mitigation plans

2. U.S. Water Sector

Drivers: Long-lived civil infrastructure constructed in the post-war growth period is coming due for renewal or replacement. Federal funding for water projects is becoming more difficult to obtain, risk exposure associated with large buried infrastructure is considerable in some instances. Water businesses are being pushed toward preparing for financial self-sufficiency. This means that they need to better understand the true cost of provision of water and wastewater services so that funding strategies can be determined and negotiated with customers for a corresponding level of service, and within legislative requirements.

- Organization Structure and Function
  - Develop corporate asset management group to drive asset management improvements across service businesses (water and wastewater); ensure consistency in the evaluation of risks and capital priorities, as well as consistency with the corporate asset management policy
  - Asset owner, strategy manager, and service provider roles set up within the business with asset owner responsible for setting objectives and goals, asset strategy manager responsible for determining what needs to be done to meet the goals and objectives, and service providers doing what needs to be done to meet the goals and objectives
  - Establishment of corporate or enterprise levels of service statements or agreements that drive the development of asset strategies
- Lifecycle Processes and Practices
  - Compete asset registers represented in hierarchy from the network level down to maintenance managed items (level at which work orders are recorded)
  - Integration between maintenance management system, GIS, and financial systems
  - Maintenance strategy reviews undertaken to ensure that critical assets are managed with interventions undertaken at the optimal point in terms of repair/replace cost and risk exposure, and not run to failure
  - Asset hand-over procedures ensure that contractors/engineers provide all required asset lifecycle attribute data necessary for managing the asset from commissioning through renewal/disposal
  - Engineering records, standards and specifications reviewed and maintained so that assets are fully documented, an approved equipment list is in place to ensure that poor performing equipment is not approved for installation, and that standards and specifications are continually updated in terms of reliability and maintainability requirements
  - Processes are in place to monitor asset configuration (e.g., pumps are operated within their design range, and should circumstances arise where they are required to operate outside design range, mitigations are put in place to manage any increased risk exposure, additional maintenance requirements, and any change in asset remaining life is managed through strategic planning process for renewal
  - Risk and service levels are managed by understanding what the organization's tolerance is to risk—tolerable risk limits are determined quantitatively either using a score or dollar values, and any risks that exceed the tolerable limit are mitigated through the implementation of controls such as redesign, redundancy, renewal, replacement with a different asset, or emergency response plans to reduce the consequence of failure

3. Rail Sector (United Kingdom/Australia)

Drivers: Improvement in safety, on-time performance, and cost of service in the face of increasing demand (in many cases) and aging infrastructure.

- Organization
  - Restructuring to include an asset management function to develop and oversee the application of asset strategies across the business. London Underground reorganized during the privatization and PPP period to include asset management function to ensure preservation of assets and performance, and seamless interfaces between London Underground and partners
- Processes and Practices
  - Improvement programs determined using maturity assessments to identify areas of weakness that can be improved to gain the greatest improvement in performance
  - Review business processes and practices and maintenance management system functionality to identify system improvements to enhance monitoring and maintenance decisions such as defect coding, analysis, and workflows to capture defect information

  - Use regular condition assessment techniques to identify cracks, misalignment, and other defects on rails to enhance proactive maintenance
  - Use decision support systems to predict future asset condition as an input to strategic renewal planning
  - Use integrated decision support systems, with maintenance management systems (e.g., Maximo and Optram) to enhance decision making and timeliness of work to improve performance

4. Gas Sector

Drivers: Safety and pipeline integrity legislation. Safety is given the most importance as a driver for asset management while environmental issues are given the least. In regimes based on incentive regulation it is indicated that issues related to response to customers increase importance compared to cost-based regimes. This can be explained by the need to meet specific customer service level standards, which are set as an objective in incentive regulation regimes.

- Organization
  - Recent research team surveys indicate that around 20 percent of gas businesses worldwide claim to have a well-developed, holistic approach to asset management
  - Most gas companies have a branch/group/division dedicated to asset management and have sufficient executive support to implement change where necessary
- Processes and Practices
  - Majority of gas businesses have complete asset registers
    - Remote operational control is used by the majority of the companies and has consistently been the most common method of implementing maintenance and control of the gas networks; before 1995 almost 60 percent of companies had implemented this, with a prediction of 85 percent by 2010
    - Not more than 60 percent of the companies will have implemented risk-based maintenance, gas leakage search programs, and smart metering by 2011
    - Utilization of remote data access from field was very low at under 20 percent pre-1995, but was recorded as nearly 70 percent in 2007 and is predicted to increase a little more by 2011
    - Renewal and replacement planning is typically undertaken on a 10-year planning horizon, with asset strategies applying for longer time periods

PART 2

Asset and Infrastructure Management for Airports—Guidebook

GUIDEBOOK CONTENTS

Reader's Guide for Guidebook

Steps For Applying The Guidelines	
Airport Examples	

CHAPTER 1

Guidebook Asset and Infrastructure Management for Airports

Introduction

The aviation industry is faced with changing requirements and regulations, increasing passenger volumes, and fluctuating financial conditions. In this environment, airport management may benefit from an overarching asset management framework to be able to respond to changes in the environmental, regulatory, and economic environment and to identify and manage the entire airport asset portfolio to continue to meet service level standards in the face of change.

Experience in highway transportation, water, wastewater, electricity, and gas industries indicates that an appropriate asset management framework can improve a manager's ability to make proactive, timely, and optimal decisions to maintain the level of service delivered to customers and stakeholders with the best trade-offs between cost, risk, and service levels.

What Has Been and Can Be Gained through Asset Management Implementations in the Aviation Industry?

ACRP addressed this question by commissioning the development of this guidebook for asset and infrastructure management of airports. The panel justified the need for developing an asset management framework for airport infrastructure by stating

"Asset and infrastructure management is commonly used by organizations around the world to coordinate and oversee the safe, secure, and environmentally sound operation and maintenance of assets in a cost-effective manner. With the limited resources that airports are typically facing, airport managers are constantly looking for more efficient and effective ways to manage infrastructure overtime. An asset and infrastructure management program can be one such tool. This type of systematic management approach promotes the efficient use of those resources in a proactive, rather than reactive, decision-making process, providing data and information in an integrated manner for the long-term preservation of the asset value.

Many airports have a systematic data and information process in use to some degree on some of their assets or types of assets. Examples can include pavement maintenance management programs or other computerized maintenance management systems. These data may not be available at the enterprise level, or they may not be formally managed. Many organizations, including airports, operate in a "silo" fashion where it is common that employees have developed their own data and information for the systems in which they are responsible without necessarily sharing access to those systems with other members of the organization.

Colin Kennedy, Head of Asset Maintenance, Gatwick Airport, London, United Kingdom "For Gatwick, the improvement arising from asset management lies in achieving better value for money rather than significant cost savings. There is a much better focus on common objectives, and effort is coordinated and integrated across the whole site, with far less fragmentation driven by "local" perspectives. All in all, there is much better productivity, communication, and a far more sophisticated approach and informed assessment of future asset requirements to support future service needs."

Julieanne Alroe, CEO of Brisbane Airport, Australia, "One of the greatest benefits of asset management has been the ability to provide information to the Board on infrastructure capabilities and future needs—this type of knowledge is invaluable and is essential for making the best, justified investment decisions."

Encouraging centralization of, and access to, these data can enhance the ability of the airport to make effective financial and strategic decisions.

Research is needed in this area to provide airports with a holistic approach to asset and infrastructure management that includes physical, financial, and human resource assets."

Guidebook Objectives

This guidebook provides guidelines for airport managers on how to assess and drive meaningful improvements to existing asset management initiatives, develop an airport asset management plan, and implement that plan.

Current practices being undertaken at agencies that participated in the research for this study are provided as examples throughout this document.

Many airport operators have existing infrastructure asset management systems, practices, and protocols that address the strategic objective of airport asset management. This guidebook is not intended to replace such systems, practices, or protocols, but rather to serve as a reference point for integrating these practices into an overarching framework wherein capital renewal and operations and maintenance decisions are made.

Intended Audience

Dave Tomber, Aviation Planning, Seattle-Tacoma International Airport, "Asset Management is a planned and proactive strategy for optimizing the life of vital facilities. The business management practices are based on total cost of ownership for ongoing renewal, maintenance, and operation. They are a source of competitive advantage and critical to the long-term stewardship of airport infrastructure."

This guidebook is intended for airport managers, planners, designers, developers, and operators, and is directed at those individuals responsible for implementing improvements to existing asset management practices. As such, private-sector planning and engineering firms, airport management companies, airport authorities or the aviation departments of municipalities, and aviation consultants would derive value from this document. The guidebook provides a comprehensive reference that will help the user understand what constitutes an airport asset management system. It describes its components and their interactions and offers guidance in the planning, funding, implementation, and operation of an airport asset management system. It also provides information on how to carry out the asset management system processes.

The guidelines may be valuable to those entities seeking to lease space within an airport to provide a framework for understanding the performance of facilities they are agreeing to lease.

Airport managers from airports of all sizes and classifications can use this guidebook to adopt the asset management best appropriate practices to improve current management practices and generate a return or value to the airport as a result.

Document Structure and Content Overview

Figure 1-1 lists the content of this guidebook in a quick-reference format.

Asset management requires integration between airport departments and a breakdown of silos in the way that processes are performed and decisions are made. Airport managerial staff involved in the planning and delivery of capital, and the operations and maintenance of infrastructure, including budgeting and finance, risk, and customer relations, are encouraged to familiarize themselves with all of chapters of this guidebook.

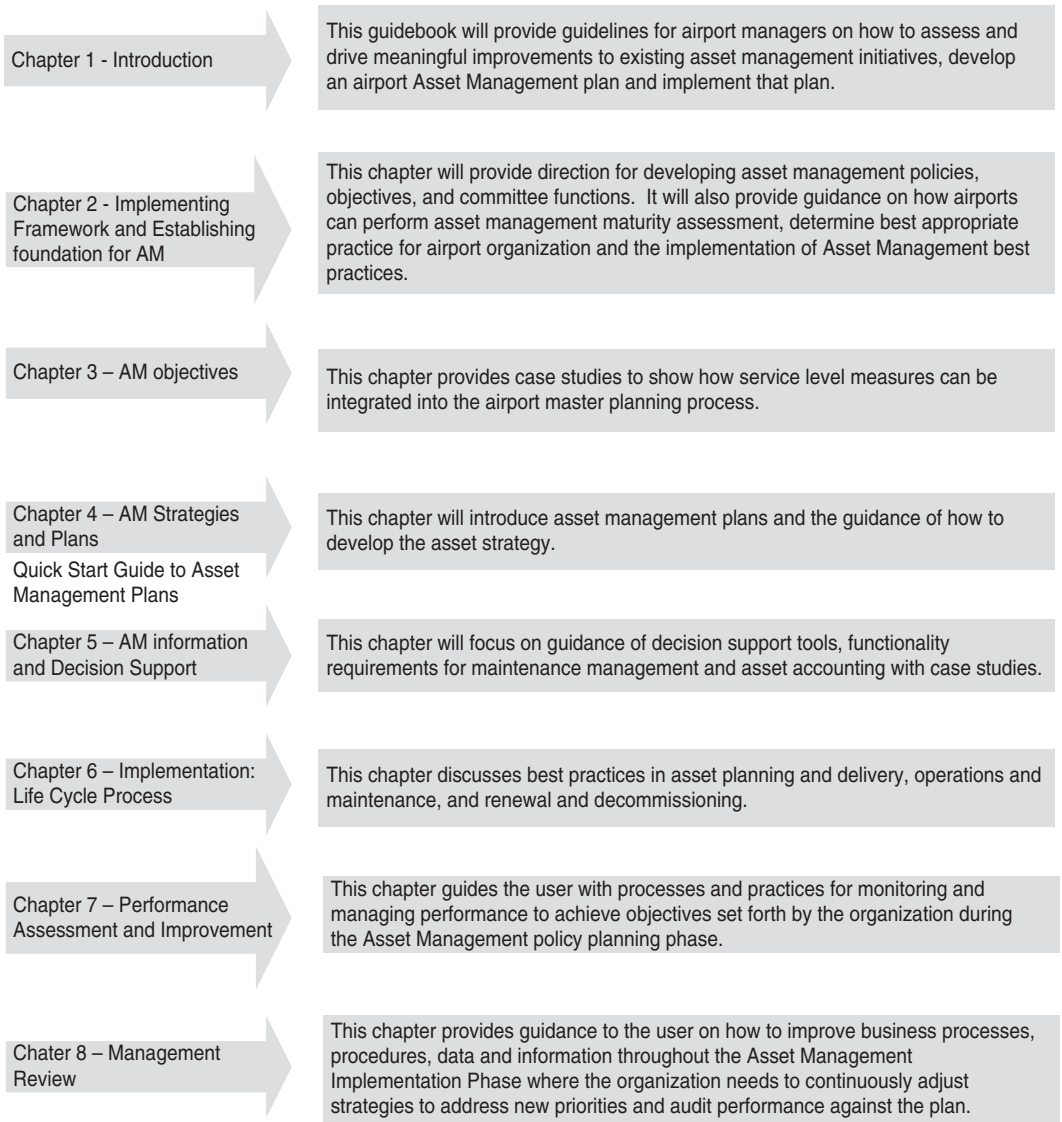


Figure 1-1. Guidebook layout.

Port Authority of New York and New Jersey, "To provide the consistently high levels of service that the region requires, the Port Authority spends nearly $1 billion annually to maintain the region's ports and airports, bi-state bridges, tunnels, and rail facilities in a state of good repair . . . using systematic asset management to ensure cost-effective use of capital resources, replacing aging facilities based upon economic lifecycle analysis to avoid failures of operational facilities while mini-mizing unnecessary maintenance costs . . ."

CHAPTER 2

Implementing an Asset Management Framework: Establishing the Foundation

Introduction to Asset Management

There is no single standard in the United States to guide infrastructure businesses in the implementation and application of asset management.

An International Organization of Standards (ISO) standard for asset management is currently under development, with the support of the American National Standards Institute (ANSI). The ISO 55000 series standards for asset management are using the British Standards Institute Publicly Available Specification, PAS 55 as a basis. The definition for asset management as defined in PAS 55 is used for this guidebook. The definition states that asset management is the

> Systematic and coordinated activities and practices through which an organization optimally and sustainably manages its assets and asset systems, their associated performance, risks, and expenditures over their lifecycles for the purposes of achieving its organizational strategic plan.

An organizational strategic plan is defined as follows:

> Overall long-term plan for the organization that is derived from, and embodies its vision, mission, values, business policies, stakeholder requirements, objectives, and the management of its risks.

Refer to Appendix A for a list of standards for asset management and sources from which these standards may be obtained.

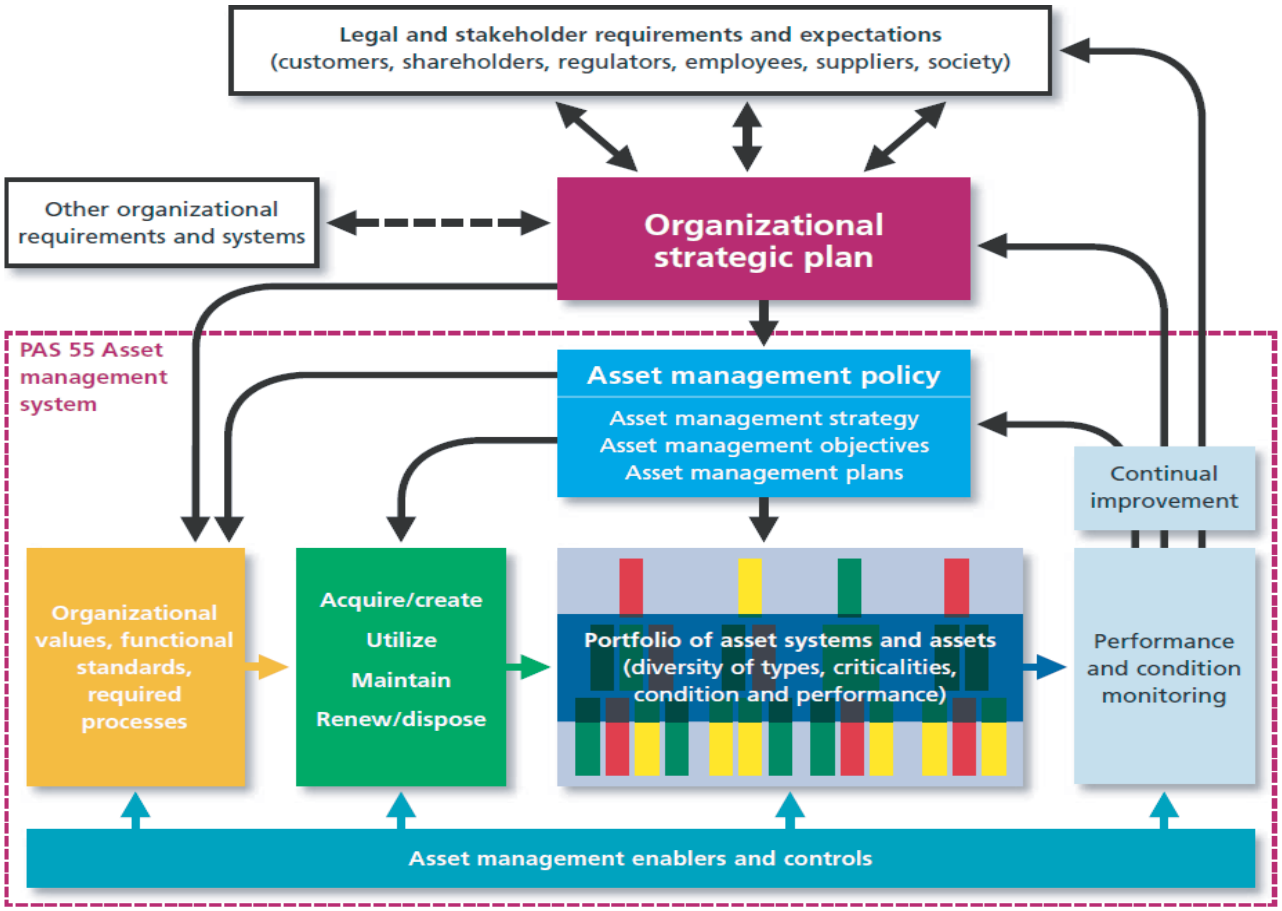
The organizationwide functioning of the processes and systems illustrated in Figure 2-1, and required for asset management to work effectively, relies on executive management to

- Establish and maintain an organization structure that facilitates asset management processes, with clear direction and leadership;
- Ensure staff awareness, competency, commitment, and cross-functional consultation; and
- Enable the retention of information and knowledge of asset condition, performance, risks, and costs, and the interrelationships between the organization's asset management policy and the organization's strategic plan.

Figure 2-1 shows a high-level outline of what is commonly known as the asset management framework, the central governance tool of which is the asset management policy.

Asset Management Framework

The asset management policy sets the framework for the management of airport infrastructure and assets. Each policy statement is endorsed and upheld by all executive staff. The statements are intended to guide the airport organization by specifying the minimum set of considerations and actions to be undertaken by staff in the execution of asset management analysis and decision making and the development of asset strategies as illustrated in Figure 2-1. PAS 55 describes the



Source: PAS 55

Figure 2-1. Holistic integration of processes and systems for asset management.

asset management policy as defining the mandated requirements, overall intentions/principles, and framework for the control of asset management.

Most airports visited during the course of the research do not have a specific asset management policy in place, but tend to have a common understanding of the need to derive benefits from smarter management decisions regarding assets and infrastructure.

These airports tend to have executive positions with responsibility for asset management; hence the concepts outlined within a typical policy are already imbedded in the way that the airport functions.

The asset management policy is an important change management tool that provides executive support for investments and activities for maintaining the asset management framework. For example, the policy may ensure a continuing focus on the importance of the data collection and update process such that the integrity of asset data and information is maintained, and staff can rely on the available system information on a continuing basis.

The International Infrastructure Management Manual (IIMM) and the research suggest that the typical content of an asset management policy includes the following:

- Organizational context and importance of asset management;
- Overall vision and goals of the organization and supporting asset management vision and goals including

  - Sustainable management of infrastructure with respect to economic, social, and environmental impacts;
  - Commitment to capturing and maintaining quality asset data and information;
  - Optimization of asset management decisions to achieve sustainable desired cost, service level and risk outcomes;
- Executive and key position roles and responsibilities; and
- Audit and review procedures.

Developing the Asset Management Policy

The asset management policy is developed by an executive staff group and requires a common understanding of what asset management is and what it means when applied to the airport.

Steps to developing the asset management policy include the following:

1. Use a strategic planning exercise to determine the goals and objectives for the airport over the short, medium, and long term;
2. Determine what asset management outputs are required to achieve the goals and objectives;
3. Formulate policy statements around the Step 2 outputs;
4. Discuss and develop a consensus on the policy statements and their achievability; and
5. Adopt the policy at the executive level.

Given the differences in organizational design and function, and the variance in governance structures (authority, municipal, private) from one airport to another, the makeup of the executive staff group may vary. However, typical participants include senior-level executives from

- Operations,
- Maintenance,
- Finance,
- Engineering,
- Environmental,
- Planning, and
- Information technology.

Observations indicate that this group may be formed as a steering committee to guide the implementation of the asset management framework, or asset management improvements, and make take the form of a

- Process improvement committee,
- Asset management steering committee, or
- Continuous improvement team.

Figure 2-2 provides an excerpt of an asset management policy. The full policy is included in Appendix B.

Maturity Assessment, Implementation Planning, and Best Appropriate Practice

The IIMM and PAS 55 both recommend the evaluation of the current approach to asset management used by an organization as a first step to evaluating where value-adding asset management

I. STATEMENT OF THE POLICY:

The Port of Seattle uses a sustainable asset management approach to guide its decisions related to the planning, design, construction, operation, maintenance, renewal, and demolition of its airport, seaport and other facilities. This approach integrates environmentally and economically sustainable development by maintaining a focus on the total cost of ownership and implementing a comprehensive asset management program. This policy is consistent with and reinforces the Port Commission's strategic goals to "ensure Airport and Seaport vitality," "exhibit environmental stewardship through our actions," and "be a high performance organization."

II. PURPOSE

A. Provide an added tool for the Port Commission in the decision making process. The sustainable asset management policy provides a pro-active approach to monitor long term thinking about our facilities development and ownership, focuses on the total cost of facility ownership to better link capital investment and ongoing operating costs, provides clear data on project performance, institutes an industry best management practice that maximizes and links the efficient use of available funds and further integrates environmental and financial performance.

B. Reduce long-term capital and operating costs. The focus on both initial and ongoing costs will help determine the total cost of ownership for a facility over its projected lifetime. This will help us make better decisions on our capital investments. Where these costs are split between the Port of Seattle and its tenants, these capital *investment* decisions need to be evaluated given that business relationship

C. Support environmentally-sustainable development. Sustainable asset management can guide decision-making toward materials and operational practices that have lower impacts on the environment through the entire lifecycle of an asset. Examples of reduced operating impacts are the reduction in green house gases, latent heat, solid waste and waste water. In addition, when a facility has served its useful life, sustainable asset management will guide decision making on disposal of facilities and building materials with consideration about the further usefulness of the materials, opportunities for recycling, or appropriate waste disposal.

D. Conserve resources. Conserving resources is necessary for the long term viability of our businesses and a strategic objective of sustainable facilities management. Evaluating the lifecycles of facilities and their components will enable the Port to maximize the effective life of the resources we have invested in, consistent with the expected useful life of these resources. Taking a long-term view of asset ownership can result in decisions that reduce energy and water consumption, reduce waste generation, maximize use of recycled materials, and conserve other resources. For example, modern lighting systems that provide high quality light at low wattage are increasingly available and can reduce electrical energy use for decades.

III. APPLICABILITY

The requirements of this policy apply to all assets owned, leased, constructed, or otherwise managed by the Port of Seattle.

IV. PRINCIPLES

A. Consider the Total Cost of Ownership When Making Asset Investment Decisions. Total Cost of Ownership is the sum of all recurring and non-recurring capital and expense costs incurred over the life of a facility or system from planning through demolition (does not include furnishings or non-facility specific equipment). Total cost of ownership may also be referred to as "life cycle costs" and can be expressed in real dollars, nominal dollars or net present value. The evaluation must include the established split in responsibilities (e.g. between the Port of Seattle and its tenants) for those cost components. Also note that land values and financing costs are specifically excluded. Total cost of ownership includes five major components:

- Operational
    1. Utilities
    2. Operations
    3. Maintenance and repair
- Capital
    1. Initial Cost
    2. Component Renewal

B. Perform Comprehensive Asset Management from a Whole Organization Perspective. Comprehensive Asset Management is the identification and prioritization of facility and infrastructure physical, functional, and budgetary needs, spanning a multi-year timeframe. It also includes the process of reinvesting funds into physical assets in support of the Port's mission and driven by the organization's business plans and strategies.

Figure 2-2. Sample asset management policy.

improvements can be made. The industry refers to this evaluation as both a maturity assessment (used in PAS 55), and a gap analysis (used by the Water Environment Research Federation).

A maturity/gap assessment should evaluate the level of asset management practice and integration of process and practice across the airport in terms of the following areas:

- Lifecycle processes and practices,
- Information and decision support systems,
- Data and knowledge,
- Commercial tactics,
- Organization,
- People, and
- Asset management plans.

This assessment is a powerful communication and continuous improvement tool since it can reveal areas of deficiency clearly to parts of the organization. It also provides a logical basis for prioritizing improvement. For example, data and knowledge gaps impact all decision making for any stage of an asset's lifecycle. Improvement in data and knowledge gaps can provide benefits to more than one area of operation and are often the highest priority in getting started.

Undertaking Periodic Asset Management Maturity Assessment or Gap Analysis

One of the key uses of gap analysis is to establish and monitor the implementation of an asset management improvement plan by undertaking further gap analyses to identify where gaps have been closed and what the new priorities are for improvement. It is important that the gap analysis tool, which typically consists of many questions associated with the functional areas mentioned above, is reasonably static, and allows comparison from one assessment to the next. Gap analyses are usually undertaken by applying available tools such as those provided through groups recommending industry practice, such as the Institute of Asset Management United Kingdom-PAM tool (PAS 55 Assessment Methodology), or the Water Environment Research Foundation-GapEx tool. Membership in these organizations is required in order to access these tools. Some consulting businesses also have proprietary tools for this purpose.

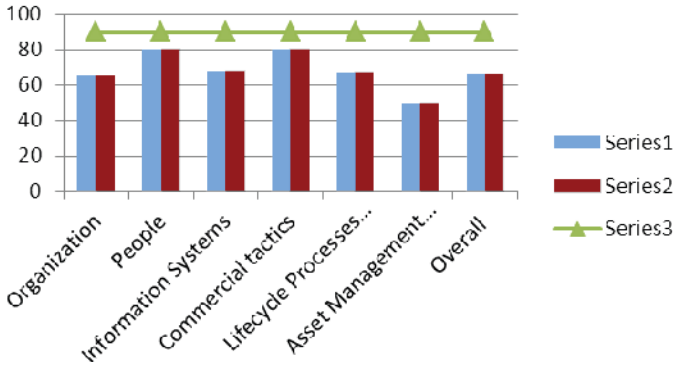
Figure 2-3 shows an example of output from a gap assessment. Note that for the airport assessed, the areas for improvement include the availability, completeness, and accuracy of asset data and knowledge; the function of the organization itself with respect to roles and responsibilities for asset management; and better use of asset management planning.

Figure 2-4 shows an example of gap analysis questions. A typical gap analysis tool will hold between 300 to 800 questions that measure the level of practice for each element of asset management.

The concept of best appropriate practice is raised in the IIMM and refers to the level of application of a practice that delivers value to an organization. If the investment required to improve the level of practice to a higher level does not result in a return to the organization then, by definition, best appropriate practice has already been reached.

A simple example of best appropriate practice can be illustrated as follows for the use of integrated information systems for asset management purposes:

> A small, non-hub airport investigated the possibility of using an integrated accounting and maintenance management system to replace the in-house-developed solution for maintenance management.



Series 1 = Your assessment
Series 2 = Top 10 percent of airports in the United States
Series 3 = Best appropriate practice

Figure 2-3. Gap analysis for large hub airport in the United States.

A business case analysis resulted in a business decision not to move away from the spreadsheet solution due to the lack of increased benefits to airport management compared to the additional cost of the license and disruption to current processes through installation.

For this airport, the spreadsheet solution is considered a best appropriate practice because the business case indicated that the additional investment required to upgrade to a more sophisticated solution did not result in a return to the airport.

The online survey undertaken as part of the development of this guidebook indicated that 63 percent of respondents had a computerized maintenance management system; 35 percent of those use Maximo (an IBM maintenance management product), Infor EAMS (Enterprise Asset Management System), or Oracle WAM (Work and Asset Management).

For a tabular best practices guide, refer to Appendix C.

3 Data and Knowledge		
3.01.01 Asset Categorization (e.g., ability to group assets by type, location, material, facility, etc. for reporting and manipulation)	0 1 [2] 3	0 = Assets are unable to be grouped, 1 = Assets can be grouped in one way only, 2 = Assets can be grouped in two or more ways, 3 = Assets can be grouped in any way.
3.01.02 Asset Hierarchical Structure (e.g., level [maintenance managed item] to which asset information is collected and the ability to amalgamate asset costs and performance)	0 1 2 [3] 4 5	0 = None, 1 = Service type, 2 = Facility or system level, 3 = Asset type level, 4 = Asset level, 5 = Maintenance managed item level.
3.01.03 Drawing/Plans (e.g., drawings and plans of assets and facilities)	0 35 50 65 [80] 95	0 = No data, 35 = 35% accurate and complete, 50 = 50% accurate and complete, 65 = 65% accurate and complete, 80 = 80% accurate and complete, 95 = 95% accurate and complete.
	0 35 50 65 [80] 95	0 = No data, 35 = 35% accurate and complete, 50 = 50% accurate and complete, 65 = 65% accurate and complete, 80 = 80% accurate and complete, 95 = 95% accurate and complete.

Figure 2-4. Gap analysis sample questions.

Organization, Leadership, and Change Management

The organization structure and function is an important enabler for the continuous improvement of asset management in airports. During asset management maturity assessments, a review of the organization is undertaken to identify missing functions or broken processes that are detrimental to executing work. For example, poor asset handover processes result in a loss of asset data and information, which negatively affects the ability of the asset manager to determine strategies to maintain service levels and manage risk until those data and information gaps are closed.

PAS 55 specifies that an organization will establish and maintain an organizational structure of roles, responsibilities, and authorities consistent with the achievement of its asset management policy, strategy, objectives, and plans, and that these roles, responsibilities, and authorities shall be defined, documented, and communicated to the relevant individuals (BSI PAS 55-1, 2008).

The IIMM (NAMS Steering Group, 2006) recommends that an asset management implementation program should be championed by an executive staff member and that a cross-functional asset management steering committee of executive staff and relevant support staff be used to integrate asset management decision making across department silos and to manage the realization of benefits from an implementation program.

Designation of asset owners, asset managers, and service providers for all assets owned by an organization is recommended, using the following role definitions:

- Corporate asset owner: Short- and long-term corporate governance sets investment objectives.
- Asset manager: Determines what needs to be done to achieve investment objectives.

Organization Change Example—Large Airport

A system of asset stewardship was implemented to assure the ongoing safety and performance expectations of customers and stakeholders, focusing on the prevention of any unacceptable incidents due to asset failure.

The system of asset stewardship is based around processes to ensure sustainable management of assets, focusing on integrity, performance, and condition. Asset stewardship teams have been created, led by business-unit-level asset stewards. The asset stewardship team is responsible for managing existing assets and setting up a continuous improvement cycle. Capital project/maintenance integrators are responsible for operational and maintenance integration of new projects. Planners and facility managers are responsible for planning, execution, measurement, and improvement of maintenance activities.

The chief operating officer attends daily meetings with operations to review issues with respect to customer interfaces, other service providers, and contractors. Information from these meetings is fed back to the planning process to ensure that solutions will address identified problems. The projects then pass through a development and delivery process through to acceptance by maintenance and operations, with all training and supporting material.

The significant culture change involved the fact that projects are delivered as service solutions addressing specific situations, rather than the previous approach where projects were delivered as corporate solutions.

- Asset services: Delivers services to meet the objectives; design, construct, operate, maintain, renew/decommission.

Improvements in asset management often require a change in organization structure. This can be a local change within operations, maintenance, and engineering to better allocate roles and responsibilities with new process activities, or it can be part of a more holistic change to realign airport activities to be more customer centric. An example of the customer centric organization model used in a small privatized airport is shown in Figure 2-5.

In this model, asset services provides engineering maintenance services to each of the profit centers (aviation, commercial, and property). Asset services includes four departments; mechanical, electrical, grounds, and administration. The mechanical, electrical, and grounds departments manage contractors to provide maintenance services on all infrastructures apart from activities with a high public impact. A reactive team is retained for maintenance of critical cost assets. This type of organization structure is in use in airports where leadership has determined that the future emphasis will be on customers and people rather than on infrastructure and capacity building. The asset management function tends to be service-level driven, using key performance indicators for airport services to customers.

The asset management function within an organization does the following:

- Sets strategic asset management policy;
- Develops and maintains asset management plans;
- Determines, implements, and monitors the asset management improvement program;
- Determines asset strategies and operational-level policies and practices;
- Ensures quality and completeness of asset data;
- Ensures that decision algorithms and business logic align with achieving the goals and objectives of the organization;
- Ensures consistency in the approach to identifying and prioritizing investments across the networks, systems, subsystems, and facilities;
- Monitors and manages performance; and
- Ensures sustained performance of the infrastructure.

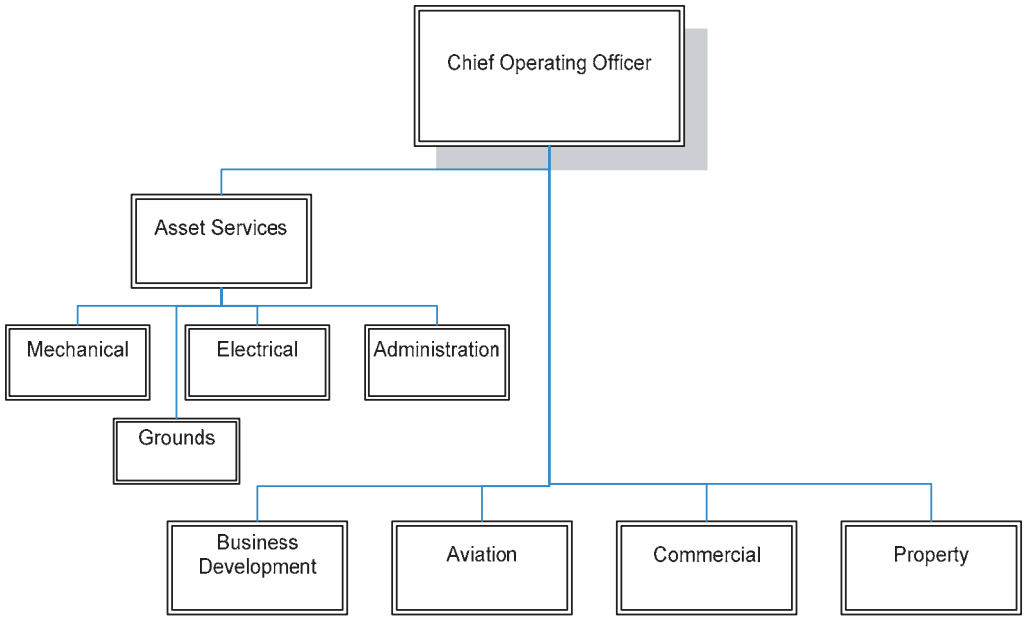


Figure 2-5. Customer-centric model.

This function can be centralized or decentralized (distributed across infrastructure groups and support functions) and coordinated by a corporate asset management team and/or a committee structure.

Staff Competencies and Training

A review of staff competencies and training requirements should be undertaken on a regular basis as part of standard human resource procedures. Once processes and procedures are determined, the skills and competency requirements should be assessed and any gaps identified. Figure 2-6 shows the competency requirements for asset management according to the IAM competences framework. This is a comprehensive resource for understanding asset management competences and can be used directly in a human resource process for managing staff skill sets and training needs to support the asset management framework or system.

Committee Functions

The IIMM recommends that an asset management steering committee structure be used to coordinate improvement activities and investment decision making. Figure 2-7 describes the use of asset management steering committees in a large U.S. water utility. Asset management steering committees are used at the corporate level and within each service delivery group.

The corporate asset management steering committee has the following objectives:

- Guide and provide oversight of the implementation of the asset management policy.
- Ensure that the needs of stakeholders are being fulfilled.
- Provide leadership and strategic direction for the planning process and the associated asset management plans.
- Set goals, objectives, key performance indicators (KPIs) and priorities for improving asset management.
- Ensure that measurable progress toward meeting the goals and objectives for the improvement of asset management is being achieved.
- Process proposals related to the capital budget in accordance with the capital project development process and procedures.
- Report on levels of service, cost, and risk management.
- Provide recommendations for the 10-year fiscal plan.
- Evaluate and recommend changes to asset management policies, planning processes, practices, and procedures to be applied across the organization.
- Evaluate and recommend asset management training programs and staffing levels to support the asset management plans on an ongoing basis.
- Review, direct modifications, recommend, and/or approve asset management plans including trade-offs between cost, levels of service, and business risk exposure.

The service delivery group asset management steering committees have the following objectives:

- Process and practice rollout,
- Process quality audits,
- Coordinate training,
- Approve equipment list proposals, and
- Process changes to standards (maintenance, operations, input to design).

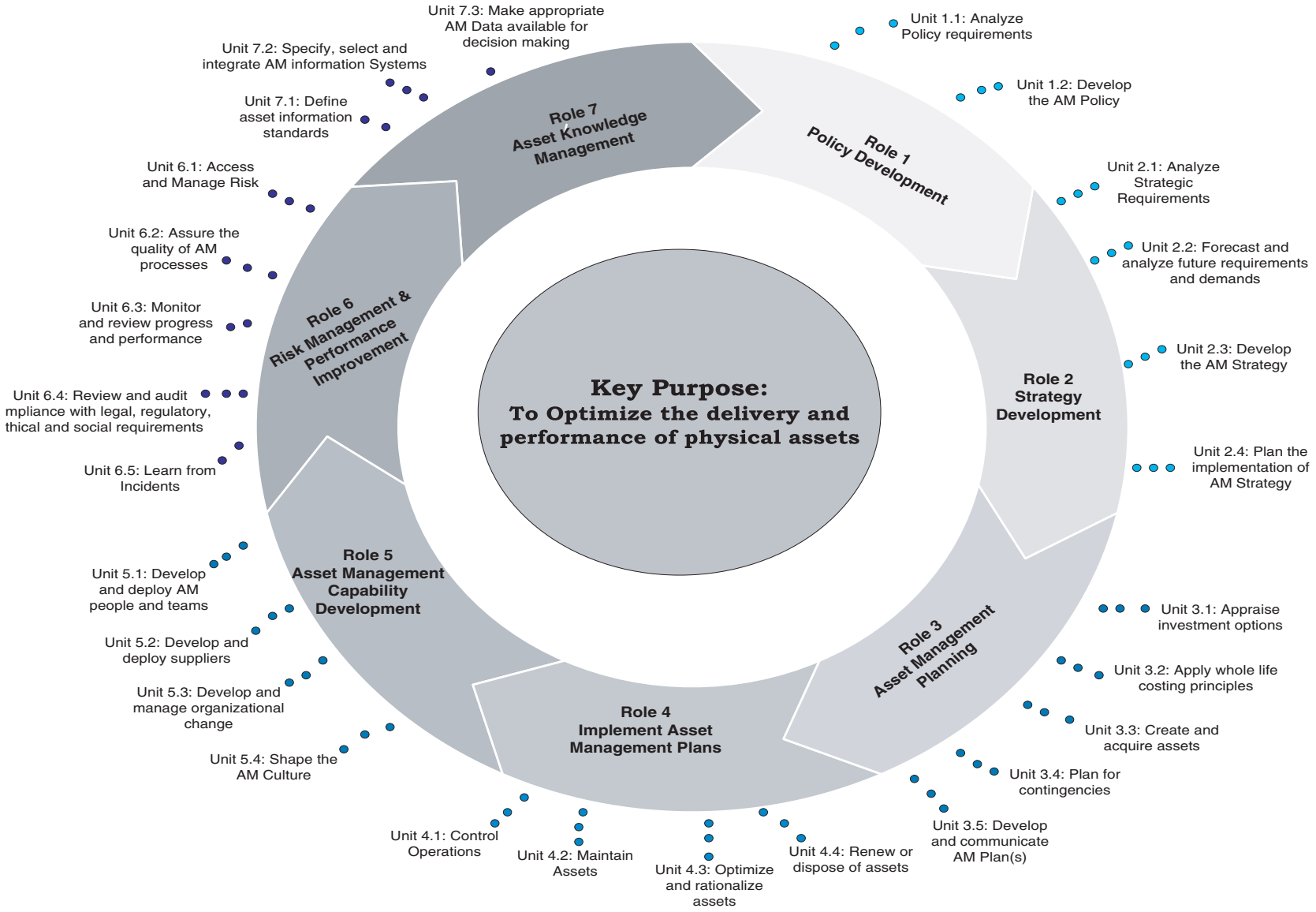


Figure 2-6. Roles and competencies for an asset management (AM) organization.

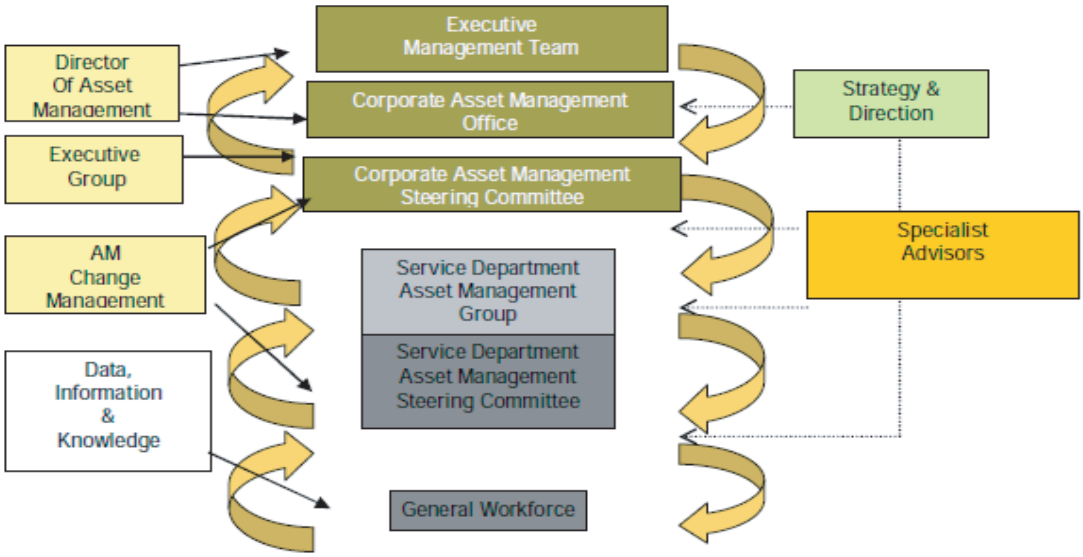


Figure 2-7. Committee structure and interactions for a decentralized AM organization model.

In the case of small airports, a single committee, or existing meeting structure through the addition of agenda items, is often sufficient to facilitate AM decision making and continuous improvement, since multiple roles are often undertaken by a handful of positions at the airport.

CHAPTER 3

Asset Management Objectives

Strategic Planning, Airport Master Plans, and Asset Management Objectives

Airport Strategic Planning

The airport strategic plan describes the mission, vision, KPIs and targets, and action plans for their realization. *ACRP Report 20: Strategic Planning in the Airport Industry* (Ricondo and Associates et al., 2009) states that the airport strategic plan should guide all other airport planning analyses. The airport strategic plan sets forth the foundation for planning initiatives and defines the road map that the organization should follow to achieve its vision. All other planning analyses should be aligned with, and support, the strategic plan.

The airport strategic planning process generates the KPIs and targets to be achieved. *ACRP Report 20* lists the following operational/managerial benefits of the strategic planning process:

- Facilitating the development of metrics to help measure airport performance, leading to increased efficiency,
- Creating a blueprint for prioritizing projects, and
- Enabling airport management to examine, in a more comprehensive manner, bold initiatives, strategies, and alternatives more easily than during the master planning process.

The inputs to the strategic planning process are illustrated in Figure 3-1 and include views of internal and external stakeholders, the commercial and competitive environment, performance of the airport, industry trends and existing constraints, which include statutory and regulatory requirements. The outputs of the process include action plans and KPIs that become inputs to the master planning and other planning processes.

ACRP Report 20 describes the interrelationships of airport planning processes in Figure 3-2. Research under ACRP project 01-16 indicates that the asset management planning activity is undertaken prior to the development of the resource and staffing plan, using inputs from all planning documents. This modification to the *ACRP Report 20* figure is shown in orange in Figure 3-3. (See online version for color.)

Airport Master Planning

The airport master plan outlines the 5- to 20-year plan for airport development and investment required to meet forecast demand and strategic goals. The outputs of this process are inputs to the process for determining the objectives for asset management in terms of meeting strategic objectives and customer and stakeholder needs.

The FAA Advisory Circular, AC 150/5070-6B states, "an airport master plan is a comprehensive study of an airport and usually describes the short-, medium-, and long-term development plans to meet future aviation demand. The category of study that includes master plans and

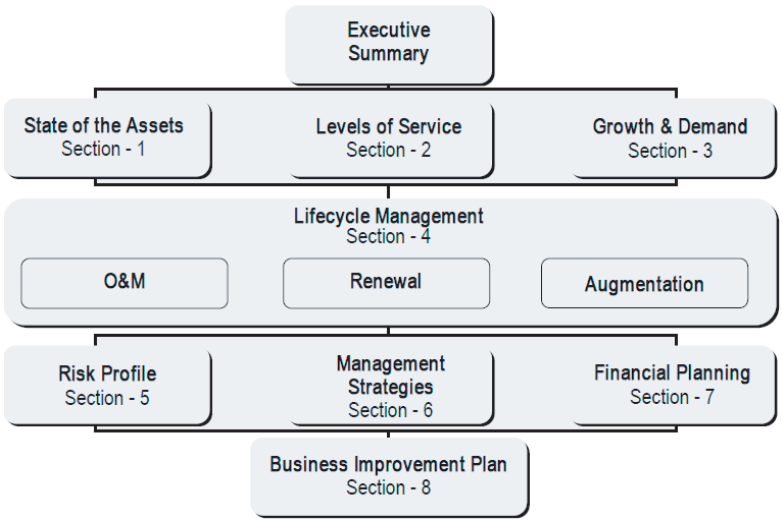


Figure 3-1. IIMM—asset management plan table of contents.

master plan updates can therefore be thought of as a continuum that varies by level of detail and associated effort."

Master planning is particularly important to asset management execution, since its outputs are an input to the asset management planning and strategy development process. The asset management planning processes result in strategies and investments in operations, maintenance, and renewal capital of the existing and new infrastructure to deliver the required levels of performance on a short-, medium-, and long-term basis.

Master planning as required by the FAA is concerned with meeting future aviation demand through FAA terminal area forecasts (TAF) and other means, and the vision of the airport from the point of view of development, whereas asset management planning is concerned with ensuring that the assets and infrastructure of the airport are adequately funded and managed to deliver that vision.

The majority of airports surveyed employ methods for predicting demand beyond the extrapolation of patterns. These include

- Using the outputs of integrated regional planning studies for transportation services and economic growth and
- Reviewing local land use plans and air traffic and passenger growth projections.

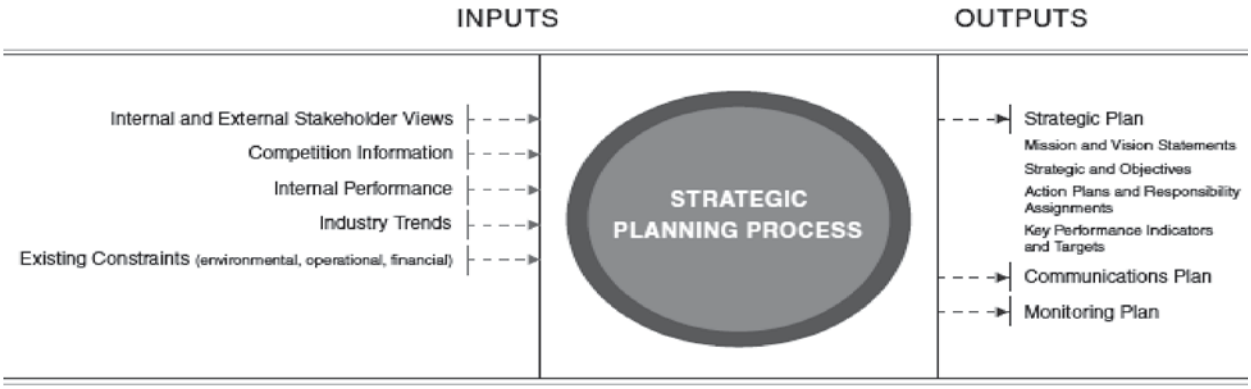


Figure 3-2. Inputs and outputs of the strategic planning process (Strategic Planning in the Airport Industry).

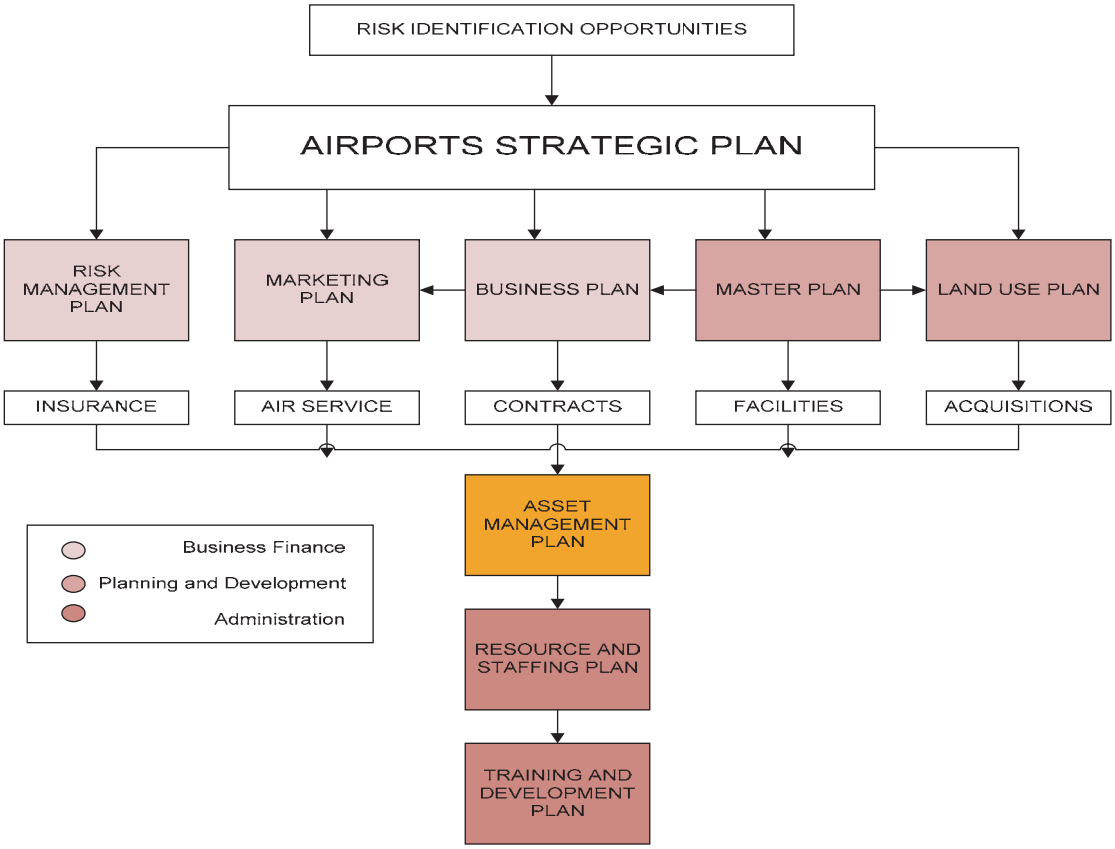


Figure 3-3. Interrelationship of airport planning process.

The online survey undertaken as part of the development of this guidebook indicated that 87 percent of respondents undertake community and stakeholder consultations as part of the process for developing Airport Master Plans, with 54 percent addressing levels of service with respect to noise abatement, flight paths, traffic planning, and land development.

Link between Asset Management Objectives and Airport Master Plan

PAS 55, Part 1, 2008, states that asset management objectives should be

- Specific and measurable outcomes or achievements required of the asset system(s) in order to implement the asset management policy and asset management strategy, which are required to meet the objectives of the strategic plan.
- Detailed and measurable levels of performance or condition required of assets.
- Specific and measurable outcomes or achievement required of the asset management framework or system.

An example of the linkage between the airport master plan implementation and asset management objectives can be illustrated in the following:

An airport is experiencing terminal capacity problems. The master plan indicates that additional runway and terminal expansions are required. However, the lead time to commission such expansions requires that changes need to be made to operating processes and asset management in order to improve the capacity of the existing terminal in the interim. This may require:

- Use of process improvement techniques such as Lean 6 Sigma (a quality management and statistical analysis approach to eliminate defects and reduce the variability in business

processes) to increase the capacity of terminals in terms of passenger throughput and aircraft turnaround, and
- Review of maintenance strategies for passenger boarding bridge to ensure that operational downtimes are limited in order to meet arrival processing and aircraft turnaround time targets.

Customers, Regulators, and Performance Requirements

The research showed that service-level agreements between the airport and contracted service providers are not uncommon. Regular review of these requirements during the asset management planning process is necessary to continually improve the level of service to customers and to ensure the translation of any new requirements to the asset level for the purposes of updating maintenance and renewal strategies.

For discretionary levels of service (not regulated or required by law), many airports run customer surveys to establish customer priorities and the level of customer satisfaction with aspects of their experience while using the airport. A simple example is the cleanliness of restrooms and their availability. For one medium-sized airport visited during the research, inspection and maintenance practices for restroom lighting were modified and planned group relamping was adopted.

Another example for a small airport relates to the KPI for passenger processing and aircraft turnaround. Changes to electrical maintenance activities were put in place to ensure that power supporting the check-in process is not interrupted during airport operating hours.

Setting Performance Requirements

Performance requirements are set through the airport planning processes, using three key steps:

For large airports

1. Update the airport strategic plan, KPIs, and targets;
2. Update the risk management plan, business plan, land use plan, marketing plan, and airport master plan to achieve the airport strategic plan objectives; and
3. Revise asset performance standards to support each of the plans developed in Step 2.

For small airports

1. As part of the annual business planning and budgeting cycle, liaise with customers and stakeholders to address any performance concerns and agree on any changes to service levels, if any;
2. Update the master plan when, and as, required; and
3. Revise asset performance standards to support customer and stakeholder negotiation and master plan outputs.

CHAPTER 4

Asset Management Strategies and Plans

Asset Management Plans, Content, and Development

Asset management plans use master planning and other airport planning activity outputs to determine what the assets need to do in order to support these plans. This includes understanding the imminent failure modes in terms of levels of service, regulation, capacity, and physical failure, and the management of renewal and operations and maintenance of the existing and new assets to achieve the stated strategic objectives.

Asset management plans contain many variants of the following content:

- Overview of the facility/system or network,
- Levels of service—current performance and targets,
- Strategies and investments to close performance gaps,
- Risk assessment,
- Risk mitigation,
- Renewal plan,
- Demand and growth,
- Capital plan (new assets),
- Ten-year infrastructure investment plan,
- Ten-year funding plan,
- Business improvement (business process, data)
- Challenges for implementing the plan, and
- Human resource requirements to implement the plan.

Figure 4-1 shows an example of the asset management plan contents for a small municipal airport in Australia (Part 4 Kingscot Airport Asset Management Plan, April 2010).

The IIMM describes a roadmap for developing asset management plans as shown in Figure 4-2.

The EPA describes the process for developing an asset management plan as answering 5 core questions in 10 steps. The 5 core questions are

1. What is the state of the assets?
2. What is the required level of service?
3. Which assets are critical to sustained performance?
4. What are my best operations, maintenance, and capital investment strategies?
5. What is the best funding strategy?

Question 1 is concerned with the development or update of the basic asset financial and performance information needed as an input to the investment planning stage. The investment decision making is then driven by Question 2, where the levels of service to be delivered are set. In Question 3 the determination of asset criticality is completed using a triple bottom-line

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Figure 4-1. Small municipal airport asset management plan table of contents.

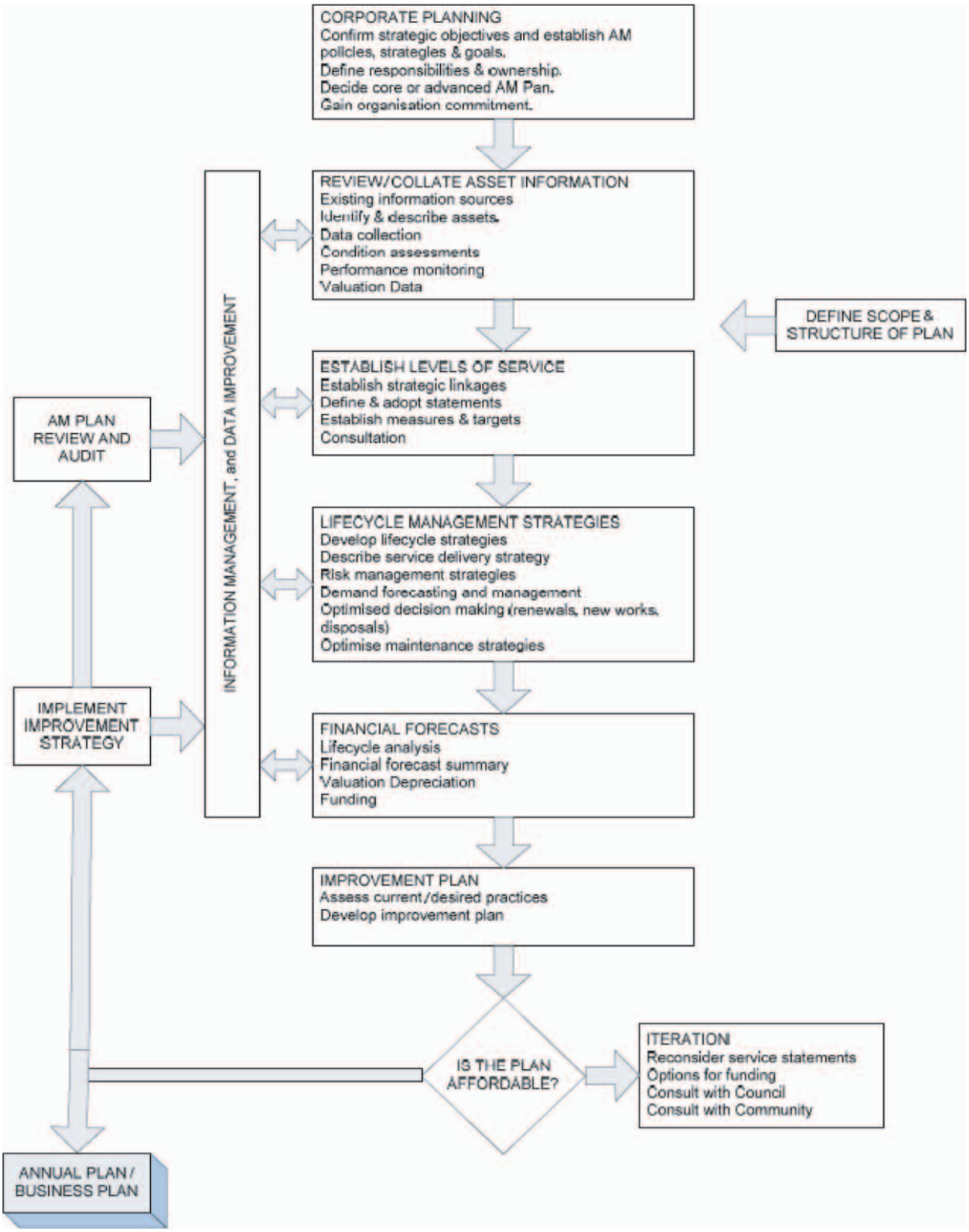


Figure 4-2. International Infrastructure Management Manual road map for developing asset management plans.

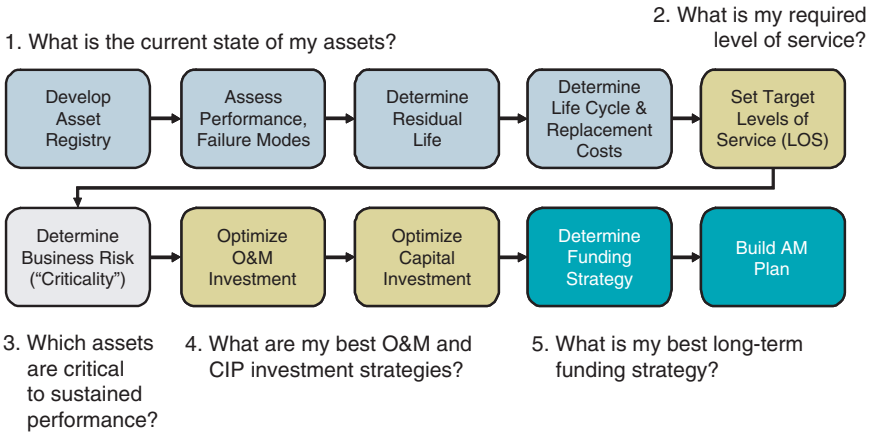


Figure 4-3. EPA 10-step asset management process.

assessment of the consequences of failure of each asset or systems of assets. The triple bottom-line approach assesses the economic, environmental, and social impacts of failure. Question 4 involves running scenario analyses for different asset strategies and investment options in order to identify the best, feasible trade-offs between cost, risk, and levels of service. Question 5 identifies the funding strategies, and may involve a reevaluation of the operations, maintenance, and capital strategies, depending on the funding strategy outcome.

The EPA 10-step process for developing an asset management plan is a particularly useful guide for airports, especially for the development of the first asset management plans, and is illustrated in Figure 4-3. As the asset management planning activity becomes embedded in the airport planning processes, the update of the asset management plans focuses on re-running the investment analysis using updated data rather than a full establishment of the state of the assets data and information and constraints, and therefore, involves far fewer resources and time to execute. An MS Excel or commercial off-the-shelf model is necessary to achieve this. Asset management plan models are discussed further in section titled "Asset Management Information and Decision Support."

Variants of the EPA five core questions are not uncommon. One U.S. seaport uses the following (Grotheer):

1. What do we own and how long do we want it to last?
2. Who is responsible for the maintenance?
3. What is the age, condition, and cost to replace?
4. How long will the assets last based on appropriated maintenance funding?
5. Where do we place strategic priorities?

Guidelines for Developing an Asset Management Plan

Step 1: Develop Asset Registry

The asset registry is a database or spreadsheet inventory of all assets within an asset group or service for which the asset management plan is being developed.

The asset registry has a hierarchical logic associated with it so that it is possible to evaluate investment needs for individual assets, or the systems within which they function. For example, investment needs can be determined for all airport infrastructure (the enterprise level), or for all aviation infrastructure, or one asset group within aviation infrastructure (e.g., airfield lighting, or runway lighting or for a single lamp within any part of the airfield lighting system). A complete asset registry for asset management planning is essential for understanding the total cost of service.

The level to which the asset hierarchy is built is typically to the maintenance managed item (MMI) level, which is the level at which work orders are written. Asset components are not included in the hierarchy unless they are critical, or of high value. The business rules for determining the level to which the hierarchy is built needs to be agreed upon.

Some key questions for defining assets and the hierarchy structure are as follows:

1. Does the hierarchy structure align with the functions of the business?
2. How will the item be replaced/renewed/retired?
3. Will the item be replaced as a unit with a parent asset?
4. Will the item be replaced individually?
5. Does the item have a capital replacement value?
6. Is the item critical?

Figure 4-4 shows an example of an asset register hierarchy from a large airport.

In this example, the asset functional code and name is one of the key classifications around which the whole structure of document management, work planning, maintenance reporting, handover deliverables, and information cataloguing has been built. This airport uses a hierarchical system where Level 1 is an independent system, with Levels 2 and 3 being dependent systems. For example, within the 200 series (building, structure, fabric), 217 (lightning protection) has

Example Asset Hierarchy

LEVEL	ASSET (S)
100	Airfield
200	Buildings, Structure and Fabric
300	Baggage
400	Safety, Security and Fire
500	Information and Communications
600	People and Related Transport
700	Areas, Railways and Vehicles
800	Services and Utilities

LEVEL 1

Code	Name
200	Buildings, Structure and Fabr
212	Roof
213	Facade
214	Canopies
215	Bridges
217	Lighting Protection
221	Check in Desk
223	Interior Walls
224	Floor Finishes

LEVELS 2 and 3

217	Lighting Protection for Removeable Structures
73	Cable
140	Control Panel
182	Arrestors
269	Bonding
269	
321	Masts
367	Rods

Figure 4-4. Asset register hierarchy example—large airport.

dependent subcomponents such as an arrestor (182) and the arrestor has a dependent subcomponent such as a spike (345).

Step 2: Assess Performance and Failure Modes

Asset performance has the following three primary components:

1. Operating cost,
2. Utilization, and
3. Condition.

Operating cost, utilization, and condition of the asset should be known to estimate the timing of each of the following possible failure modes:

- Economic failure likelihood and timing,
- Capacity failure likelihood and timing against demand predictions, and
- Physical and functional failure likelihood and timing.

Evaluating Economic Failure—An asset has reached a point of economic failure when it is no longer competitive with asset options that are available in the marketplace for delivering the same or improved function. A business case including a lifecycle cost analysis of feasible alternatives is usually required before a change-out of the asset goes ahead.

Tips for addressing economic failure

- Stay current with available technologies, their cost, and performance capabilities;
- Ensure that the question of more economic options is a part of the review of systems and their cost performance; and
- Require that lifecycle cost analysis of economic alternatives is undertaken and pay back periods and accumulated savings are understood.

Evaluating Capacity Failure—The airport master planning process estimates the future growth in operational demand and provides a plan for meeting this demand in terms of airport services such as runway capacity, terminal capacity, and ground transportation services such as buses, car parks, and light rail.

Tips for addressing capacity failure

- Include the master plan demand forecast information and capacity upgrade plans in the analysis of total capital investments,
- Include the lifecycle operations and maintenance costs associated with the proposed new assets included in the capacity upgrade plans resulting from the master planning process,
- Review work order histories and staff knowledge to identify existing assets that are experiencing capacity failure or impending capacity failure and include budget and timing information in the investment needs assessment, and
- Initiate projects for meeting capacity needs for existing assets.

Undertaking Condition Evaluation—Asset condition evaluation serves two purposes: (1) to identify maintenance and rehabilitation needs and (2) to monitor the health of the asset network.

To identify rehabilitation and maintenance needs, the condition evaluation must be timely (usually annual or biannual) and detailed. Condition evaluation requires the identification of individual defects, such as transverse cracks in pavements, blocked drainage appurtenances, or roof leaks and the evaluation of their severity and extent. Monitoring this detailed level of condition has several advantages as follows:

- Detailed condition information is available for design of preventive maintenance and rehabilitation activities,
- Types of distresses and rate of deterioration are monitored for each to identify ways of improving current design and construction practices, and
- Better prediction of future needs and more accurate estimation of network condition and budget estimates are likely.

Recording and rating of features provides the ability to have the "show me" features in the asset management software application such as "show me the length of all taxiways that have a condition rating greater than 6 but less than 8, that have raveling of moderate severity, or those with poor surface drainage."

Tips for evaluating the condition of assets for asset management planning

1. Undertake a desktop analysis using work order histories and recent condition evaluations, and work sessions with operations and maintenance staff that are most familiar with the current performance and condition of the assets;
2. Use the condition scores as a service-level requirement and consequence of failure assessment to identify assets for visual inspection and/or diagnostic testing; and
3. Use condition assessment protocol or scoring procedures so that future condition assessments can be compared on the same basis.

Table 4-1 provides a simple approach to the evaluation and scoring of asset condition.

Condition Assessment of Assets Subject to Regulation—Assets that are subjected to regulatory driven inspections follow specific standards for assessing condition, such as ASTM D5340

Table 4-1. Simple condition scoring protocol.

Condition Score	Description
1	New or Excellent Condition
2	Minor Defects Only
3	Moderate Deterioration
4	Significant Deterioration
5	Virtually Unserviceable

Table 4-2. Asphalt and concrete pavement distress types.

PCI asphalt distress list*		PCI concrete distress list*	
Distress type	Severity levels**	Distress type	Severity levels**
Alligator cracking	L, M, H	Blow up	L, M, H
Bleeding	N/A	Corner break	L, M, H
Block cracking	L, M, H	Linear cracking	L, M, H
Corrugation	L, M, H	Durability cracking	L, M, H
Depression	L, M, H	Joint seal damage	L, M, H
Jet blast erosion	N/A	Small patching	L, M, H
Joint reflection cracking	L, M, H	Large patching	L, M, H
Longitudinal and transverse cracking	L, M, H	Pop outs	N/A
Oil spillage	N/A	Pumping	N/A
Patching	L, M, H	Scaling	L, M, H
Polished aggregate	N/A	Faulting	L, M, H
Raveling and weathering	L, M, H	Shattered slab	L, M, H
Rutting	L, M, H	Shrinkage cracking	N/A
Shoving	L, M, H	Joint spalling	L, M, H
Slippage cracking	N/A	Corner spalling	L, M, H
Swelling	L, M, H		

* FOD distresses are in bold.
** Severity levels are defined as (L)ow, (M)edium, and (H)igh.

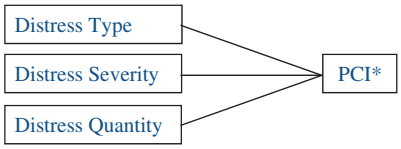
Test Method for Airport Pavement Condition Index Surveys and ASTM D6433 for Road and Parking Lot Pavements.

The ASTM standard uses a zero-to-100 numerical scale for its Pavement Condition Index (PCI). The PCI is a measure of distress type quantities and severities. Table 4-2 shows the asphalt and concrete pavement distress types used to determine the PCI as shown in Figure 4-5.

The asset breakdown for determining the PCI is to define sample units associated with a pavement section. The sample units are 5000-square-foot areas for asphalt pavements and 20 slabs for short jointed concrete pavements.

Pavement sections are divided according to structure, condition, and traffic requirements. The PCI for the pavement section is the average of the PCI for each of the sample units. Many airports use pavement management system software to assist in the calculation of the PCI.

A simplified visual inspection approach for airfield pavements has been adapted from the flexible and rigid road Pavement Surface Evaluation and Rating (PASER) tool by the University of Wisconsin-Madison. This approach is not intended to replace the PCI approach previously explained, but does provide a simple, cost-effective, visual inspection methodology that can be used as part of a condition assessment approach for airfield pavements (Mitchell 2011).



*PCI=Pavement Condition Index

Figure 4-5. Pavement condition index inputs.

Note that PASER manuals are an appendix to the FAA Advisory Circular 150/5320-17; Airfield Pavement Surface Evaluation and Rating Manuals.

Step 3: Determine Residual Life

Residual life is determined once the likelihood and timing of the imminent failure mode is known. Residual life is the time left until failure and is particularly important for managing high-cost and high-risk (high-consequence) assets. A prediction of time to failure enables the asset manager to initiate a planning process for the renewal of the asset prior to incurring the costs and service-level impacts of failure.

Assets do not always reach their design life, or can sometimes exceed design life due to a number of factors including

- Requirement to operate the asset at a level not envisaged during the design phase,
- Human factors,
- Operating environment, and
- Maintenance type and frequency.

Therefore, the determination of remaining life is one that can be unique to the asset and its application. This is particularly true for long-lived civil and structural assets.

Asset management investment models can use a straight-line relationship to deteriorate the assets with time, or they can use either an empirically derived decay curve or an adopted decay curve to mimic what operators and maintainers believe to be the pattern of decay of a class of assets.

Step 4: Determine Lifecycle and Replacement Costs

Lifecycle costing (LCC) includes all costs of owning and operating the asset from planning through retirement or replacement as illustrated in Figure 4-6.

The lifecycle cost of an asset is determined as follows:

LCC = capital cost + lifetime operating costs + lifetime maintenance costs
+ disposal cost – residual value.

Lifecycle costs are largely locked in at the design stage, indicating that collaboration between operations, maintenance, and design staff is an essential requirement during the design of new facilities, or the modification of existing facilities, as is the need for full lifecycle cost comparisons to be made of feasible alternatives.

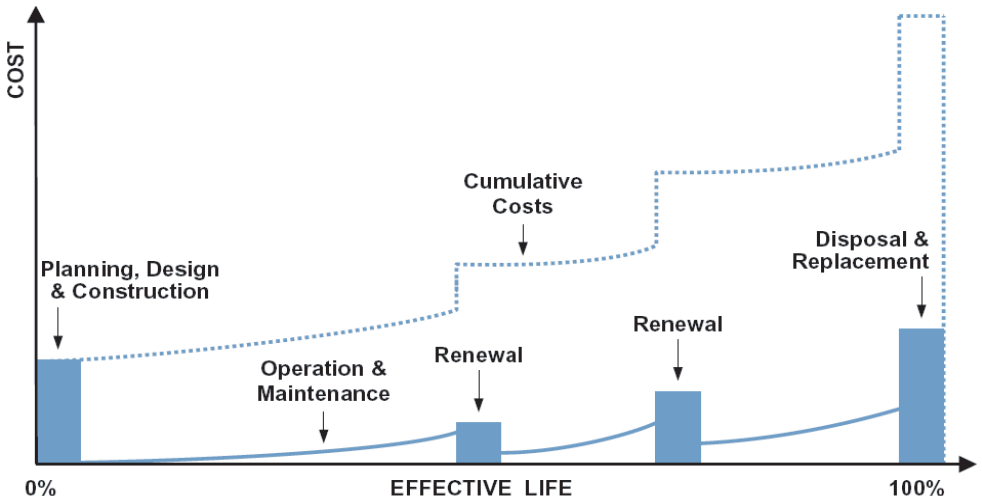


Figure 4-6. Lifecycle cost components.

Asset management plans endeavor to minimize the cost of ownership and operation while achieving levels of service within an acceptable level of risk exposure. The asset management planning process tests asset strategies (capital investments and operations and maintenance approaches) against lifecycle cost and risk, across the full set of assets of the organization.

Steps for undertaking lifecycle costing for asset strategy modeling or analysis

- Determine the current replacement cost of each asset as follows:
  - Note current replacement costs are used to program replacement investments when they come during the asset lifecycle; current replacement costs can be determined using
    - Current purchase price plus installation and commissioning cost of the asset,
    - Review of the past contracts, and
    - Determination of quantities and application of current unit rates for labor and materials.
- Determine the current maintenance cost of each asset and if it is likely to increase as the asset ages;
- Determine the current operating cost of each asset (for example, labor, energy consumption, chemical usage) and if it is likely to change as the asset ages; and
- Estimate future maintenance and operating costs;
  - Note future costs are usually subject to a level of uncertainty that arises from a variety of factors, including the following:
    - Prediction of the pattern of use of the asset over time,
    - Nature and scale of operating costs,
    - Need for, and cost of, maintenance activities,
    - Impact of inflation and the opportunity cost on individual and aggregate costs,
    - Prediction of the length of the asset's useful life, and
    - Significance of future expenditure compared with present day expenditure.

For many airports, maintenance and operating costs will not be known at the asset level for all assets. It is an acceptable practice to escalate current maintenance costs at the level that they are known (system or facility, or by program) and to limit more detailed analysis of cost to assets that incur a significantly high recurrent cost to the airport.

Step 5: Set Target Levels of Service

This step involves establishing target levels of service for each asset. Levels of service can be expressed in terms of

- Condition,
- Reliability and availability, and
- Operational parameters.

Levels of service are usually defined at the planning stage but they can change throughout the life of the asset and therefore warrant periodic review. In fact, the asset management processes and practices of the airport should support ad hoc changes to asset, systems, and facility levels

of service as required and/or negotiated with customers and stakeholders. The cost of service associated with a change in level of service can be more easily determined and communicated if asset management planning investment models are in place.

Target levels of service are used in the asset management planning process to

- Identify the gaps or poor performance relative to the target,
- Specify budget estimates for investments to close performance gaps, and
- Identify changes to maintenance or operating strategies to close performance gaps.

Steps for assigning levels of service to assets for the purposes of asset management planning

- Review contract agreements with operations and maintenance service providers,
- Collate minimum regulatory requirements,
- Review strategic plan KPI and targets,
- Translate these needs to systems and assets in terms of
  - Availability (e.g., must operate 24 hours per day, 7 days per week);
  - Reliability (e.g., must not fail);
  - Condition (e.g., must be maintained at not greater than condition rating of 3); and
  - Throughput/output (e.g., 30 bags per minute).

Figure 4-7 shows an example of levels of service used in asset management planning for a small airport (Kangaroo Island Airport Asset Management Plan).

Step 6: Determine Business Risk (Criticality)

This step identifies critical assets, which are those assets that are high cost and/or result in detrimental levels of service and significant consequences if they fail. By understanding where the greatest risks lie, it is possible to focus investment and attention where it matters most, and actively mitigate against non-tolerable risks through the asset management planning process.

Risk exposure is calculated as follows:

$$\text{Risk Exposure} = \text{Probability of Failure} \times \text{Consequence of Failure}$$

Many methods can be used for evaluating risk exposure associated with the physical failure of assets. One method is illustrated in Figure 4-8 for a large airport.

Another common method is to use the condition score for the asset as a proxy for the probability of failure, and to determine the consequence of failure as either high, medium, or low, or as a score associated with impacts to the triple bottom line (social, economic, environmental).

The key objective of the asset management plan is to work toward the most achievable trade-off between level of service, cost, and risk exposure. Asset management planning software models include links to level-of-service impacts through the risk assessment consequence of failure calculation. This enables modeling of the impact on level of service and risk associated with

Key Performance Measure	Level of Service	Performance Measure Process	Performance Target	Current Performance
Maintain or improve quality of service				
Quality	To provide a well maintained, safe and efficient airport service	TOMM Exit Surveys Reports from within Tourism Industry Customer service request	Work toward meeting KPIs in strategic plan Maintain or Improve quality of service Meet with requests	Action feedback from TOMM survey Act on feedback from Tourism Industry Satisfactory
Function	Ensure that the airport facility meets user requirements	Usage of facilities	Average use > 5,000 passengers per month in peak times	Satisfactory
Safety	To provide safe and suitable facilities free from hazards	Number of injuries/incidents	Reduction in recorded number of injuries/incidents	TBA
Technical Levels of Service				
Condition	Provide appropriate airport facilities that are maintained to meet CASA regulations and user requirements	Service and maintenance request responses Emergency response	Less than 5 reactive service requests per month Provide full assistance to emergency service authorities	TBA Satisfactory
Availability	To meet the criteria of council and community demand	Record of closure of facilities	Facilities available when scheduled 100% on time	Satisfactory
Cost Effectiveness	Provide appropriate airport facilities in a cost-effective manner	Maintenance cost: $ per facility per year	Reduce maintenance costs Increase user contributions/charges to the RPT sector to reduce costs	$85,000/year

Figure 4-7. Example of levels of service for a small airport asset management plan.

Asset at Risk	What can Happen	Risk Rating (VH, H)	Risk Treatment Plan
Runway	Tire blow out due to debris on runway	H	Increase frequency of runway sweeping. Monitor current program, increase if required
Runway	Tire blow out due to pavement failure	H	Increase frequency of resealing. Engineers Assessment and report
Drainage	Water hardstand areas due to blocked drains	H	Increase frequency of resealing. Increase visual inspections
Terminal Building	Security/Vandalism	H	Security review and design review and change. Continue currect program and implement renewal program
Terminal Building	Electrical Fault	H	Regular inspections and preventative treatments. Increase Visual inspections
Terminal Building	Public liability	H	Regular and documented inspections. Upgrade safety inspections to include action report
Terminal Building	Fire (internal generated within building)	H	Maintain fire equipment in high use and building rules and auditing. Implement Annual Inspections
Aircraft	Damage due to animal Activity	H	Regular monitoring and upgrade of existing perimeter fencing. Occasional eradication and bird dispersal.

Figure 4-8. Example of a risk management plan for a small airport.

alternative operations, maintenance, and capital investment scenario. An alternate approach for a small airport is shown in Figure 4-8.

Step 7: Optimize Operations and Maintenance Investment

Optimization of operations and maintenance investment requires that strategies are actively considered for the purposes of meeting asset service-level performance requirements. The online survey undertaken as part of the development of this guidebook indicated that 6 percent of respondents undertook reactive maintenance only, and 46 percent stated that their maintenance was somewhat proactive but mostly reactive.

However, there are many instances where running an asset to failure is an acceptable strategy. Figure 4-9 shows a simple decision diagram for determining which maintenance strategy, other than routine preventive maintenance, is most appropriate for each asset:

- Run to failure with planned corrective failure response;
- Condition-based maintenance, which undertakes maintenance once inspection indicates the need; or
- Usage-based maintenance (e.g., undertake condition after 40 hours run).

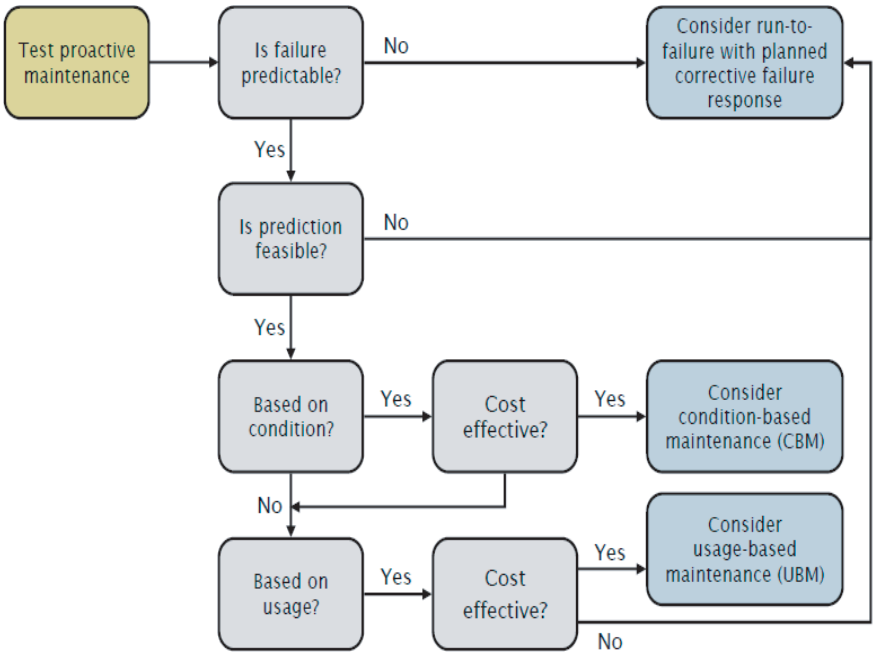


Figure 4-9. Selecting maintenance strategies.

Steps for identifying the best maintenance strategies

- Using a spreadsheet analysis for business risk exposure from Step 6, identify the critical assets by their high risk-exposure scores,
- For all critical assets, apply the decision process in Figure 4-9 for identifying the best maintenance strategies,
- Determine the maintenance tactics associated with each strategy and estimate percentage impacts to the maintenance budget,
- Implementation of the changes to maintenance strategies will involve a review of the maintenance program or contract agreements, and
- Add projected maintenance cost to the asset management plan investment requirements.

Step 8: Optimize Capital Investment

Steps 1 through 6 have provided the following information:

1. An asset register spreadsheet on which to build the asset management planning analysis,
2. Condition of each asset and likely failure modes,
3. Likely remaining life or timing of asset failure,
4. Current replacement cost of each asset,
5. Current and targeted levels of service,
6. Identification of critical assets using a risk-exposure score calculation method, and
7. Current and likely future operations and maintenance costs after reviewing maintenance and operations strategies to meet level-of-service targets.

This next step, Step 8, is to bring the data and information established through Steps 1 through 7 together to evaluate the best operation, maintenance, and capital investment strategies needed to

The Greater Toronto Airport Authority (GTAA) facilities asset management system supports the overall capital planning process by providing a technically prioritized listing of required restoration requirements for all fixed assets.

A high-level planning and capital expenditure tool is used to understand the condition of the airport's physical assets, their replacement costs, lifecycle costs, and the implication of deferred investments. Each major asset type has its own inventory and condition monitoring tools (e.g., baggage handling and people mover equipment, buildings, bridges, pavements). Information from these systems feeds a commercial software application called Renewal Capital Asset Planning Process (ReCAPP). ReCAPP includes a fixed asset ledger, asset valuation and condition deterioration and weighting tools, minimum condition thresholds and requirements, and financial reporting to assist in programming asset renewal.

Commencing in 2010, individuals responsible for a particular asset type perform regular formal condition assessments to establish performance models for the assets. The performance data is used to determine investment needs, which are then fed into the GTAA 5-year capital restoration plan.

Figure 4-10. Operations, maintenance, and capital investment decision making.

deliver the required level of service at the best cost and level of risk exposure. This is often referred to as optimization. To optimize the decisions for all assets, especially for large airports, analysis tools are required. Figure 4-10 explains the process used at Toronto Pearson International Airport.

For initial asset management plans, it is appropriate to first develop a plan using a simple renewal decision-making tool, such as a spreadsheet, and test a selection of feasible renewal strategies and their likely outcomes to arrive at the best combination of investments. A simple renewal decision-making tool would allow the user to manually move an asset replacement out several years and increase maintenance on the asset, and compare the cash flow requirements with an option where replacement occurs earlier.

Asset renewal includes replacement and major rehabilitation, including emergency and planned replacement activities, to upgrade the condition of the asset to an almost new condition with the expectation of a significant increase in service life. However, there are usually several options to be considered as part of renewal decision making to ensure that the most cost-effective option is adopted in terms of lifecycle analysis, risk, and service level performance. These include

- Do nothing,
- Maintain differently,
- Operate differently,
- Repair,
- Refurbish/rehabilitate,
- Replace asset with similar,
- Replace with an improved asset, and
- Reduce levels of service.

The following approach can be used for planning renewal:

1. Using the failure mode analysis from Step 2, identify those assets due for renewal during the planning period,
2. Review renewal options for each asset and determine the most feasible option,
3. Develop a budget estimate of the renewal option capital and recurrent costs,
4. Use the residual life estimate from Step 3 as the timing for the investment, and
5. Input investment information in the spreadsheet and generate a renewal investment profile.

Description	Type
Do nothing	Non-Capital
Maintain differently	Non-Capital
Operate differently	Non-Capital
Repair	Capital
Refurbish/rehabilitate	Capital
Replace asset with similar	Capital
Replace with improved asset	Capital
Reduce levels of service	Non-Asset

Figure 4-11. Investment scenario types and classification.

Step 9: Determine the Best Funding Strategy

This step evaluates the available funding strategies to implement the asset management plan investment requirements developed through Steps 1 through 9.

Airports use a handful of options for funding new and renewal capital requirements including bond financing, the FAA Airport Improvement Program (AIP), and Passenger Facility Charges (PFC).

Asset management staff provides the financial analysts with investment requirements represented in the funding "buckets" using the rules and policies established by the airport for allocating costs to customers and other funding sources. Figure 4-11 shows an example of the allocation of renewal investment needs to capital expenditure.

An analysis of the impact on charges of the proposed maintenance, operations, and capital expenditures required to meet the prescribed levels of service over the planning period should be included in the asset management plan. This information then represents the net increase (or decrease) in the cost of service associated with the plan. Figure 4-12 shows a typical rate impact analysis undertaken as part of asset management planning for a single facility.

As asset management plans are developed for each of the airport's asset groups, a full picture of the impact on airport customer charges for sustainable infrastructure support can be provided to executive decision makers. This then also provides a basis for levels of service discussions with customers and stakeholders, and with administrators of FAA and state funding.

Step 10: Document the Asset Management Plan

Step 10 is the final step in the process and is concerned with the packaging of the asset management plan information into a form that communicates well with operators and executive decision makers.

Figure 4-10 shows the IIMM suggestion for asset management plan content. This approach uses eight sections that are condensed in the Executive Summary:

Section 1: State of the Assets—Summarizes the current condition and performance of the assets.

This figure shows a typical 10-year incremental rate impact representation used to communicate the impact that the plan is expected to have on customer charges.

FY	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Rate Impact	0.00%	0.78%	0.70%	0.68%	0.77%	0.85%	0.85%	0.83%	0.84%	0.85%

Figure 4-12. Rate impact summary for a facility asset management plan 10-year investment requirements.

Section 2: Levels of Service—Outlines the current and target levels of service.

Section 3: Growth and Demand—Shows the forecast growth and demand requirements for the planning period.

Section 4: Lifecycle Management—Describes the current operations, maintenance, and capital renewal and augmentation or expansion plans and approaches.

Section 5: Risk Profile—Describes how risk exposure is evaluated and identifies at-risk assets.

Section 6: Management Strategies—Describes the operations, maintenance, and capital investment strategies determined for the planning period. This may include changes to maintenance strategies to implement more proactive maintenance or could include changes to emergency response plans for specific events.

Section 7: Financial Planning—Summarizes all costs associated with the implementation of the management strategies described in Section 6. It also includes a funding strategy and the associated impact on charges and key financial indicators.

Section 8: Business Improvement Planning—Describes any process improvements or projects required to improve the quality of asset management planning at the airport. Examples of typical business improvement projects include the implementation of an enterprise resource planning system, a computerized maintenance management system, or new maintenance schedules or changes to the project delivery process.

The asset management plan needs to speak to the following three groups:

- Operators,
- Executive decision makers, and
- Stakeholders.

A proven successful approach is to include detailed information on asset register data and analysis in appendices, provide sufficient technical detail in the body of the document to inform facility managers, and add a comprehensive but brief Executive Summary that answers the five core questions:

1. What is the current state of my assets?
2. What is my required level of service?
3. Which assets are critical to sustained performance?
4. What are my best operations, maintenance, and capital investment strategies?
5. What is my best long-term funding strategy?

EXAMPLE: Application of 10-Step Process to a Passenger Boarding Bridge (PBB)

The assumptions made in this example include

- The airport owns and maintains all of their PBBs that provide potable water, 400 Hz power, and pre-conditioned (PC) air, as well as passenger boarding;
- The airport provides hydrant fuel at the gates;
- Airlines lease gate space, ticket counter space, and baggage makeup areas;
- The airport provides an accounting of total capital and operating cost details for leased areas to airlines in developing their rates and charges; and
- The planning period for this analysis is 20 years.

A spreadsheet tool has been used to illustrate the analysis. All cost figures are indicative only and do not represent actual costs.

Step 1—Develop Asset Registry

To easily categorize asset costs associated with leased gates, the airport's asset registry assigns the highest level asset code to the leased areas. A tabular referencing to the MMI (maintenance managed item) level results in the asset register hierarchy shown in Figure E-1. The development or review of the existing asset registry is undertaken by staff responsible for the maintenance and update of the CMMS (computerized maintenance management system) or airport facility maintenance software using a standard procedure developed by the asset manager for asset register development and review. For small airports, this might be a spreadsheet tool maintained by the maintenance manager.

Step 2—Assess Performance and Failure Modes

The purpose of this step is to determine how the PBB is most likely to fail in terms of

- Level of service (includes regulatory/safety requirements, aircraft sill height range of servicing requirements);
- Economic efficiency;
- Physical mortality (failure of critical components, for example, the wheel motor drives); and
- Capacity (passenger live loads and power/pre-conditioned air service, utilization).

Level of Service Failure

A full inspection of the PBB indicates that it currently meets all safety, regulatory, and design requirements in terms of aircraft and passenger servicing. The PBB is certified to NFPA 415 and UL#QGLA for passenger boarding bridges.

A review of the airport master plan shows that the gate is likely to continue operating under current service level performance requirements in terms of aircraft sill height ranges and passenger live load requirements, as well as pre-conditioned air and power requirements for the next 10 years. It is assumed, for the purposes of this asset management plan, that the levels of service requirements will remain unchanged for the duration of the 20-year planning period.

Current levels of service standards for operation of the PBB are

- Availability is 99.86 percent (down 12 hours per year maximum),
- Last 12 month's availability is 95.2 percent due to extended maintenance outage, and
- Allow for docking of CRJ type (Bombardier Canadair Regional Jet) aircraft.

Economic Efficiency Failure

Economic failure occurs when the NPV (net present value) of future cash flows associated with existing equipment costs is greater than the NPV of future cash flows associated with a replacement asset. The airport has not undertaken a lifecycle cost analysis of components of the PBB, and currently lacks the data to do this type of analysis. Component data collection will be facilitated through the review of business processes and CMMS gap analysis as part of an upgrade initiative during the next 18 months.

Level 1	Level 2	Level 3	Level 4
1 – Gate	-11 Gate 1 PBB	-111 PC Air	-1111 Air hose
			-1112 Condenser
			-1113 Compressor
		-112 400 Hz power	-1121 Cord
			-1122 Plug
			-1123 Retractor/cable hoist
		-113 Potable water	-1131 Cabinet
			-1132 Hose
		-113 Interiors	-1131 Wall covering
			-1132 Carpet
			-1133 Hand rails
		-114 Rotunda	-1141 Bearings
			-1142 Curtain
			-1142 Base column
		-115 Pedestal	
		-116 Tunnel assembly	-1161 Tunnel assemblies
			-1162 Tunnel roller assemblies
		-117 Wheel bogie	-1171 Assembly
			-1172 Wheel 1
			-1173 Tire pneumatic
			-1174 Wheel motor DC drive
			-1175 Wheel motor AC drive
			-1176 Tire solid
		-118 Lift Column 1	-1181 Lift Column 1 motor
		-119 Lift Column 2	-1191 Lift column ball screws
		-120 Cab assembly	
		-121 Cab curtain	
		-122 Cab bumper	
		-123 Stairs	
		-124 Bag chute	
		-125 Use/power meter	

Figure E-1. PBB asset register hierarchy.

A PBB itself may become economically outdated based on best management practices for aircraft loading and servicing. For example, the pursuit of increased efficiencies with aircraft turnaround and power consumption have resulted in modifications to PBBs to provide power and pre-conditioned air. This has achieved significant savings for airlines by reducing the need to operate aircraft systems while parked at the gate. Likewise, baggage lifts and chutes constructed as part of the PBB improve aircraft turnaround times for ultimate savings to the airline. PBB upgrades of this kind would be included in an asset management plan for the PBB or portfolio of PBBs. No modifications are anticipated for the PBB considered in this example.

PBB operating costs consist of the power consumed (each passenger boarding bridge has its own meter that tracks hours of usage and electricity used) and the maintenance costs (both labor and material costs as tracked in the work order management system).

Maintenance costs are recorded at the subcomponent, or MMI level, as appropriate. A history of preventive maintenance activities is available through the maintenance management system, and reports of preventive maintenance tasks completed against planned are available. A current backlog report indicates that preventive maintenance has not been completed on this PBB for the past 2 years and a run-to-failure approach has been adopted. Step 6: Determine Business Risk (Criticality) of the asset management plan development process may indicate that preventive maintenance activities need to be reinstated for this PBB.

Physical Mortality

A condition assessment of the equipment has been completed using the condition assessment protocol outlined in Table E-1.

The condition of the subcomponent-level assets is assessed and recorded against the asset register as shown in Figure E-2.

Maintenance staff updates condition assessment information as breakdown and preventive maintenance is completed on any PBB components.

A record of the maintenance and/or renewal activity required to restore PBB components to the required state of repair and level of performance is made during the condition assessment activity.

Table E-1. Condition Assessment Protocol.

Condition Rating	Description	Maintenance Level
1	New or Excellent Condition	Normal PM
2		
3	Minor Defects Only	Normal PM, Minor CM
4		
5	Moderate Deterioration	Normal PM, Major CM
6		
7	Significant Deterioration	Major Repair, Rehabilitate
8		
9	Virtually Unserviceable	Rehab Unlikely
10	Unserviceable	Replace

Asset Register and Hierarchy				Installed Date	Asset Class	Original Cost	Estimated Effective	Condition Rating
Current Year	2011			Year		$	Years	1 to 10
Level 1	Level 2	Level 3	Level 4	Act or Est	Tab A	Act or Est		Tab A
1 - Gate	-11 Gate 1 PBB	-111PC Air	-1111 Air Hose	2010	2	$ 1,275	5	2
			-1112 Condenser	2005	2	$ 2,705	15	3
			-1113 Compressor	2005	3	$ 1,445	15	3
		-112 400 Hz Power	-1121 Cord	2010	5	$ 765	5	2
			-1122 Plug	2008	5	$ 595	3	2
			-1123 Retractor/Cable Hoist	2005	5	$ 765	15	5
		-113 Potable Water	-1131 Cabinet	2005	7	$ 595	15	7
			-1132 Hose	2010	7	$ 1,725	5	2
		-114 Interiors	-1141 Wall covering	2005	7	$ 340	7	6
			-1142 Carpet	2008	7	$ 442	3	7
			-1143 Hand rails	2005	7	$ 765	15	3
		-115 Rotunda	-1151 Bearings	2005	3	$ 595	15	8
			-1152 Curtain	2008	7	$ 765	3	2
			-1153 Base Column	2005	3	$ 9,000	15	2
		-116 Pedestal		2005	7	$ 595	15	7
		-117 Tunnel assembly	-1171 Tunnel Assemblies	2005	7	$ 85	7	7
			-1172 Tunnel Roller Assemblies	2005	3	$ 8,600	10	8
		-118 Wheel Bogie	-1181 Assembly	2005	7	$ 595	10	6
			-1182 Wheel	2005	3	$ 1,360	15	8
			-1183 Tire Pneumatic	2008	3	$ 765	3	7
			-1184 Wheel Motor DC Drive	2010	4	$ 595	5	6
			-1185 Wheel Motor AC Drive	2009	3	$ 4,250	5	5
			-1186 Tire Solid	2005	3	$ 6,800	10	6
		-119 Lift Column	-1191 Lift Column Motors	2005	4	$ 5,100	15	6
			-1192 Lift Column Ball Screws	2005	4	$ 850	15	6
		-120 Cab Assembly		2005	7	$ 595	25	6
		-121 Cab Curtain		2005	7	$ 765	15	6
		-122 Cab Bumper		2005	7	$ 595	15	7
		-123 Stairs		2005	7	$ 595	15	6
		-124 Bag chute		2005	7	$ 765	15	4
		-125 Use/power meter		2005	5	$ 765	15	4

Figure E-2. Recording of condition values in asset management plan spreadsheet.

Capacity

The utilization of the PBB is recorded monthly and taken from the usage meter. Current utilization is 74 percent. The PBB is currently providing safe structural support for the design live loads. Current capacity of pre-conditioned air and power system amperage is adequate.

Step 3—Determine Residual Life

Residual life is the life of the asset left from the date of assessment until the asset can no longer provide the function required of it.

Residual life is determined for all components of the PBB. The asset manager has discussed potential lives (how long the components are expected to last) with contractors and maintenance staff to be sure that environmental and operating conditions at the airport are factored in to the asset life estimates. A review of the work order system records also has been undertaken as an input to these estimates.

$$\text{Residual Life} = \text{Potential Life} - (\text{Current Year} - \text{Installation Year})$$

Asset lives used in this example are shown in Figure E-3.

Asset Register and Hierarchy				What is the State of					
				Installed Date	Asset Class	Original Cost	Estimated Effective Life	Condition Rating	Calc Residual Physical Life
Current Year	2011			Year		$	Years	1 to 10	
Level 1	Level 2	Level 3	Level 4	Act or Est	Tab A	Act or Est		Tab A	Calculated
1 - Gate	-11 Gate 1 PBB	-111PC Air	-1111 Air Hose	2010	2	$ 1,275	5	2	4
			-1112 Condenser	2005	2	$ 2,705	15	3	9
			-1113 Compressor	2005	3	$ 1,445	15	3	9
		-112 400 Hz Power	-1121 Cord	2010	5	$ 765	5	2	4
			-1122 Plug	2008	5	$ 595	3	2	0
			-1123 Retractor/Cable Hoist	2005	5	$ 765	15	5	9
		-113 Potable Water	-1131 Cabinet	2005	7	$ 595	15	7	9
			-1132 Hose	2010	7	$ 1,725	5	2	4
		-114 Interiors	-1141 Wall covering	2005	7	$ 340	7	6	1
			-1142 Carpet	2008	7	$ 442	3	7	0
			-1143 Hand rails	2005	7	$ 765	15	3	9
		-115 Rotunda	-1151 Bearings	2005	3	$ 595	15	8	9
			-1152 Curtain	2008	7	$ 765	3	2	0
			-1153 Base Column	2005	3	$ 9,000	15	2	9
		-116 Pedestal		2005	7	$ 595	15	7	9
		-117 Tunnel assembly	-1171 Tunnel Assemblies	2005	7	$ 85	7	7	1
			-1172 Tunnel Roller Assemblies	2005	3	$ 8,600	10	8	4
		-118 Wheel Bogie	-1181 Assembly	2005	7	$ 595	10	6	4
			-1182 Wheel	2005	3	$ 1,360	15	8	9
			-1183 Tire Pneumatic	2008	3	$ 765	3	7	0
			-1184 Wheel Motor DC Drive	2010	4	$ 595	5	6	4
			-1185 Wheel Motor AC Drive	2009	3	$ 4,250	5	5	3
			-1186 Tire Solid	2005	3	$ 6,800	10	6	4
		-119 Lift Column	-1191 Lift Column Motors	2005	4	$ 5,100	15	6	9
			-1192 Lift Column Ball Screws	2005	4	$ 850	15	6	9
		-120 Cab Assembly		2005	7	$ 595	25	6	19
		-121 Cab Curtain		2005	7	$ 765	15	6	9
		-122 Cab Bumper		2005	7	$ 595	15	7	9
		-123 Stairs		2005	7	$ 595	15	6	9
		-124 Bag chute		2005	7	$ 765	15	4	9
		-125 Use/power meter		2005	5	$ 765	15	4	9

Figure E-3. PBB component asset residual lives.

Step 4—Determine Lifecycle and Replacement Costs

The current replacement cost for each MMI or component, or the cost of the most appropriate renewal option is determined using cost estimates based on current year values. Inputs to this process include engineering estimates, input from manufacturers and agents and airport staff. Renewal cost estimates should include all aspects of the renewal activity, for example, planning, design, construction, commissioning, and overhead, as appropriate.

As long as the structural metal in the tunnels is in good condition, PBBs generally can be reconditioned for approximately 55 to 60 percent of the cost of a new PBB. Replacement costs should address modern equivalent components where appropriate, as opposed to replacement in kind.

A component replacement cost approach has been used for this example asset management plan. Figure E-4 shows the replacement/renewal costs included in the spreadsheet.

Asset Register and Hierarchy				What is the State of My Assets?								
				Installed Date	Asset Class	Original Cost	Estimated Effective Life	Condition Rating	Calc Residual Physical Life	Judgment Resid Life	% Asset Consumed (Physical)	Cost of Renewal Option
Current Year	2011			Year		$	Years	1 to 10			%	$
Level 1	Level 2	Level 3	Level 4	Act or Est	Tab A	Act or Est		Tab A	Calculated		Calculated	Estimate
1 - Gate	-11 Gate 1 PBB	-111PC Air	-1111 Air Hose	2010	2	$ 1,275	5	2	4	5	0%	$ 5,000
			-1112 Condenser	2005	2	$ 2,705	15	3	9	13	13%	$ 20,000
			-1113 Compressor	2005	3	$ 1,445	15	3	9	12	20%	$ 15,000
		-112 400 Hz Power	-1121 Cord	2010	5	$ 765	5	2	4		20%	$ 2,500
			-1122 Plug	2008	5	$ 595	3	2	0	1	67%	$ 400
			1123 Retractor/Cable Hoist	2005	5	$ 765	15	5	9		40%	$ 3,000
		-113 Potable Water	-1131 Cabinet	2005	7	$ 595	15	7	9		40%	$ 5,000
			-1132 Hose	2010	7	$ 1,725	5	2	4		20%	$ 1,500
		-114 Interiors	-1141 Wall covering	2005	7	$ 340	7	6	1		86%	$ 9,000
			-1142 Carpet	2008	7	$ 442	3	7	0	1	67%	$ 4,000
			-1143 Hand rails	2005	7	$ 765	15	3	9		40%	$ 2,500
		-115 Rotunda	-1151 Bearings	2005	3	$ 595	15	8	9		40%	$ 1,800
			-1152 Curtain	2000	7	$ 765	3	2	0	2	33%	$ 3,500
			-1153 Base Column	2005	3	$ 9,000	15	2	9		40%	$ 15,000
		-116 Pedestal		2005	7	$ 595	15	7	9	10	33%	$ 10,000
		-117 Tunnel assembly	-1171 Tunnel Assemblies	2005	7	$ 85	7	7	1		86%	$ 25,000
			-1172 Tunnel Roller Assemblies	2005	3	$ 8,600	10	8	4		60%	$ 6,000
		-118 Wheel Bogie	-1181 Assembly	2005	7	$ 595	10	6	4		60%	$ 12,000
			-1182 Wheel	2005	3	$ 1,360	15	8	9	12	20%	$ 2,000
			-1183 Tire Pneumatic	2008	3	$ 765	3	7	0		100%	$ 2,000
			-1184 Wheel Motor DC Drive	2010	4	$ 595	5	6	4		20%	$ 17,000
			-1185 Wheel Motor AC Drive	2009	3	$ 4,250	5	5	3	3	40%	$ 18,000
			-1186 Tire Solid	2005	3	$ 6,800	10	6	4		60%	$ 15,000
		-119 Lift Column	-1191 Lift Column Motors	2005	4	$ 5,100	15	6	9		40%	$ 7,500
			-1192 Lift Column Ball Screws	2005	4	$ 850	15	6	9		40%	$ 16,000
		-120 Cab Assembly		2005	7	$ 595	25	6	19	5	80%	$ 120,000
		-121 Cab Curtain		2005	7	$ 765	15	6	9	10	33%	$ 4,000
		-122 Cab Bumper		2005	7	$ 595	15	7	9	5	67%	$ 1,500
		-123 Stairs		2005	7	$ 595	15	6	9	5	67%	$ 4,000
		-124 Bag chute		2005	7	$ 765	15	4	9	10	33%	$ 3,750
		-125 Use/power meter		2005	5	$ 765	15	4	9	10	33%	$ 2,500

Figure E-4. Replacement/renewal costs.

The asset management planning process requires that the lifecycle costs of all airport passenger boarding bridges be reviewed annually during the asset management plan update process, ahead of budget review. Any unusual lifecycle costs for an individual passenger boarding bridge will be identified to see if replacement/reconditioning should be considered sooner than previously planned.

Step 5—Set Target Levels of Service

The following specific levels of service/performance standards apply for this asset management plan:

- Passenger boarding bridges should be maintained in neat/attractive condition (both exterior and interior) because they contribute to the image of the airport.
- The condition of all critical components should be maintained at a rating of 2 or less to mitigate failure likelihood.
- Passenger boarding bridges shall be operable 99.86 percent of the year (down no more than 12 hours per year).
- Utilization should be greater than 85 percent and less than 88 percent.

The current performance of the PBB indicates

- Current average condition rating of 5,
- Current availability of 95.2 percent, and
- Utilization of 74 percent.

Step 6—Determine Business Risk/Criticality

A review of PBB equipment failures indicates minor failures that have been corrected with minimal impact on operations. However, consequences of failure for a PBB can be considerable, including

- Injury to airport workers, airline staff, and passengers
- Damage to aircraft
  - L-1 door, associated hardware, and control rods that may require replacement
  - Possible damage to nose gear, which would require inspection for side-load stress to verify the presence of defects
  - If the PBB falls onto the aircraft, a crane may be required to lift the PBB off and away from the aircraft
- Disruption to service
  - Establishment of a command group and development of an action plan to deal with the incident
  - Aircraft may be temporarily out of commission while PBB is cleared, damage inspections are completed, and the aircraft is cleared for service, causing schedule impacts
  - Passengers may be trapped on the aircraft until such time as a mobile stair truck can get on site
  - Disruption to schedules

Table E-2 is used to score the relative criticality of the PBB components. This information is used to prioritize maintenance and capital investments across asset groups, and to review maintenance strategies and operations strategies to ensure that intolerable risks are managed. PBB performance requirements should ensure that any failure mode that causes the PBB to be unusable for docking aircraft and disembarking passengers has a high operational impact and should be avoided.

Consequence of failure impacts are recorded in the spreadsheet. Figure E-5 shows a consequence of failure assessment for the PBB.

Probability of failure is directly related to the percentage of asset life consumed. Business Risk Exposure (BRE) is then calculated as a product of probability and consequence scores. A plot of BRE is shown in Figure E-6.

A review of spares, as well as emergency response plans and procedures for the high BRE components, has been undertaken. No recommendations are included in this asset management plan for additional risk mitigation efforts beyond the requirements of the preventive and corrective maintenance contract.

Step 7—Optimize Operations and Maintenance Investment

A review of current maintenance strategies showed run-to-failure options for all PBB components. The risk assessment exercise undertaken in Step 6 indicates that the PBB is a critical asset with respect to airport operations. Condition-based maintenance strategies have been identified for all critical components to reduce the level of risk exposure currently associated with the operation of the PBB to within acceptable operational limits. Table E-3 shows the preventive maintenance activities to be undertaken as part of this asset management plan. A maintenance contract will be let for preventive and corrective maintenance of the PBB for a

Table E-2. Consequence of failure assessment matrix.

Social/Community/Organizational					
Score	1	2	3	4	5
Loss of Service Impact	No impact	Impact to concessions and other airport businesses	Significant impact to local economy and community	Significant impact to regional commerce and community	Widespread disruptions to air traffic and impact to interstate commerce
Public Health & Safety	No impact	Minor injury/ inconvenience	Moderate injury and some sickness	Major injury, sickness, one death	More than one death, widespread injury and/or illness
Airport Credibility	No impact	Loss of staff confidence in airport asset management processes and procedures and executive decision-making	Adverse media and loss of good will with airlines	National adverse media	International adverse media, loss of airline service
Economic/Financial					
Cost of Failure (Restoration Cost)	$0-$100k	$100k-$500k	$500k-$1M	$1-2M	>$2M
Resource and Operational Impacts	Low cost and low operational impact	Diversion of staff and monetary resources for more than 3 days	High cost, high operational impact, including compensation claims	Painful change of priorities	Likely to trigger rate/charge increase
Level of Service Impact	No impact	Minor disruption to airline schedules, disruption to passengers, compensation payments , Negative impact on aircraft turnaround time KPI for the day	Major disruption to airline schedules (>5 hour delays, cancelled flights), Negative impact on aircraft turnaround time KPI for the month	Major disruption to airline schedules, aircraft turnaround time KPI and airport passenger throughput KPI	Major disruption to airline schedules > 48 hours, impact to airline route profitability for the month
Environmental/Regulatory					
Regulatory Violations, Air/Water/Land Contamination	No impact	Minor violations, recoverable within month	Moderate violations, damage reversal less than 6 months	Damage reversal 6 months or more, significant violations	Damage reversal 5 years or more, significant violations and fines

Asset Register and Hierarchy				Probability of Failure	Loss of Service Impact	Public Health & Safety	Airport Credibility	Cost of Failure (Restoration Cost)	Resource and Operational Impacts	Level of Service Impact	Regulatory Violations, Air/Water/Land Contamination
Current Year	2011			Rating	0.35	0.5	0.15	0.2	0.3	0.5	1
Level 1	Level 2	Level 3	Level 4	Calculated	Tab C	Tab C	Tab C	Tab C	Tab C	Tab C	Tab C
1 - Gate	-11 Gate 1 PBB	-111PC Air	-1111 Air Hose	0	1.5	1	1	1	1	1	1
			-1112 Condenser	1	1.5	1	1	1	1	1	1
			-1113 Compressor	2	1.5	1	1	1	1	1	1
		-112 400 Hz Power	-1121 Cord	2	1.5	1.5	1.5	1	1	1.5	1.5
			-1122 Plug	7	1.5	1.5	1.5	1	1	1.5	1.5
			-1123 Retractor/Cable Hoist	4	1.5	1.5	1.5	1	1	1.5	1.5
		-113 Potable Water	-1131 Cabinet	4	1.5	1	1	1	1	1	1
			-1132 Hose	2	1.5	1	1	1	1	1	1
		-114 Interiors	-1141 Wall covering	9	1.5	1	1	1	1	1	1
			-1142 Carpet	7	1.5	1	1	1	1	1	1
			-1143 Hand rails	4	1.5	1	1	1	1	1	1
		-115 Rotunda	-1151 Bearings	4	2	1.5	1.5	1	1.5	2	1.5
			-1152 Curtain	3	2	1.5	1.5	1	1.5	2	1.5
			-1153 Base Column	4	2	1.5	1.5	1	1.5	2	1.5
		-116 Pedestal		3	2	2	2	1.5	2	3	2
		-117 Tunnel assembly	-1171 Tunnel Assemblies	9	2	2	2	1.5	2	3	2
			-1172 Tunnel Roller Assemblies	6	2	2	2	1.5	2	3	2
		-118 Wheel Bogie	-1181 Assembly	6	2	2	2	1.5	2	3	2
			-1182 Wheel	2	2	2	2	1.5	2	3	2
			-1183 Tire Pneumatic	10	2	2	2	1.5	2	3	2
			-1184 Wheel Motor DC Drive	2	2	2	2	1.5	3	3	2
			-1185 Wheel Motor AC Drive	4	2	2	2	1.5	3	3	2
			-1186 Tire Solid	6	2	2	2	1.5	2	3	2
		-119 Lift Column	-1191 Lift Column Motors	4	2	2	2	1.5	3	3	2
			-1192 Lift Column Ball Screws	4	2	2	2	1.5	2	3	2
		-120 Cab Assembly		6	2	1.5	1.5	1	1.5	2	1.5
		-121 Cab Curtain		3	2	1.5	1.5	1	1.5	2	1.5
		-122 Cab Bumper		7	2	1.5	1.5	1	1.5	2	1.5
		-123 Stairs		7	1	1	1	1	1	1	1
		-124 Bag chute		3	1	1	1.5	1	1.5	2	1.5
		-125 Use/power meter		3	1	1	1	1	1	1	1

Figure E-5. Consequence of failure assessment.

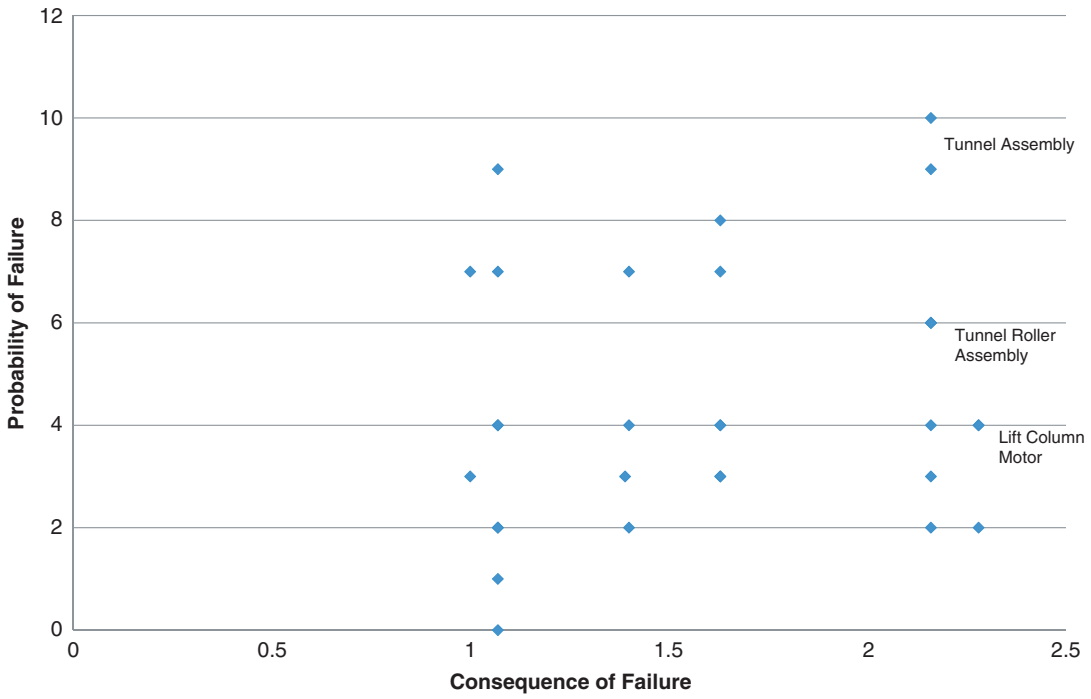


Figure E-6. Business risk exposure.

Table E-3. Preventive maintenance tasks.

	Preventive Maintenance Task
General Overview	Inspect tire wear-damage
	Inspect wheel fasteners
	Inspect-lubricate axle bearings
	Inspect-lubricate trunnion pin
	Inspect turntable bearings, fasteners, lubricate bearings
	Inspect drive motors, wiring and brake pack wear and function
	Inspect drive motor heaters (during cold weather months)
	Inspect gear reduction units
Cab Unit	Inspect-lubricate cab unit drive chain
	Inspect and lubr icate drive chain sprockets and pins
	Inspect-lubricate cab unit rollers and rail
	Inspect cab rotation motor and wiring
	Inspect-lubricate CRJ floor
	Inspect-lubricate cab unit adjustable floor
	Inspect-lubricate cab curtain bearings and guide rails
	Inspect-lubricate top cab unit
Lift Column Assembly	Inspect lift column wear pads
	Inspect-lubricate motor sync drive shaft
	Inspect drive motors, wiring brake pack wear and function
	Inspect drive motor heaters during cold weather months
	Inspect gear reduction units
	Inspect-lubricate jack screw bearing and nut [fill oilers]
Rotunda Assembly	Inspect base column and mounting hardware
	Inspect-lubricate turntable bearing and fasteners
	Inspect-lubricate curtain bearings and hardware
	Inspect-lubricate top
Tunnel A	Inspect bearing assemblies
	Tunnel adjustments and alignments
Tunnel B	Inspect bearing assemblies
	Tunnel adjustments and alignments
Tunnel C	Lubricate bearing rails
	Inspect equalization cable
	Inspect-lubricate festoon cable arms and pins
	Inspect Tunnel C mounting hardware to lift columns
	Vertical pivot pins
	Tunnel adjustments and alignments

Source: Harrisburg International Airport Passenger Loading Bridge PM Inspection Worksheet.

5-year period with 12-month extensions. This program will be rolled out to all PBBs owned and managed by the airport. An additional FTE is required to manage the PBB maintenance contract.

A review of the current availability rates for this PBB shows that the response time, investigation, and restoration time to repair a failed jackscrew drive chain and bearing assembly replacements in the last quarter were unusually lengthy. An investigation into the maintenance servicing of the PBB showed a lack of coordination and ad hoc arrangements to corrective maintenance. The proposed maintenance contract, including performance requirements with respect to downtime and response time

for corrective maintenance, as well as a fully documented preventive maintenance program are expected to bring the availability performance for this PBB back within requirements.

Step 8—Optimize Capital Investment

The maintenance manager regularly reviews the maintenance and performance histories recorded in the CMMS to evaluate the condition of the PBB relative to the maintenance record and identify any components that have a higher-than-expected maintenance frequency or costs or higher-than-acceptable downtime.

The maintenance manager reviews the Capital Improvement Program (CIP) relative to the PBB. The replacement/reconditioning of PBBs has been scheduled previously in the CIP based on residual life based on asset condition. Based on the last 9 months of maintenance data, the maintenance manager will consider whether the replacement/reconditioning of this PBB should be revised.

The asset manager reviews the strategic and master plan with airport planners and evaluates the utilization and service-level capability of PBB relative to the PBB requirements across the airport. Utilization of the PBB will be increased in Year 2 of the plan, once the current gate-lease agreement expires. The current CIP strategy for renewal is reviewed in the context of future operating needs by the asset manager, airport planner, and maintenance manager. The review for this PBB indicates that the PBB is expected to continue to provide the same level of service, with component part renewal as indicated in this plan.

The asset manager will undertake an assessment of the most optimal timing and type of PBB replacement for this PBB, based on an economic analysis of future cash flows for the operation, maintenance, renewal, level of service, and risk exposure costs of the existing PBB versus its replacement. An investment allocation is made in the spreadsheet for the optimized renewal choice and timing.

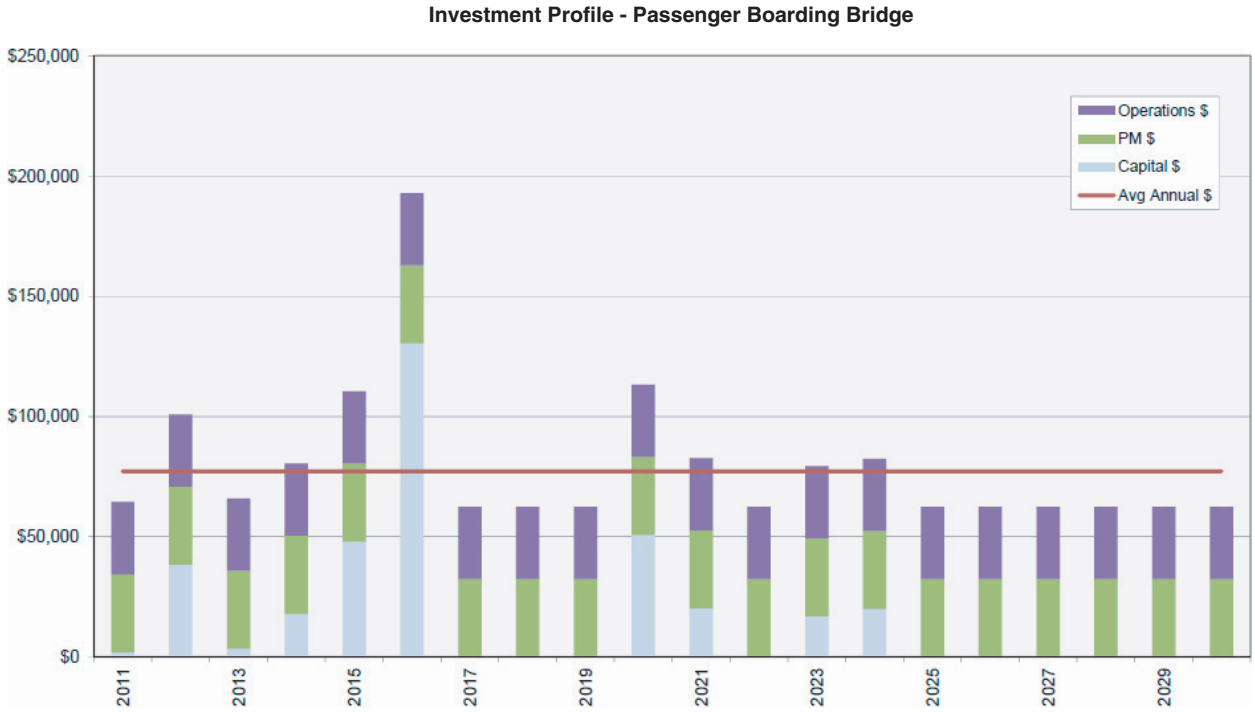
Step 9—Determine the Best Funding Strategy

Figure E-7 shows the investment cash flows associated with activities and investments recommended in this example asset management plan for a PBB. (Note that figures are indicative only and do not represent an actual PBB.)

The asset manager prioritizes investment recommendations for all asset management plans developed for all infrastructure groups within the airport and develops a 5- or 10-year fiscal plan for pricing and budgeting purposes and a longer term (10- to 20-year) plan as a view to future trends in renewals and charges.

The asset manager works with the CFO to determine a pricing and funding plan for changes to operating and capital budgets for cost/revenue centers for the purposes of identifying funding sources, and determining rates and charges impacts. The asset manager provides impact assessments on airport service level performance and risk exposures associated with funding scenarios required to meet budget constraints.

The Airport AM Committee reviews the recommended funding scenario and impacts, and approves the airport asset management plan, and 5- or 10-year fiscal plan.



	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Capital $	$ 2,000	$ 38,400	$ 3,500	$ 18,000	$ 48,000	$ 130,500	$ -	$ -	$ -	$ 50,800
	$294,617.85									
Avg Annual $	$77,180.89	$77,180.89	$77,180.89	$77,180.89	$77,180.89	$77,180.89	$77,180.89	$77,180.89	$77,180.89	$77,180.89
Annual Depreciation $	$ 6,079.01	$ 6,079.01	$ 6,079.01	$ 6,079.01	$ 6,079.01	$ 6,079.01	$ 6,079.01	$ 6,079.01	$ 6,079.01	$ 6,079.01
PM $	$ 32,450	$ 32,450	$ 32,450	$ 32,450	$ 32,450	$ 32,450	$ 32,450	$ 32,450	$ 32,450	$ 32,450
Operations $	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000

Figure E-7. Investment cash flows for example PBB.

Step 10—Document the Asset Management Plan

An asset management plan for the PBB is documented with the following sections:

Executive Summary

Section 1 State of the Assets summarizes the current condition and performance of the assets

Section 2 Levels of Service outlines the current and target levels of service

Section 3 Growth and Demand shows the forecast growth and demand requirements for the planning period

Section 4 Lifecycle Management describes the current operations, maintenance and capital renewal and augmentation or expansion plans and approaches

Section 5 Risk Profile describes how risk exposure is evaluated and identifies at risk assets

Section 6 Management Strategies describes the operations, maintenance and capital investment strategies determined for the planning period. This may include changes to maintenance strategies to implement more proactive maintenance, or could include changes to emergency response plans for specific events.

Section 7 Financial Planning summarizes all costs associated with the implementation of the management strategies described in Section 6. It also includes a funding strategy and the associated impact on charges and key financial indicators.

Section 8 Business Improvement Planning describes any process improvements or projects required to improve the quality of asset management planning at the airport. Examples of typical business improvement projects include the implementation of an Enterprise Resource Planning System, or a Computerized Maintenance Management System, or the implementation of new maintenance schedules or changes to the project delivery process.

The asset management plan for the PBB is rolled into the airport asset management plan by the asset manager. The airport asset management plan includes all the service level, cost, risk assessments, and needs for all airport infrastructures, including priorities and a preferred investment scenario moving forward.

The asset management plans will be updated on a routine bases, as a live process involving staff across the airport organization including planning, information systems support, engineering, finance and budget, human resources, environment, risk management, and operations and maintenance.

CHAPTER 5

Airport Information and Data Systems

Airport Information Systems for Asset Management

"An asset management information system is a combination of processes, data, and software applied to provide the essential outputs for effective asset management such as reduced risk and optimum infrastructure investment."

CMMS tend to act as the focal point of information systems supporting best practice asset management. Some CMMS products are being rebranded as enterprise asset management systems (EAMS). Best practices require that a capable and well-implemented CMMS not only tracks the day-to-day activities and changes to assets, but that it can coordinate those activities through preventive maintenance schedules and resource allocation tools.

A CMMS must perform the following core functions:

- Equipment/asset inventory and condition assessment data management and reporting;
- Work order processing including scheduling, tracking, cost accounting, and reporting; and
- Failure histories and defect coding.

An effective asset management program typically requires a holistic approach with integration or coordination between information systems to support strategic requirements. Figure 5-1 shows a schematic example of an airport asset management information system for large airports. The following systems and applications cover the essential functionalities required for effective asset management:

1. Financial system,
2. Customer complaint/inquiry system,
3. Complete asset registry and hierarchy,
4. Geographical information system,
5. CMMS or EAMS,
6. Electronic document management system for operations and maintenance manuals and as-built drawings,
7. Data warehouse for data sharing between applications, and
8. Facilities management system.

Integrated systems deliver significant benefits including understanding cost components that develop approaches for recovering those costs; improving the efficiency and effectiveness of maintenance, operations, and capital delivery processes; and improving the overall management of assets and infrastructure. Figure 5-2 provides three specific examples that demonstrate these benefits.

For small airports, fully integrated systems are not always necessary. The research indicated that small airports (processing around 5 million passengers per year) are able to quite adequately perform maintenance and capital planning tasks using spreadsheet tools developed by airport staff.

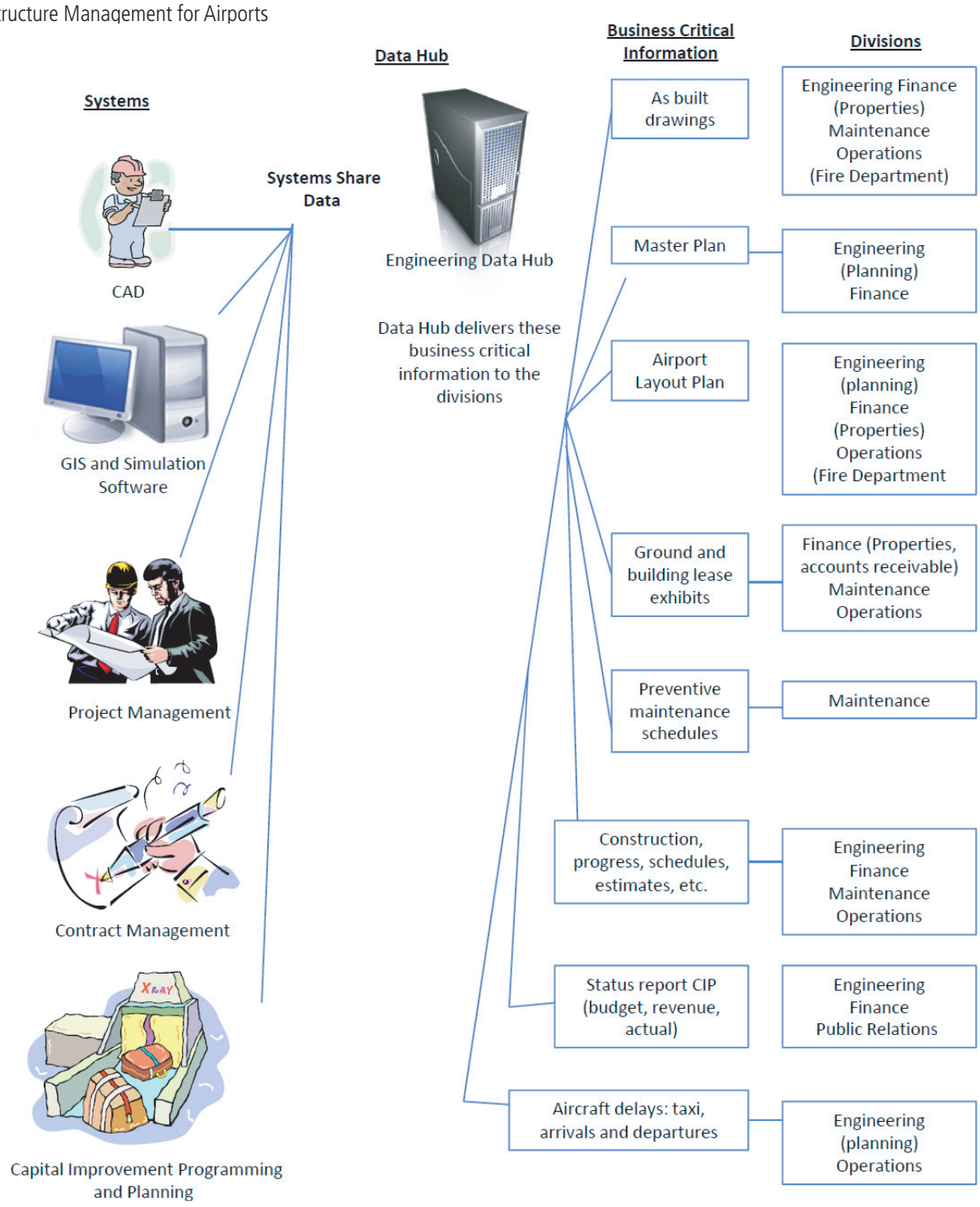


Figure 5-1. Schematic of asset management information systems for large airports.

Decision Support Tools

Decision support tools help agencies to make difficult trade-off decisions for resource allocation while considering asset preservation concerns and the broader set of policy objectives (e.g., mobility, safety, and economic development) that must be taken into account when making investments in transportation assets.

- Miami International Airport (U.S.) is introducing a detailed cost accounting structure to enable assigning costs to the provision of a service, for example, linking facility management costs to the user of a leased space within the airport terminal. This also enables the identification of preventive maintenance that is appropriately cost justified.
- Denver International Airport (U.S.) is implementing an enterprise GIS and also is using Maximo's Route capability as a means of improving productivity by avoiding missed PMs and ensuring that all assets are managed. It recognized that there are three elements critical to the success of new information systems roll out— communication, training, and incentives.
- London Airport Gatwick (U.K.) uses an integrated security system to assist with energy conservation strategies. Energy savings are achieved by enabling specific equipment only when they are needed, for example, by using a gate room reader to sense arrivals and enable lifts and escalators for arriving passengers. When the gate room is not in use, these systems are shut down, therefore conserving energy.

Figure 5-2. Example system integration benefits for large airports.

Decision support tools are used by asset managers to determine the best alternative among a set of feasible alternatives. The alternatives may be potential solutions to a range of questions related to

- Strategic planning,
- Airport development,
- Outsourcing, and
- Asset renewal or replacement.

The majority of asset management decisions involve some level of financial and economic assessment. Decision support tools tend to be customized in MS Excel spreadsheets for this purpose.

Decision Support Tools for Developing Asset Management Plans

There are three levels of practice for analyzing investment requirements for asset management planning purposes.

- Level 1
  - Age- and design-life-based assessments
  - Replacement cost basis for renewal
  - Current maintenance and operations expenditures carried forward
- Level 2
  - Condition- and performance-based remaining life assessments
  - Replacement cost basis for renewal
  - Some adjustment of maintenance and operations cost based on new assets and replacements
- Level 3
  - Decay modeling
  - Asset strategy scenario testing
  - Service level impact estimates
  - Maintenance and capital investment trade-offs

Example Decision Support Tool

A. Primary Considerations

Part A Weighting: 50

Consideration	Rating	Weighting	Weighted Value	Weighting Guidelines Low	Medium	High
Time constraints for implemenation	Medium	25.0	15.0	Sufficient time for standard procurement	Need to accelerate delivery	Insufficient time for standard delivery
Cost	High	50.0	50.0	No fixed budget	Some budget flexibility	Fixed budget
Well defined scope	Medium	25.0	15.0	Concept only	Scope needs refinement	Clearly defined scope
Total		**100.0**	**80.0**			
		Weighted Total:	**40.0**			

B. Secondary Considerations

Part B Weighting: 35

Consideration	Rating	Weighting	Weighted Value	Weighting Guidelines Low	Medium	High
Overall complexity	High	35.0	35.0	Simple	Moderate complexity	Significant complexity
Complexity of performance requirements	High	25.0	25.0	Performance requirements unknown	Performance requirements established	Performance requirements known
Availability	Medium	20.0	12.0	< 3 possible bidders	3 to 5 possible bidders	> 5 bidders
Owner experience and resources	Medium	10.0	6.0	No experience	Some experience	Significant experience
Allocation of risks	Medium	10.0	6.0	Owner retains majority of risk	Risks shared with supplier	Risk transferred to supplier
Total		**100.0**	**84.0**			
		Weighted Total:	**29.4**			

C. Other Considerations

Part C Weighting: 15

Consideration	Rating	Weighting	Weighted Value	Weighting Guidelines Low	Medium	High
Operational constraints	Low	40.0	8.0	Significant operational constraints	Some operational constraints	No operational constraints
QC/QA responsibilities	Medium	30.0	18.0	Owner's responsibility	Shared responsibility	Supplier responsibility
Performance guarantees/warranties	Medium	30.0	18.0	Short term coverage	Medium term coverage	Long term warranties
Total		**100.0**	**44.0**			
		Weighted Total:	**6.6**			

Sub Totals

A. Primary Considerations	50	40.0
B. Secondary Considerations	35	29.4
C. Other Considerations	15	6.6
Grand Total	**100**	**76.0**
Decision		**Yes**

Decision Range		
From	**To**	**Implement Alternative**
0	50	**No**
50	65	**Can Consider**
65	100	**Yes**

Level 1 and Level 2 assessments often are used for obtaining the first high-level understanding of future investment needs. The assessment based on age and design life is simple and can easily be developed using a spreadsheet tool.

Level 3 modeling includes decay curve development that requires the processing of data and modeling of an assets movement along the decay curve with time. Sophisticated tools are required to undertake this level of analysis, especially at an enterprise level (all assets of the airport), to provide an optimized analysis of replacement and renewal and investments across the different asset groups. This exercise is difficult to do in a spreadsheet if the number of assets to be processes is more than 50,000. There are commercially available software solutions that can be used. These solutions fall into three categories

- Enterprise resource planning systems with work and asset management modules and business intelligence suites that allow the user to use customized business rules and logic to assess renewal needs and timing;
- Maintenance management system software that includes asset management analysis functionality; and
- Solutions specifically focused on processing work order and other asset information and data to undertake the asset management planning phase analysis to select the best management strategies and trade-offs between cost, risk, and levels of service.

Figure 5-3 shows a schematic from *ACRP Report 13: Integrating Airport Information* on systems asset management systems. Decision support systems are utilized to analyze the data held in the Asset Management Data Hub, using agreed-upon business rules, as shown in this figure.

Functionality Requirements for Maintenance Management

Maintenance management is a method of allocating resources to accomplish a predetermined level of service through planning, budgeting, scheduling, executing, and reporting and reviewing maintenance strategies and tactics. The major functions of maintenance management systems are shown in Figure 5-5.

There are three levels of practice observed in maintenance execution and systems support.

- Level 1
  - Asset hierarchy to maintenance managed item
  - Records work done on assets and when
  - Limited planning and scheduling
- Level 2
  - Asset hierarchy to maintenance managed item
  - Records labor and materials usage on work order completion
  - Records defect codes for asset failure
  - Records asset condition
- Level 3
  - Asset hierarchy to maintenance managed item
  - Records labor and materials usage on work order completion
  - Records defect codes for asset failure
  - Records asset condition
  - Enables failure history analysis
  - Linked to stores and ordering capability
  - Enables maintenance performance reporting

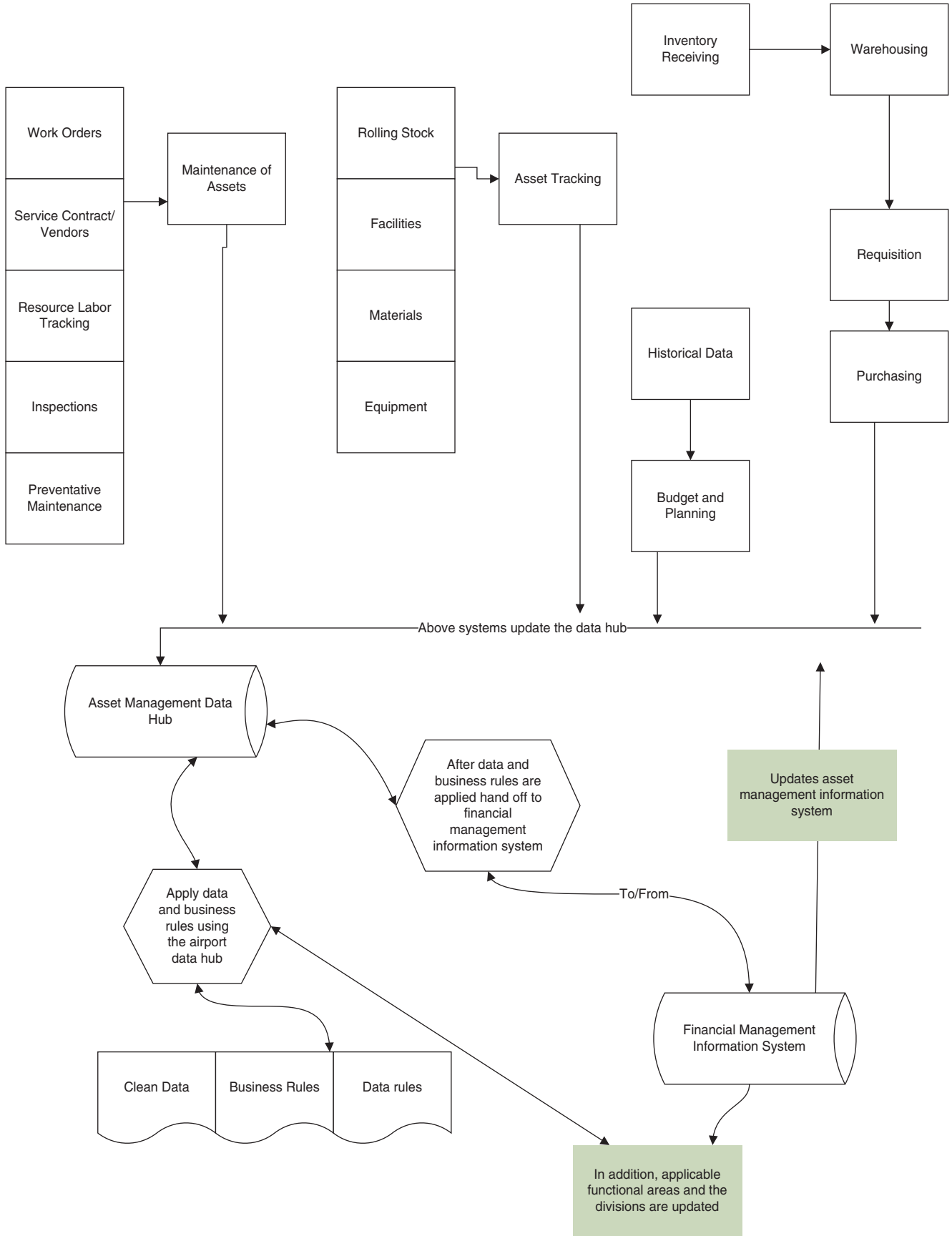


Figure 5-3. ACRP Report 13 asset management systems.

Level 1 execution is normally performed using spreadsheets or simple maintenance management systems designed for small applications. Levels 2 and 3 usually require sophisticated maintenance management systems software with links to other aspects of airport management, often through an enterprise resource planning system.

A small airport might use a simple spreadsheet system to support the maintenance function, relying on manual processes to achieve integration between maintenance management and finance.

Figure 5-4 provides an example of an airport processing around 3 million passengers per year, and providing services to commercial airlines and general aviation. This airport outsources over 80 percent of its maintenance, and manages the activity using a series of spreadsheets and word processing document tools. Maintenance work orders are developed and distributed on hard copy forms to maintenance contractors for execution. Once the maintenance is complete, the contractor signs the form. The completed work is then cross-referenced with invoices through the accounting department, and once the airport asset services staff signs off on the work having been completed, the contractor is paid. The information captured on the hard copy work order is used by the airport maintenance planning staff to adjust maintenance frequencies. This process has been successful in dramatically improving the condition and performance of the infrastructure, and although the cost of service has increased, the airport asset managers believe that they have reached an appropriate trade-off between service level and cost. A simple process was applied, which was supported by simple and appropriate tools.

Large airports require comprehensive maintenance management systems that enable financial and asset performance reporting for any asset group by any organizational group within the airport.

Figure 5-5 illustrates the major functions and data requirements for implementing and maintaining a maintenance management system.

Regardless of the information systems methods used to support the maintenance function, there are five major elements of best appropriate practice applicable to maintenance management systems. Table 5-1 outlines these key practice elements and shows their applicability with respect to the size category in which an airport falls.

Task Name	Jobs budgeted to this task include…	Jul-11
		5
110 : BUSINESS UNIT: AVIATION		
Lighting		
Lighting - Scheduled	Perform Maintenance, documentation, + weekly, 6-monthly & 12-monthly	2,018.00
Lighting - Reactive	Assumptions Based on FY10/11monthly averages	4,775.00
Contract Support -	Scheduled Contract Support - every 4 Months.	2,829.75
Maintenance	Scheduled Maintenance	1049.95
Reactive Repairs	Reactive Repairs	833.25

Figure 5-4. Example maintenance budgeting spreadsheet excerpt for a small airport.

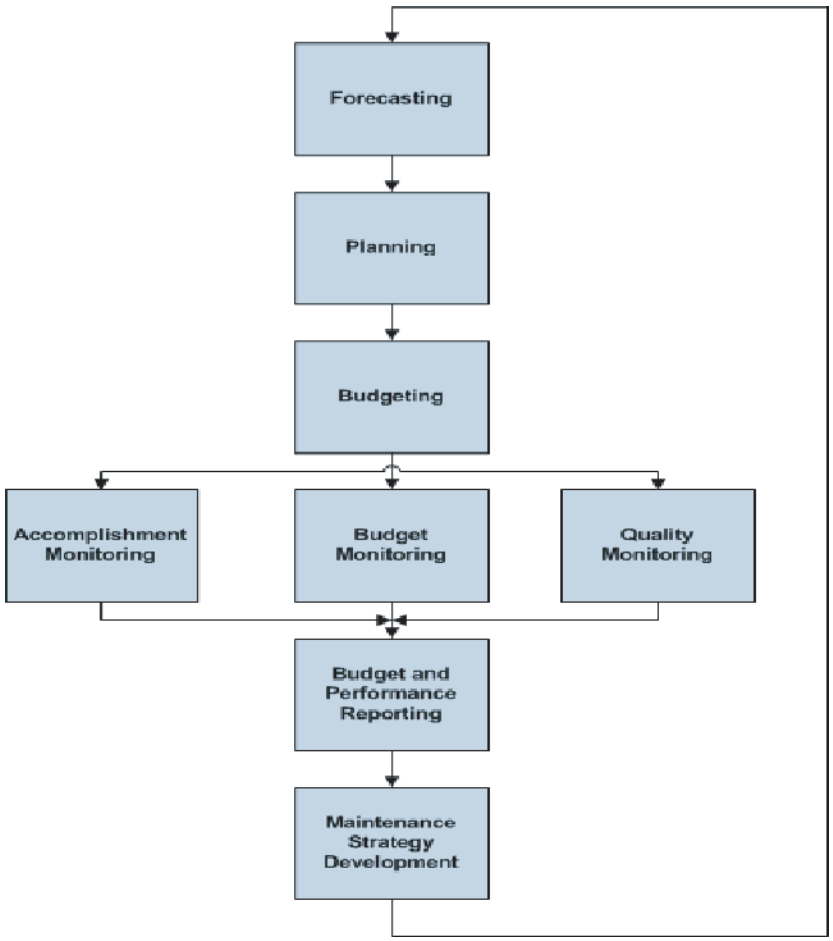


Figure 5-5. Major functions and data requirements for maintenance management systems.

Functionality Requirements for Asset Accounting

Asset accounting is a key element of financial and managerial accounting. Financial accounting is a process that is GAAP driven, based on historic costs, and focused on audited reporting of financial condition to external stakeholders. Managerial accounting is a process based on

Table 5-1. Summary of information systems best practice elements according to size category.

Information Systems	Equipment/asset inventory and condition assessment data management and reporting	Work order processing including scheduling, cost accounting and reporting	Defect coding and failure history analysis	Integration with financial and GIS systems	Integration with investment decision support and capital planning tools
Large/Medium Hub	**X**	**X**	**X**	**X**	**X**
Small/Non-Hub, General Aviation	**X**	**X**	**X**	**Consider**	

replacement costs that is business-case driven and focused on internal decision making. Both financial and managerial accounting processes are necessary and important for asset management decision making. The two types of accounting activities are interrelated because they use some of the same base data.

Asset (managerial) accounting should provide the cost information and methods for lifecycle costing, valuing assets, planning and design, maintenance strategy development, optimized renewal decision making, budget preparation, monitoring and maintenance, capital asset financial reporting, cost forecasting, and the setting of fees and charges.

An asset accounting information system should keep corporate asset registers of all owned assets, and should hold costing information at the appropriate level of the asset registry to support decision making, as outlined in Table 5-2.

The lifecycle cost of an asset is defined as the total cost of the asset throughout its life, including creation or acquisition, operations, maintenance, refurbishment, disposal and replacement, and other costs directly attributable to owning and using the asset. Lifecycle cost analysis uses a discounted cash flow method to analyze and evaluate these lifecycle costs by converting cash inflows (i.e., benefits) and outflows (i.e., costs) that occur over time to equivalent amounts that represent their NPV. This method appraises options based on the concept of "discounting" future costs and benefits to their NPV. The discounting of future costs and benefits to present value allows the organization to take into account the opportunity cost of the capital being used.

To enable effective asset management, an asset accounting information system needs to record information required to conduct a lifecycle cost analysis on a periodic basis. One of the

Table 5-2. Asset cost data needs.

AM PROCESSES	RELEVANT PROCESS SUMMARY	COST DATA NEEDS
Planning and Design	Evaluate viable design options through lowest lifecycle cost analysis using present value (PV) of lifecycle costs	Estimated future lifecycle costs to acquire/create, operate, maintain, refurbish, and replace
Develop AM Maintenance Strategy	Identify financial inefficiencies in operations and/or maintenance through spikes in costs (e.g., increased power consumption or more frequent repairs)	Historical records of current expenditures to operate and maintain
Optimized Renewal Decision-Making	Identify optimal investment program by evaluating treatment options using net present value (NPV) of lifecycle benefits less costs	Historical records for operate and maintain, and estimated future lifecycle costs to operate, maintain, refurbish, and replace
Prepare, Monitor, and Maintain Budget	Estimate (budget) future costs for operating (operate and maintain) and capital (acquire/create new, refurbish, dispose, and replace); track actuals against budgets	Budget: Estimated future costs to operating and capital Actual: Current costs for operating and capital funds
Tangible Capital Asset Financial Reporting	Record assets at original cost and, using estimated useful life, calculate accumulated depreciation and net book value	Historical records of current expenditures to acquire/create new, refurbish, and replace
Cost Forecasting and Rate Setting	Determine annuity of all lifecycle costs	Estimated future lifecycle costs to acquire/create new, operate, maintain, refurbish, and replace

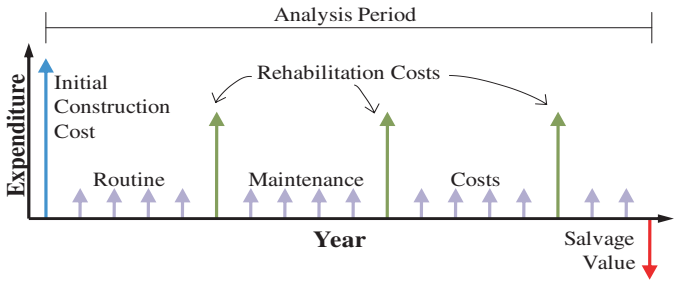


Figure 5-6. Cost flow diagram.

key functionality requirements for this purpose is to have the ability to assign replacement cost information against individual assets in the hierarchy.

Lifecycle Cost Analysis

Lifecycle cost analysis builds on principles of financial analysis to evaluate the overall economics between competing alternative investment options. The initial service life of an asset is defined as the time between the initial installation or commissioning and the time when the condition of the asset reaches a minimum acceptable level of service. Lifecycle costing quantifies all of the costs necessary to commission and maintain the asset over a set analysis period. Future costs are discounted back to an equivalent present worth by using a discount rate that takes inflation and interest rates into account. When evaluating the alternatives, the costs that occur at different phases of the analysis life are summarized to a total lifecycle cost in terms of either the net present worth (NPW) or an equivalent uniform annual cost (EUAC).

The development of feasible design alternatives is the first step in determining which alternative should be considered. The lifecycle comparisons are then performed between two or more mutually exclusive alternatives that meet all of the functional requirements. For each alternative, the initial construction cost, as well as an estimate of future routine maintenance, preservation, and rehabilitation costs, are determined. The costs of the proposed alternatives are quantified. The cost flow diagram in Figure 5-6 illustrates this process. This deterministic approach provides a typical expected lifecycle cost that can be used to represent the various alternatives.

To evaluate competing alternatives, infrastructure investments are converted into a single parameter, which most commonly is the NPW or EUAC. Using the cost flow diagram in Figure E-5, the costs for all items after initial construction would be reduced to the present worth (PW) using the discount rate to be in equivalent dollars at the beginning of the analysis period according to the following equation.

$$PW = C \times \left[\frac{1}{1 + iDiscount} \right]^{n}$$

Where:

PW = Present worth ($)
C = Future cost ($)
$i_{Discount}$ = Discount rate (e.g., 4% = 0.04)
n = Period in years between future expenditure and present

When this calculation is performed for all individual costs, as shown in the following equation, the total NPW for each alternative can be evaluated. This value represents the total dollars, if allocated today, that could pay for the project for the analysis period.

$$NPW = IC \pm \sum_{j}^{k}{}_{=1}\left(M\ \&\ R \times \left[\frac{1}{1 \pm iDiscount} \right]^{nj} \right) - SV \times \left[\frac{1}{1 \pm iDiscount} \right]^{A.}$$

Where:

NPW = Net present worth ($)
IC = Initial cost ($)
k = Number of future maintenance and rehabilitation activities
$M\&R_j$ = Cost of jth future maintenance and rehabilitation activity ($)
$i_{Discount}$ = Discount rate
n_j = Number of years from the present of the jth future preservation or rehabilitation treatment
SV = Salvage value ($)
AP = Number of years in analysis period

It often is not feasible to set aside funding for the entire lifecycle of the infrastructure. However, it is necessary to look at annualized costs to aid in the generation of airport-wide budgets (Figure 5-6). Thus, NPW is often given as an annualized cost. EUAC is calculated by using the discount rate to determine a consistent amount of money that would need to be allocated every year to pay for the project. EUAC allows for a better understanding of costs and comparison to total annual budgets to ensure that long-term funding will be available.

$$EUAC = NPW \times \left[\frac{iDiscount \times \left(1 \pm iDiscount\right)^{AP}}{\left(1 \pm iDiscount\right)^{AP} - 1} \right]$$

Where:

EUAC = EUAC ($)
NPW = NPW ($)
$i_{Discount}$ = Discount rate
AP = Number of years in analysis period

Asset Replacement Cost

An airport's asset management system (AMS) supports capital planning by providing a prioritized listing of all fixed assets. The AMS does this by managing data related to the age, type, and condition of systems and equipment.

The AMS system comprises several software tools specifically designed for management of asset types such as buildings, structures, pavements, and other infrastructure systems. The assets are organized in subgroups pertaining to purpose, such as terminal buildings, runways, roads, electrical distribution, etc. Each asset is further broken down into its main component parts, using a predefined component structure.

Each component group has an installation date, expected useful life, and replacement value. Initial useful life and replacement value are modeled data, based on the type and size of the asset. Using the installation date and the expected useful life, AMS generates a replacement event for each component, scheduled for the end of the useful life.

Asset replacement is closely linked to performance assessment and performance modeling functions in that these systems provide the forward planning function of asset replacement. By performing a condition assessment 5 to 6 years prior to the expected replacement event, the AMS unit can ensure that the replacement event is entered in the airport's capital plan to provide guidance during the capital planning process, and to ensure that by the time the replacement is required, the information needed for approval (scope, cost, and schedule) is available.

CHAPTER 6

Implementation of Asset Management Plans: Lifecycle Processes and Best Appropriate Practices

Each of the following sections includes guidance on implementing asset management plan outputs and best appropriate practice elements for the following lifecycle processes:

- Project initiation, planning, and design;
- Project delivery; and
- Operations and maintenance.

Project Initiation, Planning, and Design

Project initiation refers to the identification of a problem for which a capital project solution may be required. The problem may have been identified either through the monitoring of maintenance management system data indicating that a failure is imminent or that the asset or system of assets may no longer meet regulatory standards requirements. The problem or project initiation inputs may also be a result of

- Operational issues,
- Changes in regulations,
- Capacity requirements,
- Decommissioning a no-longer-needed asset, or
- Energy efficiency needs or other lifecycle cost issues.

Projects are initiated during the operations and maintenance stage of the asset lifecycle and through the asset management planning process. Once the asset management planning process is embedded in the strategic planning and budget cycle, the number of capital project needs that emerge after budgets are passed should significantly diminish. However, it is important that the asset management plan is implemented as adopted to realize this benefit. Implementation involves

- Formal initiation of projects,
- Business cases to evaluate solution alternatives,
- Prioritization of projects,
- Adoption into the capital program, and
- Planning and design.

Best practices in project initiation include a process to validate that a problem warrants a project or should continue to be monitored. The online survey undertaken as part of the development of this guidebook indicated that 97 percent of the airports surveyed have a validation process, with 71 percent developing a business case. Thirty-six percent are using a triple-bottom-line approach

to evaluating project solution alternatives. Best practice suggests that a triple-bottom-line approach should be used that evaluates the social, environmental, and economic impacts of each project alternative.

Project planning and design can take on a number of forms depending on the method used to deliver the project (e.g., the complete outsourcing of the planning and design phases or the use of public-private partnerships). Regardless of the methodology, it is within the best interests of the airport to ensure that lifecycle cost considerations are included at all stages of project development.

Tips for the project initiation, planning, and design stage

- For airports with large volumes of capital project initiations, use a formal decision-making process to evaluate the need for the project. This includes the use of project initiation forms or a similar record that includes a description of the problem, information on the risk exposure should the problem not be addressed, the levels-of-service requirement, whether or when levels of service will be violated, budget estimates for the most likely solution, and feasible options for further investigation (e.g., do nothing, maintain or operate differently, change level of service, replace or renew asset).
- Undertake a business case assessment for projects that meet predefined criteria, such as having high cost or high public or customer visibility, or are contentious, or where the potential cost savings associated with business-case development warrant the additional analysis.
- Include operator and maintainer input to the design process to ensure maintainability and operability.
- Include asset owner input into reliability requirements and limits on risk exposure to guide the level of redundancy built into the design.

Table 6-1 summarizes essential practice elements. The checks indicate whether the practice applies to each size category of airport. Note that while the practice may apply to all airports, the way in which it is implemented may vary depending on factors that may or may not include size. These factors may include the mission of the airport, governance structure, or skills and capabilities of staff.

Figure 6-1 outlines value-adding practices associated with the project validation and prioritization processes that were identified during the research.

Capital Project Delivery

The asset management planning process will generate initiated projects that are developed through business cases and on through planning and design. The project delivery workload that emerges from initial asset management plans can be higher than the normal planned capital project delivery workload unless the airport already has good asset management processes and practices in place. Estimates for resource needs to implement the asset management plan should be made during the asset management planning process so that the organization fully understands the implementation requirements and can plan how the project delivery function will be managed.

The choice of capital project delivery method is typically driven by the ability of the airport to raise funds, availability of appropriately qualified staff to manage the process, availability of contractors, or the strategic direction the airport has taken with respect to strategies for completing

Table 6-1. Summary of project imitation and planning best appropriate practice elements by airport size.

Project Initiation and Planning	Asset management steering committee or equivalent executive team approves final project prioritizations	Project prioritization using predefined criteria and economic assessments	Business cases completed for qualifying projects	Do nothing, maintain differently, non-asset solutions alternatives lifecycle cost comparisons	Formal project initiation stage checks against predefined criteria to ensure that sufficient knowledge and data is available to confirm the existence of a problem
Large/Medium Hub	**x**	**x**	**x**	x	**x** Using formalized processes and decision tools to establish whether the problem will continue to be monitored or included in a project development process
Small/Non-Hub, General Aviation	Applicable if there is a strong silo approach between infrastructure service groups	**x**	**x**	x	**x** Informal process for evaluating projects

functions in-house or by external providers. However, it is important to note, that U.S. airports have constraints regarding project delivery methods and outsourcing that result from state and local governance requirements and, in some cases, collective work agreements that apply to city or county airports.

Project delivery in this section refers to the methods used to procure and deliver new assets. Project delivery processes include

- Procurement methods
  - Design, build, operate (DBO)
  - Build, own, operate (BOO)

- The Greater Toronto Airport Authority (GTAA) undertakes business case analysis on an asset by asset basis (silo), to determine the most appropriate investment in airside pavements, people moving equipment (escalators, elevators, moving walkways, etc.), bridge structures, for example. Each of the investments in maintenance, rehabilitation or replacement are identified and prioritized and then passed on to a higher level cross-asset evaluation and life-cycle benefits using a software application (ReCAPP).
- Bangor Airport analyzes the return on investment for new projects. An 18 month payback is the target for revenue generating projects, and a 10 year payback is the target for energy efficiency projects.
- Lifecycle costing of project alternatives has been used successfully at Sarasota/Bradenton International Airport. Lifecycle costing assessments include all standard operations, maintenance and capital component assessments, with the addition of comparison of delivery mechanisms, such as turn-key and annual maintenance contracting.
- Brisbane Airport has a set of development objectives that are used in the evaluation of asset options. These include; facilitation of safe passenger, freight, and aircraft

Figure 6-1. Examples of project validation & prioritization practices.

  - Build, own, operate, transfer (BOOT)
  - Public-private partnership (PPP)
  - Service level agreement (SLA)
  - Construction manager-at-risk (CMR)
- Bid evaluation
  - Lowest price
  - Best value

ACRP Report 21: A Guidebook for Selecting Airport Capital Project Delivery Methods documented the benefits and disadvantages of various project delivery methods for capital airport projects and provided guidelines for selecting an appropriate delivery method for a specific project. Project delivery methods considered in this study were design-bid-build (DBB), construction manager-at-risk (CMR), and design-build (DB). A two-tiered project delivery selection framework was developed that can help the owners to evaluate pros and cons of each delivery method and select the most appropriate for their project (see ACRP Web-Only Document 6).

The Innovative Pavement Research Foundation (IPRF) completed a project (IPRF 01-G-002-06-1) on the use of design/build acquisition for airfield pavements. The project included a detailed project flowchart, screening matrix to determine the applicability of the use of design/build procurement for a particular project. Best practices guide and draft FAA Advisory Circular (AC) and U.S. Department of Defense Unified Facilities Criteria (UFC) documents provide guidance on the preparation of design/build alternate procurement contracts for airfield pavement construction projects.

Public-private partnerships (PPPs) are used by some U.S. airports. Examples of U.S. airport PPPs include Orlando-Sanford Airport, private Greenfield commercial airport in Branson and JFK Terminal 4 (ARTBA presentation). Most PPPs have been contractual in nature and are largely outside the FAA's Airport Privatization Pilot Program. These contractual PPPs have mainly been executed for contract management, operating lease, and concessions.

The online survey undertaken as part of the development of this guidebook indicated that in terms of bid evaluation, 15 percent of airports surveyed use a best value approach for over 90 percent of bids. A best value approach involves the assessment of both the qualifications of the company and individuals involved in the bid and the bid price. Projects that utilized FAA Airport Improvement Program funds for planning and design services are required by the Brooks Act to use a qualifications-based selection process rather than price. Other projects may select first based on qualifications, then evaluate the price and negotiate to determine a preferred supplier/vendor. Others evaluate qualifications and bid price simultaneously. Lowest bid continues to be the preferred option among the online survey respondents with 52 percent of respondents using lowest bid for over 90 percent of their bids.

"Best practice asset management requires that policies and procedures support the most cost-effective provision of lifecycle services, which generally indicates that the use of lowest bid for all projects and services is unlikely to deliver the optimal return on investment in terms of performance and lifecycle cost."

Questions for reviewing project delivery best practices:

- Are best value processes used to determine the project delivery method?
- Is contractor performance measured and are approved contractor databases in place and kept current?
- Do bid evaluations use a best value approach where appropriate, with low bid awards limited to approved services?

Asset Commissioning and Handover

Asset commissioning and handover is the most effective time for asset owners to capture financial, technical, and operational information on new assets for inclusion in engineering records, maintenance management systems, and financial asset registers. The creation of assets in a single system of record is essential for providing a basis (and opportunity) for the ongoing management of assets that the organization owns, or for which the organization has an ongoing maintenance and operations commitment.

The following lists examples of asset attribute data to collect during commissioning and handover:

- Physical attribute data
  - Location data (GPS coordinates, building markers, landmarks, etc.)
  - Size or dimensions
  - Material type
  - Capacity, etc.
- Asset lifecycle data
  - Installation year or year of manufacture
  - Projected useful life
  - Installation cost
  - Replacement cost
  - Annualized operations and maintenance costs, etc.
- Testing, operations and maintenance data
  - Contractor name and contact details
  - Vendor contact details
  - Design consultant contact details
  - Vendor order number
  - Startup test results
  - Photographs
  - Construction documentation
  - Operations and maintenance manuals
  - Warranty terms and dates
  - Spare parts list
  - Calibration information, etc.
- Building data
  - Occupancy (per floor, per square foot, per building)
  - Building codes
  - Design loads
  - Design occupancy
- Other specialized attributes

Ninety percent of the online survey respondents indicated that they receive operations and maintenance manuals at commissioning, whereas 29 percent indicated that they capture asset attribute information such as design life and replacement cost, which is essential information for developing a renewal plan for a network or system of assets.

Operations and Maintenance

The asset management planning process is designed to identify where changes to operations and maintenance strategies are required on a strategic basis. These requirements may include

- The need for a full review of maintenance strategies for a particular asset group,
- Introduction of continuous condition monitoring of specific equipment,

- Changes to maintenance contract requirements with respect to maintenance frequencies or performance, and
- Establishment of performance measures to monitor and manage the effectiveness of the maintenance program.

Any additional human resource needs, tools, or contract requirements for implementing the recommended operations and maintenance strategy changes need to be determined and managed in order to implement the asset management plan recommendations.

The maintenance management function includes the following four key processes of importance for optimizing asset performance, cost, and risk exposure:

1. Developing maintenance strategy,
2. Planning and scheduling,
3. Maintenance performance monitoring, and
4. Risk management and quality audits.

For many airports that participated in the research, defining levels of service and ensuring that maintenance strategies are designed to achieve them is one of the key challenges in improving asset performance.

The online survey undertaken as part of the development of this guidebook indicated that 45 percent of airports have maintenance programs that are somewhat proactive but mostly reactive, with 6 percent indicating that maintenance is mostly reactive.

A commonly quoted rule of thumb states that proactive maintenance is, on average, one-third of the cost of the reactive maintenance undertaken once the asset fails. Of course, actual costs vary on an asset-by-asset basis, according to the cost of the consequences (including repair) associated with failure. Therefore, in order to develop a maintenance program that limits lifecycle costs, maintenance strategies need to address the prevention of failure as well as response to failure.

Tips for reviewing maintenance strategies

To validate whether an asset should be managed proactively or run to failure, the following business rules can be applied:

Implement preventive or predictive maintenance strategy if

- Failure can be prevented by preventive or predictive maintenance (including condition monitoring then replacement)
- Asset life can be extended or performance maintained or improved using preventive or predictive maintenance

Modify the current preventive maintenance task frequency if the

- Current PM interval is not at least half of the mean time between failures (MTBF) footnotes
- Current PM interval is not optimized against run times, wear rates, and performance

Adopt a run-to-failure maintenance strategy if

- Preventive maintenance will not prevent a failure or extend life or maintain performance of the asset
- The cost of routine inspections required to detect failure outweighs the cost of the consequence of failure, including the repair or replacement of the asset, required to restore service

- At Gatwick Airport, London (GAL), intelligent monitoring techniques have been introduced as part of the refurbishment of a bridge over the railway. This bridge will have built-in condition monitoring to avoid some of the need for railway possessions to undertake inspections. Maintenance comprises statutory inspections (SI) and maintenance (SM), corrective maintenance, and planned maintenance. The information system provides a readily available measure of the status of SIs and SMs, which when published proved effective in increasing the level of compliance because there should not have been a backlog. The SIs are now achieving 100 percent and the SMs are at 95 percent and improving.

  This illustrates the impact of information but also confirms that while it might be used initially to highlight failure and promote better performance, it can become a positive measure of success to broadcast to the organization.

  Standard procedures define monitoring for teams and assets, and as weekly reviews implemented through the introduction of a group-focused "scorecard," is indispensable. It has been found that the scorecard has helped focus work and drive the improvement loop (for example, updating and correcting data in Maximo).

  At the asset level, the monitoring process identifies what has been done, what was supposed to be done, and what it tells GAL about the performance of the assets. It also provides an indication of future renewal needs.

  Monitoring performance promotes root cause investigations to determine why something has failed and to prevent recurrence or build in contingency.

  Maintenance will move increasingly to planned works and monitoring will remain visible. One of the changes under GIP has been the allocation of maintenance to the "maintenance resource" and not to named individuals, which places the onus on maintenance as a group to fulfill the workload.

  A process for management review has been documented (monthly meeting with designated asset stewards to feed into it) but this is yet to be implemented.

Figure 6-2. Example of observed maintenance and operations practices.

Operability requirements influence the configuration of assets, and operating strategies influence run times and utilization, as well as automation and operating parameter data collection and analysis, the configuration of the workforce, emergency response, and strategies to adapt to changes in load, demand, or environmental impacts. From an asset management practice standpoint, operating strategies are monitored and managed to continually address regulatory, asset performance, or service level needs, as well as cost performance.

Figure 6-2 summarizes maintenance and operations practices that have delivered value to airports that participated in this ACRP research effort.

CHAPTER 7

Performance Assessment and Improvement

Monitoring and Managing Performance to Achieve Objectives

Chapter 4, Asset Management Strategies and Plans, outlined the role of asset management planning within the airport planning processes and defined asset management as the collective processes, practices, and tools used to achieve the airport strategic plan objectives. The performance management framework is the component of the asset management system that monitors and manages performance from a strategic, whole-of-airport standpoint, down to asset-level performance. The performance management framework links performance goals, through appropriate performance measures, to activities for monitoring performance and actions to improve performance where monitoring indicates a need.

In terms of customer service levels and asset response, airport executives are concerned with the controllable aspects of a small set of KPI, such as:

- Percentage of delayed flights due to the efficiency of airport operations;
- Connecting times related to the organization of the airport and efficiency of airport operations such as baggage handling and security,;
- Wait times at check-in, immigration, and security due to the efficiency of airport operations; and
- Baggage delivery (timeliness and lost bags) due to the efficiency of baggage handling operations.

Combining these with business KPI, and lower-level KPI associated with facility management (e.g., cleanliness of restrooms), there are a range of performance issues to manage from an asset management viewpoint that directly impact maintenance tactics (what maintenance is performed and how often) and renewal and new capital investment decisions.

A performance management framework that maintains its relevancy through regular strategic reviews by executive management provides the link between stakeholder needs and the airport's ability to realize them through asset management responses.

Performance management is particularly important for those airport services that directly impact customers (e.g., baggage handling). Managing the reliability of baggage handling equipment requires a good understanding of asset condition and performance, preventive maintenance, and failure response plans to ensure continuity of service to customers.

Performance monitoring is the continuous monitoring and routine reporting of asset performance to identify trends and alert the organization to systemic and asset-level problems that require attention. Performance monitoring and management systems are typically hierarchical, whereas asset-level failure impacts and performance data is reported at a facility or system level, then at a network level, and ultimately at an enterprise level.

Airport KPI

- Customer Dissatisfaction
- Number of lost baggage events
- Timeliness

Maintenance Contractor

- Continuous sortation accuracy from an encoded position (i.e., ATR (Automatic Tag Reader, BDD (Binary Decision Diagram encoding) (or manual encoding) of 99%, calculated on a weekly basis, for the total number of bags input into the baggage system.
- Continuous tracking accuracy from an encoded position (i.e., ATR, BDD or manual encoding) of 99%, calculated on a weekly basis, for the total number of bags input into the baggage system.
- Minimum daily average read rate maintained for originating baggage will be 90% successful reads of all 10 digit (i.e., Standard IATA 10 Digit Bar Coded Baggage Tag) and all Device Number (fall-back) Baggage Tags.
- The maximum time for any corrective maintenance repair shall be two (2) hours by two (2) staff.
- The maximum response time (measure from the time the issue occurs until the Operations and Maintenance Contractor has taken action is 5 minutes.

Figure 7-1. Example of baggage handling performance.

Figure 7-1 shows an approach to performance management for baggage handling systems.

In terms of asset-level performance management, the online survey undertaken as part of the development of this guidebook indicated that 58 percent of the airports routinely sought to reduce cost, risk, and environmental impacts through their design, maintenance, and operating decision making. Forty-two percent continually recorded and updated asset condition information and 29 percent indicated that they have procedures in place to detect root cause of non-performance and rectify.

Tips for undertaking performance management

- Monitor and report airport-level KPI hierarchically by location.
- Monitor and report at the department level for facilities, systems, or networks to focus investments.
- Undertake root cause analysis for critical events.
- Identify and classify causes of poor performance.
- Identify performance issues, via operations and maintenance staff, and prioritize investment through a criticality ranking approach.
- Close performance gaps through design, operations, and maintenance or renewal strategies.

Figure 7-2 shows an example of a performance management framework used at a large airport that has implemented an asset management system consistent with the PAS 55 specification.

- Gatwick Airport London (GAL) uses a comprehensive performance management framework to manage the business to ensure that asset management processes meet the objectives of the business. GAL uses a holistic measurement framework to track asset requirements assuring governance in parallel to delivering sustainable value improvements as follows:
  - Leading measures: what we say we are going to do to assure the standards are met. The measurement of activities that predict future outcomes such as compliance with statutory inspections.
  - Lagging measures: historical measures of asset effectiveness directly linked to the three performance standards.
- The governance improvement process is based around 19 asset stewardship processes (ASPs) to achieve integrity, performance, and integrity in the useful life phase at minimal total cost.
  - ASP1: New asset introduction process
  - ASP2: Identify existing assets, the knowns, unknowns, and known unknowns
  - ASP3: Assess criticality of assets from customer's perspective
  - ASP4: Assess performance requirements of asset based on criticality to the customer
  - ASP5: Establish asset lifecycle strategy to achieve performance requirements
  - ASP6: Establish and document operating protocols
  - ASP7: Develop contingency plans for maintaining operational requirements in event of failure
  - ASP8: Establish resources required to deliver asset management service
  - ASP9: Complete asset management activities
  - ASP10: Establish leading and lagging measurement framework for asset
  - ASP11: Conduct Plan, Do, Reviews assessing asset effectiveness to drive value improvement
  - ASP12: Monitor instances of asset abuse
  - ASP13: Monitor asset safety records
  - ASP14: Monitor asset permit to works
  - ASP15: Monitor asset change control
  - ASP16: Monitor asset usage against original design requirements
  - ASP17: Annual governance improvement review by asset group/location; asset health check and improvement objectives (remove? repair? restore? replace?)
  - ASP18: Update asset replacement plan
  - ASP19: Airport asset governance review
- The performance management system is illustrated schematically as

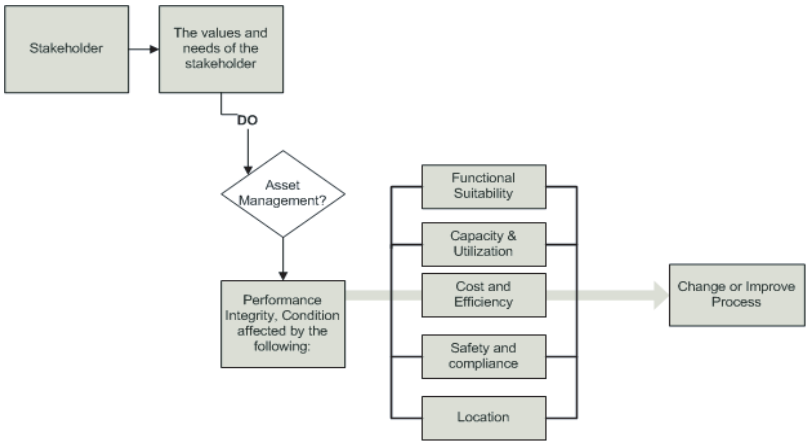


Figure 7-2. Example performance management framework for a large airport.

CHAPTER 8

Management Review

The plan-do-check-act concept applies to lifecycle asset management. Chapter 3, Asset Management Objectives, of this guidebook outlines the process for developing an asset management plan. This is the "plan" part of the cycle. The "Implementation: Lifecycle Process and Performance Assessment" chapters discuss enablers and implementation of the plan. This is the "do" part of the cycle. This chapter addresses management review, which is the "check" part of the cycle. The implementation of business improvement tasks represent the "act" part of the cycle in terms of management review.

The following sections cover

- Ensuring that the asset management system supports changing strategies;
- Improving business processes, data, and information; and
- Auditing performance against the plan.

Strategic Priority Review and Strategy Adjustment

The review of strategic priorities through the airport strategic planning process informs the asset management planning process of any modifications required to key performance indicator targets, capacity enhancements, or asset retirements.

In addition to the normal review of the airport strategic plan, it is also a good idea to review the operation of the asset management system (process, practices, procedures, and tools) to evaluate how well it is, or can continue, to assist in achieving the airport's strategic objectives.

PAS 55 Part 2 suggests that the following recommendations and guidance be used in undertaking a review of the asset management system:

a) Executive management should review the operation of the asset management system to assess whether it is being fully implemented and remains suitable for achieving the organization's stated asset management policy, strategy, objectives, targets, and plans.
b) The review should also consider whether the asset management policy continues to be appropriate. It should establish new or updated asset management objectives for continual improvement, appropriate to the coming period, and consider whether changes are needed to any elements of the asset management system.
c) Review should be carried out by executive management on a regular basis (annually). The review should focus on the overall performance of the asset management system, and not on specific details, since these should be handled by the normal means within the asset management system.
d) It is essential that any deficiencies and/or opportunities for improvement identified as a result of the management review are addressed and the asset management system amended accordingly.
e) The results of the management review including any recommendations for changes to the asset management system should be communicated to appropriate stakeholders.
f) The results of the management review should be documented and form part of the asset management system documentation.

Improving Business Processes, Procedures, Data, and Information

The asset management plan has the following two primary outputs:

- The investment plan, which outlines the capital, maintenance, and operations strategies, their associated investments and timing
- The business improvement plan, which outlines the tasks and activities to be completed to improve the accuracy or level of confidence that decisionmakers can have in the recommendations and data included in the plan, or to improve the efficiency of the asset management planning process itself

The business improvement plan is implemented as a program of tasks and projects, some of which may require a project manager, others of which may be completed as part of normal job roles and responsibilities.

The management review exercise or asset management gap analysis exercises may identify additional business improvement tasks that are prioritized and programmed for implementation.

Steps for identifying and prioritizing business improvement tasks

- Undertake a management review or maturity/gap analysis of the asset management function.
- For each business improvement task, determine the level of benefit. Key questions to ask include
  - Will the task improve levels-of-service achievement?
  - Will the task reduce costs?
  - Will the task significantly improve the level of confidence in future investment estimates?
  - Will the task improve the ability to prevent failure of critical assets?
  - Will the task reduce the likelihood of not identifying risks that need to be mitigated?
  - How much does the task cost to complete? How will it be resourced?
  - What are the lifecycle cost benefits?
  - What is the overall benefit/cost?
- Prioritize the improvement tasks by their benefit/cost (high, medium, low)
- Develop a business improvement plan, identify positions responsible for completing business improvement plan tasks and for the overall implementation of the plan

Auditing Performance against the Plan

To continuously work toward the achievement of the asset management plan objectives, regular auditing of compliance with the plan is desirable. Auditing involves answering the following questions:

- Is the airport doing what the plan says it is?
- Are the maintenance, operations, and capital strategies being implemented on time?
- Are the targeted service levels being achieved?
- Are there adequate explanations for deviation from the plan?

There are two methods for evaluating performance against the plan, as follows:

- Incorporate actual against planned key performance indicators in regular reporting on capital project delivery and asset performance initiatives for all strategies recommended for implementation in the asset management plan
- Undertake an internal audit of the asset management plan and its implementation

An internal audit does the following:

- Reviews the asset management planning processes
  - Assesses the quality of the data and information on which the plan was based
  - Reviews the level of assessment for determining investment requirements
- Reviews the implementation of the plan
  - Compares work completed against work planned for each maintenance, operations, capital project adopted for implementation
  - Documents the efficiency and effectiveness of implementation processes (such as project delivery and maintenance management) to establish the root cause for any situations in which the work completed lags the work planned for the period
- Reviews the levels-of-service performance
  - Documents the causes for non-achievement of levels-of-service targets, where necessary
- Reviews the ability of the organization to deliver the plan
  - Identifies any human resource, support tool, or financial hurdles or impediments to delivering the plan

The results of an internal audit process are discussed by executive management and an action plan is put in place to resolve issues that may prevent the achievement of the objectives of the airport strategic plan.

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Glossary

Airport Cooperative Research Program (ACRP)—an industry-driven, applied research program that develops near-term, practical solutions to problems faced by airport operators. (www.trb.org)

Airport Improvement Program (AIP)—provides grants to public agencies—and, in some cases, to private owners and entities—for the planning and development of public-use airports that are included in the National Plan of Integrated Airport Systems (NPIAS).

Airport Asset Management Plans—describe the activities and investments in infrastructure and assets required to achieve and maintain service outcome standards in the short- and long-term, according to the airport's master plan or strategic plan for servicing customers, the community, and other stakeholders.

Airport Master Plan—is a concept of the long-term development of an airport. The plan displays this concept graphically and documents the data and logic upon which the plan is based (FAA Advisory Circular).

Annual Annuity—annual payments required to cover the cost of future planned investments.

Annual Plan—a document produced annually by an organization to inform stakeholders of its objectives, intended activities, performance, income, and expenditure required for a period of one financial year. It may also indicate anticipated future short-term income and expenditure.

Asset—an item of plant, equipment, or infrastructure that contributes to the function of a "system" so that the "system" can provide a service to a community or group of customers. An "asset" is continually maintained, refurbished, replaced, or upgraded so that the system provides an ongoing, minimum level of service. An asset has a capital replacement value and is depreciated over its useful life.

Asset Accounting—recording and tracking of asset-related incoming and outgoing cash flows.

Asset Group—a group of like assets (e.g., valves) or a group of assets that comprise a system (e.g., pump system).

Asset Hierarchy—a framework of segmenting an asset base into appropriate classifications. The asset hierarchy can be based on asset function, asset type, or a combination of the two.

Asset Management (AM)—as defined by NAMS, a systematic approach to the procurement, maintenance, operation, rehabilitation, and disposal of one or more assets. AM integrates the utilization of assets and their performance with the business requirements of asset owners or users. AM is all about the continuous alignment of asset performance to meet service delivery outputs to deliver the desired outcomes.

A management paradigm and a body of management practices that is applied to the entire portfolio of infrastructure assets at all levels of the organization, which seeks to minimize the total cost of acquiring, operating, maintaining, and renewing the organization's assets within an environment of limited resources while continuously delivering the service levels customers desire and regulators require at an acceptable level of business risk to the organization.

Asset Management (AM)—as defined by PAS 55 is systematic and coordinated activities and practices through which an organization optimally and sustainably manages its assets and asset systems, their associated performance, risks, and expenditures over their lifecycles for the purposes of achieving its organizational strategic plan.

Asset Management Information System (AMIS)—computer-based software system for collecting and analyzing data, and extracting meaningful information on the performance of existing assets and their operating costs to aid in asset management decision-making. AMIS is often also referred to as an enterprise asset management system (EAMS).

Asset management plan (AMP)—document that identifies the short- and long-term service delivery requirements of the portfolio of assets belonging to an organization. It provides a framework for managing an asset, or group of assets, from within the asset portfolio.

Asset Management Policy—sets the framework for the management of airport infrastructure and assets. Most policies include

- Organizational context and importance of asset management,
- Overall vision and goals of the organization and supporting asset management vision and goals,
- Executive and key position roles and responsibilities, and
- Audit and review procedures.

Asset Management Framework—system of processes, procedures, practices, support systems, organizational roles and responsibilities, and policies used to enable sound management decisions for the optimal management of physical assets.

Asset Management Strategy—strategy for asset management covering the development and implementation of plans and programs for asset creation, operation, maintenance, rehabilitation/replacement, disposal, and performance monitoring to ensure that the desired levels of service and other operational objectives are achieved at optimum cost.

Asset Management Steering Committee—committee of people that have come together within the organization to design and build the asset management program. These people establish the program and enforce the ideas and practices within the organization.

Asset Performance—measurement of the achievement of predetermined outputs arising from the existence and operation of assets using a range of performance targets that measure the individual and collective contribution an asset makes toward service delivery and/or business outputs.

Asset Registry—a record of asset information considered worthy of separate identification including inventory, historical, financial, condition, construction, technical, and financial information about each.

Asset Rehabilitation—work performed on an existing asset to ensure that its performance capacity and capability meets its predetermined performance target. It does not refer to work that transforms the asset to an "as new" condition. Painting a room and replacing its floor covering, milling and repaving a section of road, all fall within this category.

Asset Renewal—replacement or reconstruction of an existing asset with a new asset. The resultant asset is transformed to an "as new" condition. Demolishing and rebuilding new classrooms or a hospital ward fall within this category. Renewal is comprised of

- Repair: normal periodic maintenance, minor in nature, anticipated in the normal operation of the asset; no enhancement of capabilities;
- Refurbish/Rehabilitation: replacement of a component part or parts or equivalent intervention sufficient to return the asset to level of performance above minimum acceptable level; may include minor enhancement of capabilities; typically funded out of capital budgets;
- Replace without enhancement: substitution of an entire asset with a new or equivalent asset without enhancement of capabilities; and
- Replace with enhancement: substitution of an entire asset with a new or equivalent asset with enhanced capabilities.

Asset Replacement Cost—full replacement costs associated with a given asset expressed in current dollars.

Attributes—a data item related to an asset.

Best Appropriate Practice—a method or technique that has shown results superior to those achieved with other means and that is used as a benchmark (business dictionary).

Business Improvement Plan—plan produced by an organization that translates the objectives contained in an annual plan or asset management plan into detailed work plans for a particular, or range of, business activities. Activities may include marketing, development, operations, management, personnel, technology, and financial planning.

Business Risk Exposure (BRE)—a metric to expresses risk. BRE is determined as the product of the probability of failure and the consequence of failure.

Computerized Maintenance Management Systems (CMMS)—act as a focal point of information systems supporting best practice asset management.

Condition Assessment—technical assessment of an asset based on a physical inspection, for the purpose of determining its condition and remaining useful life relative to a defined standard.

Consequence of Failure (CoF)—the resultant consequence of an asset failure expressed in triple bottomline (TBL) terms (social/community, economic, and environmental/regulatory).

Critical Assets—assets for which the financial, business, or service-level consequences of failure are sufficiently severe to justify proactive inspection and rehabilitation. Critical assets have a lower threshold for action than non-critical assets.

Current Replacement Cost—cost of replacing an existing asset with an appropriate modern equivalent asset.

Decay Curve Development—is the process by which asset time to failure data records are analyzed to develop a graph of the deterioration in asset condition time.

Decommission—activities required to take an asset out of service.

Demand Capital Plan—describes the capital projects that have been identified for the purposes of meeting the predicted growth and demand requirements over the planning period.

Depreciated Replacement Cost—replacement cost of an existing asset less an allowance for water or consumption having regard for the remaining economic life of the existing asset.

Decision Support Tools—used by asset managers to determine the best alternative among a set of feasible alternatives. The alternatives may be potential solutions to a range of questions related to strategic planning, airport development, outsourcing, and asset renewal or replacement.

Economic Failure—when the asset is no longer competitive with asset options that are available in the market place for delivering the same or improved function.

Economic Life—period from the acquisition of the asset to the time when the asset, while physically able to provide a service, ceases to be the lowest cost alternative to satisfy a particular need. The economic life is at the maximum equal to the physical life but obsolescence will often ensure that the economic life is less than the physical life.

Enterprise Asset Management Systems (EAMS)—a maintenance management system that operates across the enterprise to include the management of all physical assets owned by the enterprise.

Equivalent Uniform Annual Cost (EUAC)—payment required to fund the lifecycle cost over the service life of the asset.

Facilities—A "facility" is an installation of assets that facilitates a process or function. Assets within a "subsystem" can be classified as either linear or non-linear. Non-linear assets occupy a bound space and can be modeled as part of a parent-child hierarchy. Linear assets are continuous with linear properties. Facilities are the non-linear installations of assets within a subsystem and underground structures like pipes and valves are considered linear assets.

FAA—the national aviation authority of the United States.

GAP Analysis—assessment of the current level of practice in asset management. The gap is the difference between current practices and the best appropriate practice for that organization. It is sometimes referred to as a maturity assessment.

General Aviation Airports—(GA) airports are one of the two categories of civil aviation airports. GA airports cater to all flights other than military and scheduled airline and regular cargo flights, both private and commercial.

Geographic Information System (GIS)—a computer package that displays a map connected to a database. The package can typically combine features, such as roads and sewers, from different maps and overlay them on the same screen. To qualify as a GIS, such systems should also be able to reference a computer database for textual information, such as notes and dimensions, regarding features displayed on the map.

Infor EAMS—software used by organizations to keep track of their assets, understanding that they meet environmental, compliance, and service requirements.

Infrastructure Management—the discipline of managing infrastructure assets that underpin an economy, such as roads, water supply, wastewater, storm water, power supply, flood management, recreational and other assets.

Intergenerational Equity—ensuring that future generations are not burdened with the cost of the consumption of infrastructure by the current generations.

International Infrastructure Management Manual (IIMM)—manual produced to give an understanding of asset management practices.

ISO (International Organization for Standards)—organization known for producing and publishing international standards for all subject areas in the world. This organization forms a network between both the public and private sectors as it is not a government organization.

Key Performance Indicator (KPI)—quantitative or qualitative indicator of the quality of service, efficiency, productivity, or cost effectiveness of an agency, program, or activity that enables a comparison to be made for management purposes of performance against a standard target or norm. It may be a quantitative measure or qualitative indicator of performance.

Large Hub Airport—commercial service airports that have at least more than 10,000 passenger boardings each year and 1 percent or more of total passenger boardings within the United States in the most current calendar year ending before the start of the current fiscal year.

Level of Service—level of asset service determined by both the quality and the quantity of services provided by an asset under consideration.

Lifecycle Costing—sum of all recurring and onetime costs over the full lifespan or a specified period of an asset under consideration.

Lifecycle Process—cycle of activities that an asset goes through while retaining an identity as a particular asset.

Maintenance Managed Item (MMI)—MMI level is that level for maintenance detail elected for the organization asset register. The MMI could be a whole building in some systems, whereas in more sophisticated systems it could be a shaft beading on an electric motor.

Best Appropriate Practice requires that the level of detail in the asset register should allow for the recording of data down to the MMI level. MMI refers to the lowest level of an asset's physical structure that is to be recognized within an asset register where the registry is structured as a nested hierarchy of physical assets. Typically, an MMI is set at that level of the hierarchy at which an asset is individually maintained or at which management decisions to repair, renew, or replace are made.

Maintenance Management—method of allocating resources to accomplish predetermined levels of service through planning, budgeting, scheduling, executing, and reporting and reviewing maintenance strategies and tactics.

Management Strategies—the operations, maintenance, and capital investment strategies determined for the planning period. This may include changes to maintenance strategies to implement more proactive maintenance, or could include changes to emergency response plans for specific events.

Management Strategy Group (MSG)—assets of similar type that are managed and maintained in a similar way and have similar patterns of decay.

Management System—system to establish policy and objectives and to achieve those objectives. Note that the management system of an organization can include a range of subsets that collectively constitute the whole. These subsets usually include the following:

- Quality management system,
- Human resource management system,
- Fiscal management system,
- Asset management system,
- Information management system, and
- Environmental management system.

Manager, Asset Management Services—position within an organization that has the responsibility for the management of the Asset Management Services Team. The team's role is the implementation of the corporation's asset management improvement plan.

Master Planning—process of orderly planning of system's future improvement program that identifies the present and future needs and direction for developing the system's facilities.

Maturity Assessment—evaluation of the degree to which an organization uses recognized best practices and the availability of information required to plan for, and implement, improvements. The ultimate value of maturity assessment can only be realized in the context of an overall process improvement and organizational change program.

Maximum Potential Life (MPL)—the maximum length of time of an asset's life (including the maximum number of rehabilitations possible to extend asset life) up to which either the end of physical life, service life, or economic life (whichever occurs first) dictates that the asset be replaced, given the following definitions:

- End of physical life: when an asset physically stops working, collapses, or is otherwise nonoperational;
- End of service life: when an asset can no longer deliver what customers or regulators require it to deliver (e.g., "customer outrage"); and
- End of economic life: when an asset ceases to be the lowest cost alternative to satisfy a specified level of performance or service at an acceptable level of risk. Also, the time at which disposal or replacement of the asset results in the greatest cumulative production from the asset per cumulative dollar cost (or the "long run lowest average cost per unit of production," where "unit of production" for linear water pipe assets is "availability of water on demand").

Net Present Worth (NPW)—the Net Present Value (NPV) or NPW of a time series of cash flows both incoming and outgoing, is defined as the sum of the present values (PVs) of the individual cash flows.

Non-Hub Airport—commercial service airports that have at least more than 10,000 passenger boardings each year but less than 0.05 percent of total passenger boardings within the United States in the most current calendar year ending before the start of the current fiscal year.

Operations and Maintenance—activities related to the performance of routine, preventative, predictive, scheduled, and unscheduled actions aimed at preventing asset failure or decline with the goal of increasing efficiency, reliability, and safety.

Optimized Decision Making—An optimization process for considering and prioritizing all options to rectify existing or potential performance failures of assets.

Organizational Change—a process of change in an organization as a result of change in business processes, organizational structure, or culture within an organization.

Organizational Strategic Plan—overall long-term plan for the organization that is derived from, and embodies, its vision, mission, values, business policies, stakeholder requirements, objectives, and the management of its risks.

PAS 55 2008 (Publically Available Specification)—standards being used as the basis for development of an ISO standard, which are supported by American National Standards Institute and the International Infrastructure Management Manual.

Passenger Facility Charges (PFC)—a fee imposed by a facility owner, as an airport or those using the facility; typically added to the cost of a fare.

Pavement Condition Index—a numerical index between 0 and 100 used to indicate the condition of a roadway. It is a statistical measure and requires manual survey of the pavement.

Pavement Maintenance Management—a systematic, long-term approach in optimizing pavement maintenance that ties together various maintenance options in one plan based on available funding.

Pavement Surface Evaluation and Rating Tool—Rating manual or software that provides guidance on understanding and rating the surface condition of flexible and rigid airfield pavements and provides a simple system to visually rate pavement condition.

Performance Management Framework—the component of the asset management system that monitors and manages performance from a strategic, whole of government, down to asset level performance. The performance management framework links performance goals, through appropriate performance measures, to activities for monitoring performance and actions to improve performance where monitoring indicates a need.

Physical Effective Life (PEL)—the length of time (with no rehabilitations to extend life) from when an asset is commissioned and put in service until it physically stops working, collapses, or is otherwise non-operational. For an asset that cannot be rehabilitated, the PEL is equal to the maximum potential life (MPL).

Plan—Asset Strategic Plan (ASP)—this plan (developed at the asset level) along with the asset portfolio strategic plan are the only organizational strategic plans. In the areas of acquisition/refurbishment, operations, maintenance, and disposal, proposed annual programs are developed. Long-term strategies addressing all proposed asset lifecycle issues and objectives are fundamental to the ASP. The ASP is "rolled-up" in summary format to form the portfolio strategic plan (PSP). The PSP enables the asset planner to prioritize performance improvement initiatives, and to level-out peaks in planned expenditure. It simply provides a big picture overview of the asset portfolio.

Preventative Maintenance—a schedule of planned maintenance actions aimed at the prevention of breakdowns and failures.

Probability of Failure (PoF)—the "likelihood" that an asset will fail based on an assigned condition score. The PoF for this asset management plan is expressed as a score between 1 and 10 determined using a direct relationship between condition and probability.

Rate of Depreciation—accounting practice that aims to distribute the cost or other basic value of a tangible asset less salvage value, if any, over the estimated useful life of the assets in a systematic manner.

Rehabilitation—project to rebuild or replace parts or components of an asset to restore it to a required functional condition and extend its life, which may incorporate some modification. Generally involves repairing the asset to deliver it to original level of service without resorting to significant upgrading or renewal, using available techniques and standards.

Reliability—probability that a system performs a specified function or mission under given conditions for a prescribed time.

Remaining Life—time remaining until an asset ceases to provide the required service level or economic usefulness.

Renewal—project to upgrade, refurbish, or replace existing assets with assets of equivalent capacity or performance capability.

Repair—action to restore an item to its previous condition after failure or damage.

Replacement—complete replacement of an asset that has reached the end of its asset life, so as to provide a similar or agreed alternative, level of service.

Replacement Cost—cost of replacing an existing asset with a substantially identical new asset in current dollars.

Risk Assessment—process of establishing information regarding acceptable levels of a risk and/or levels of risk for an individual, group, society, or the environment.

Risk Exposure—extent of risk faced by an organization that is expressed in terms of a numerical F representing the product of the likelihood and impact of a loss.

Risk Profile—describes how risk exposure is evaluated and identifies at risk assets.

Residual Life—time left until failure; particularly important for managing high-cost and high-risk assets.

Small Hub Airport—commercial service airports that have more than 10,000 passengers boardings each year and at least 0.05 percent of total passenger boardings within the United States in the most current calendar year ending before the start of the current fiscal year, but less than 0.25 percent.

SWOT Analysis—analysis that provides an assessment of an organization's strengths, weaknesses, opportunities, and threats to provide a snapshot of the present and a view of the future for that organization.

Terminal Area Forecast—official forecast of aviation activity at FAA facilities; prepared to meet the budget and planning needs of FAA and provide information for use by state and local authorities, the aviation industry, and the public.

Triple Bottomline—triple bottomline accounting refers to expanding the traditional reporting framework to take into account ecological and social factors in addition to financial factors.

APPENDIX A

Standards Resourcing Information

Standards Site Location Material	
International Infrastructure Management Manual	http://www.nams.org.nz/digitiseshop/cat-3/Manuals%20&%20Guidelines.htm
British Standards – PAS 55	http://pas55.net/
PAS 55 Assessment Methodology	http://theiam.org/products-and-services/pas55-methodology
SIMPLE Gap Analysis	http://www.werf.org/AM/Template.cfm?Section=Home&Template=/Custom/home.cfm
ISO 55000 Information	http://www.iso.org/iso/iso_catalogue/catalogue_ics/catalogue_detail_ics.htm?ics1=03&ics2=100&ics3=01&csnumber=55088

APPENDIX B

Asset Management Policy

Sustainable Asset Management Policy

EX-1 5 as of 6/27/07

I. Statement of the Policy

The Port of Seattle uses a sustainable asset management approach to guide its decisions related to the planning, design, construction, operation, maintenance, renewal, and demolition of its airport, seaport, and other facilities. This approach integrates environmentally and economically sustainable development by maintaining a focus on the total cost of ownership and implementing a comprehensive asset management program. This policy is consistent with, and reinforces, the Port Commission's strategic goals to "ensure airport and seaport vitality," "exhibit environmental stewardship through our actions," and "be a high-performance organization."

II. Purpose

A. Provide an added tool for the Port Commission in the decision-making process. The sustainable asset management policy provides a proactive approach to monitor long-term thinking about our facilities development and ownership, focuses on the total cost of facility ownership to better link capital investment and ongoing operating costs, provides clear data on project performance, institutes an industry best management practice that maximizes and links the efficient use of available funds, and further integrates environmental and financial performance.

B. Reduce long-term capital and operating costs. The focus on both initial and ongoing costs will help determine the total cost of ownership for a facility over its projected lifetime. This will help us make better decisions on our capital investments. Where these costs are split between the Port of Seattle and its tenants, these capital investment decisions need to be evaluated given that business relationship.

C. Support environmentally sustainable development. Sustainable asset management can guide decision making toward materials and operational practices that have lower impacts on the environment through the entire lifecycle of an asset. Examples of reduced operating impacts are the reduction in greenhouse gases, latent heat, and solid waste and waste water. In addition, when a facility has served its useful life, sustainable asset management will guide decision making on disposal of facilities and building materials with consideration about the further usefulness of the materials, opportunities for recycling, or appropriate waste disposal.

D. Conserve resources. Conserving resources is necessary for the long-term viability of our businesses and a strategic objective of sustainable facilities management. Evaluating the

lifecycles of facilities and their components will enable the port to maximize the effective life of the resources we have invested in, consistent with the expected useful life of these resources. Taking a long-term view of asset ownership can result in decisions that reduce energy and water consumption, reduce waste generation, maximize use of recycled materials, and conserve other resources. For example, modern lighting systems that provide high-quality light at low wattage are increasingly available and can reduce electrical energy use for decades.

III. Applicability

The requirements of this policy apply to all assets owned, leased, constructed, or otherwise managed by the Port of Seattle.

IV. Principles

A. Consider the total cost of ownership when making asset investment decisions. Total cost of ownership is the sum of all recurring and non-recurring capital and expense costs incurred over the life of a facility or system from planning through demolition (does not include furnishings or non-facility-specific equipment). Total cost of ownership may also be referred to as "lifecycle costs" and can be expressed in real dollars, nominal dollars, or NPV. The evaluation must include the established split in responsibilities (e.g., between the Port of Seattle and its tenants) for those cost components. Also note that land values and financing costs are specifically excluded. Total cost of ownership includes five major components as follows:

- Operational
  1. Utilities
  2. Operations
  3. Maintenance and repair
- Capital
  1. Initial cost
  2. Component renewal

B. Perform comprehensive asset management from a whole organization perspective. Comprehensive asset management is the identification and prioritization of facility and infrastructure physical, functional, and budgetary needs, spanning a multiyear timeframe. It also includes the process of reinvesting funds into physical assets in support of the port's mission and is driven by the organization's business plans and strategies.

C. Use a sustainable development approach. Using the World Commission on Environment and Development's definition, sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Sustainable development is based on a long-term, systems-thinking point of view and balances environmental, social, and economic objectives.

V. Definitions

A. Utilities: Expenditures for providing utility service associated with the asset.

B. Operations: Expenditures that do not maintain or extend the life of the asset but that enhance or preserve the functionality, such as security and janitorial.

C. Maintenance: Planned and unplanned activities carried out to maintain and preserve the lifecycle of the component, system, or whole asset (such as painting, caulking, adjusting, and lubricating).

D. Repair: Minor corrective actions required to restore or maintain and preserve the lifecycle of the component, system, or whole asset (such as fixing cracks, repairing holes and any type of damage).

E. Component renewal: Replacement of a component, system, or portion of an asset that has reached the end of its useful or expected life.

VI. Comments

The initial guidance for implementing this policy is provided in the related PROCEDURE EX-15.

APPENDIX C

Maturity Assessment Best Practice

Best Appropriate Practice Breakdown

Master Planning	Use dynamic strategic planning approaches	Include integrated regional planning studies	Review local land use plans and air traffic and passenger growth projections	Include stakeholder and community consultation to address levels of service	Extrapolate from historic demand patterns
Large/Medium Hub	**x**	**x**	**x**	**x**	**x**
Small Hub, General Aviation, Non-Hub	In circumstances where there is considerable uncertainty in growth forecasts	**x**	**x**	**x**	**x**

Example Practices

- Schiphol Airport in the Netherlands uses a dynamic strategic planning approach to master planning by systematically identifying vulnerabilities (for example, demand for air traffic grows more quickly than forecast), their mitigating actions, and possible signposts or triggers

Vulnerabilities	**Mitigating/Hedging Actions**	**Possible Signposts/Triggers/Actions**
Certain: Resistance from Schiphol stakeholders (e.g., environmental groups, people living around the airport)	Develop green areas to compensate for environmental losses Offer financial compensation to residents in the high-noise zone Noise abatement measures in the approach and departure routes surrounding the airport	
Uncertain: Demand for air traffic grows faster than forecast	Prepare to adapt surrounding airports for specific users (e.g., all-cargo flights, low-cost carriers, and charter flights)	Monitor the growth of Schiphol in terms of passenger movements, aircraft movements (and related noise and emissions), trigger defensive, corrective , or

Vulnerabilities	Mitigating/Hedging Actions	Possible Signposts/Triggers/Actions
	Design Noise Insulation Program such that it can easily be scaled up Order a study into alternative locations for a national airport	reassessment actions as needed, for instance: Defensive: Explain increase in noise to residents, step-up noise insulation program, noise abatement measures Corrective: Switch O/D flights to other airports Reassessment: Start a new strategic planning process
Uncertain Collapse or departure of the hub carrier KLM	Prepare to adapt Schiphol to be an origin/destination (O/D) airport	If KLM leaves Schiphol, implement the plans to change Schiphol into an O/D airport

that would indicate that mitigating actions should be activated (Kwakkel, 2008). Dynamic strategic planning differs from traditional approaches in that it uses a formal method for assessing and managing the risk that forecasts do not materialize. The following table illustrates a portion of the analysis for Schiphol Airport (Kwakkel, 2008).

- Too (2010) states that infrastructure capacity analyses at the Brisbane Airport in Australia are based on peak demand, both for the passenger traffic and aircraft movement. To reduce uncertainty in the growth projections, the airport studies the trends in the airline and aviation industry through a review of Airbus Industries and Boeing forecasts and orders. This provides input into demand for runway and terminal building requirements. The airport also reviews internal operations to evaluate the capability of the existing infrastructure to support future demand requirements. Standards for passenger throughput and infrastructure performance are set against which performance is monitored.
- Too (2010) indicates that Brisbane Airport uses community and stakeholder engagement as part of the capacity planning process. A committee approach is used to undertake community and stakeholder consultation and negotiation. The airport also works with professional associations and local industry to build relationships and provide feedback to assist in delivering its vision.

Project Initiation and Delivery	Asset management steering committee or equivalent executive team approves final project prioritizations	Project prioritization using predefined criteria and economic assessments	Business cases completed for qualifying projects	Do nothing, maintain differently, non-asset solutions, alternative lifecycle cost comparisons	Formal project initiation stage checks against predefined criteria to ensure that sufficient knowledge and data is available to confirm the existence of a problem
Large/Medium Hub	**x**	**x**	**x**	**x**	**x**
Small/Non-Hub, General Aviation	Applicable if there is a strong silo approach between infrastructure service groups	**x**	**x**	**x**	**x**

Example Practices

- Brisbane Airport has a set of development objectives that are used in the evaluation of asset options. These include facilitation of safe passenger, freight, and aircraft movement, sound environmental management, accessibility and land use, improvement of quality of services, sound business management (Too, 2010).
- Brisbane Airport forms a multidisciplinary, multidepartmental team to evaluate each criterion including safety, environment, security, operations, and maintenance used to evaluate major development projects. These results are then reviewed to minimize the risk of choosing the wrong project options (Too, 2010).
- The Greater Toronto Airport Authority (GTAA) undertakes business case analysis on an asset-by-asset basis (silo) to determine the most appropriate investment in airside pavements, people-moving equipment (escalators, elevators, moving walkways, etc.), bridge structures, for example. Each of the investments in maintenance, rehabilitation, or replacement are identified and prioritized and then passed on to a higher level cross-asset evaluation and lifecycle benefits using a software application (ReCAPP).
- Bangor Airport analyzes the return on investment for new projects. An 18-month payback is the target for revenue generating projects, and a 10-year payback is the target for energy efficiency projects.
- Lifecycle costing of project alternatives has been used successfully at Sarasota/Bradenton International Airport. Lifecycle costing assessments include all standard operations, maintenance, and capital component assessments, with the addition of comparison of delivery mechanisms, such as turnkey and annual maintenance contracting.

New Capital Asset Project Delivery	Best value processes are used to determine the project delivery method	Use of approved contractor databases and contractor performance measurement	Bid evaluation uses a best value approach where appropriate, with low-bid awards limited to approved services
Large/Medium Hub, Small, Non-Hub, General Aviation	**x**	**x**	**x**

Example Practices

- Brisbane Airport outsources the majority of the design and procurement of infrastructure assets. To limit the risk to the organization, quality assurance measures are in place to ensure the quality of contract documentation and specification, and to ensure the quality of contractors. Contractor performance is assessed in terms of safety record, relationships with stakeholders, and consistency in performance. An approved contractor database is maintained (Too, 2010).

Best Practices

- GTAA requires that all as-built project data be delivered to the GTAA data center in accordance with pre-established CAD and GIS position standards. This includes all buildings, paved surfaces, fence lines, utilities, etc.
- They also have established digital document office review and field verification standards, as well as checklists and a scoring system to assign a rating to indicate the quality of the submission.

Asset Commissioning	Include the requirement to submit all basic asset attribute data prior to completion in contractor/ engineer scope of work	Asset attribute data updated in GIS, CMMS, finance, and other systems on receipt	Asset attribute data updated in a single system of record – corporate AM system	Asset attribute data is captured in database or spreadsheet as a single system of record	Training is provided to maintenance and operations staff for all new equipment	Maintenance and operations manuals are provided for all new equipment
Large/Medium Hub	**x**	**x**	**x**		**x**	**x**
Small/Non-Hub, General Aviation	**x**	**x**		**x**	**x**	**x**

- The submission score is then used as part of the procurement processes for future goods and services (i.e., poor quality submissions may limit the ability of a supplier to bid for future work).
- All components of assets are assigned an intelligent number that identifies the system and component. Maintenance tasks are assigned to the individual assets and components along with an inspection frequency and a step-by-step methodology and checklist for its inspection.
- Inspectors also are asked to provide an estimate of the asset's remaining useful life and to develop risk factors to prioritize the importance or necessity of taking any specific maintenance action.
- At McCarran International Airport, assets purchased during a CIP often are not visible to maintenance staff until after the asset fails. Maintenance departments often are asked to repair assets that were delivered during the commissioning process, and proper data and supporting documentation and parts are not available to repair the asset. This causes significant delays in repair and increased downtime. McCarran International Airport is using IBM Maximo out-of-the-box functionality aided by a custom Maximo Drawing Transmittal Module to identify all assets being proposed during the 30 percent, 60 percent and 90 percent drawing review processes. This enables McCarran to ensure that all necessary information such as spare parts, PMs, and other critical data is in the Maximo System prior to CIP asset commissioning/turnover (Pulse 2011 Agenda).

Maintenance	Establish and maintain an accurate asset inventory	Establish maintenance strategy based on critical and performance requirements	Establish maintenance inspection tasks and preventive maintenance procedures	Determine appropriate frequency for inspection/ maintenance action	Plan and schedule maintenance	Monitor maintenance performance
Large/Medium Hub, Small/Non-Hub, General Aviation	**x**	**x**	**x**	**x**	**x**	**x**

Best Practices

- GTAA has a legacy asset maintenance management system that was originally developed in the 1970s by Transport Canada when that agency was responsible for the airport. The system is fairly old and not all that well understood but it is extremely comprehensive—so much so that it is being used by other airports around the world.
- GTAA is continuing to use the system and plans to update it in the future to make it more user friendly and to integrate it with other asset management systems.
- At Gatwick Airport, London (GAL), intelligent monitoring techniques have been introduced as part of the refurbishment of a bridge over the railway. This bridge will have built-in condition monitoring to avoid some of the need for railway possessions to undertake inspections.
- At GAL, maintenance comprises statutory inspections (SI) and maintenance (SM), corrective maintenance, and planned maintenance. The information system provides a readily available measure of the status of SIs and SMs that, when published, proved effective in increasing the level of compliance because there should not have been a backlog. The SIs are now achieving 100 percent and the SMs are at 95 percent and improving.
- This illustrates the impact of information but also confirms that while it might be used initially to highlight failure and promote better performance, it can become a positive measure of success to broadcast to the organization.
- ASP11 defines monitoring for teams and assets and, as a weekly review implemented through the introduction of a group-focused "scorecard," is indispensable. It has been found that the scorecard has helped focus work and drive the improvement loop (e.g., updating/correcting data in Maximo).
- At the asset level, the monitoring process identifies what has been done, what was supposed to be done, and what it tells GAL about the performance of the assets. It provides an indication of future renewal needs.
- Monitoring performance also promotes root cause investigations to determine why something has failed and prevent recurrence or build in contingency.
- Maintenance will move increasingly to planned works and monitoring will remain visible. One of the changes under GIP has been the allocation of maintenance to the "maintenance resource" and not named individuals, which places the onus on maintenance as a group to fulfill the workload.
- A process for management review has been documented (monthly meeting with designated asset stewards to feed into this), but this is yet to be implemented.

The Ports Aviation Maintenance department of the Port of Seattle has implemented a Continuous Improvement Program, in which one of the main focuses was utilizing IBM Maximo asset management functionality coupled with process improvements and standardization to enable inventory management reduction efforts and accountability throughout airport facility maintenance operations. The Aviation Maintenance Department started from "ground

Performance Monitoring	Monitor and report enterprise-level KPI hierarchically to focus investments for best results	Monitor and report KPI at the department level for facilities, systems, or networks to focus investments	Monitor and report KPI at the facility or system level
Large/Medium Hub	**x**	**x**	**x**
Small/Non-Hub, General Aviation	**x**		**x**

Asset Performance Management	Undertake root cause analysis for critical events	Identify and classify causes of poor performance	Operations and maintenance staff identify performance issues and prioritize investment through a criticality ranking approach	Close performance gaps through design, operations, maintenance, or renewal
Large/Medium Hub, Small/Non-Hub, General Aviation	**X**	**x**	**x**	**x**

zero," with no inventory records in Maximo, to getting inventory documented and recorded in the system, establishing a baseline inventory value of $5.8 million, accounting for parts usage and consistently getting a 95 percent and above inventory data accuracy rate for inventory cycle counts. Also through these efforts, they have been able to build the link between assets and inventory through the assets spare parts functionality of Maximo (Pulse 2001 Agenda).

Best Practices

- GAL uses a comprehensive performance management framework to manage the business to ensure that asset management processes meet the objectives of the business. GAL uses a holistic measurement framework to track three asset requirements assuring governance in parallel to delivering sustainable value improvements as follows:
  - Leading measures: what we say we are going to do to assure the standards are met. The measurement of activities that predict future outcomes such as compliance with statutory inspections.
  - Lagging measures: historical measures of asset effectiveness directly linked to the three performance standards.
- The governance improvement process is based around 19 asset stewardship processes (ASPs) to achieve Integrity, Performance & Integrity in the useful life phase at minimal total cost.
  - ASP1: New asset introduction process
  - ASP2: Identify existing assets, the knowns, unknowns, and known unknowns
  - ASP3: Assess criticality of assets from customer's perspective
  - ASP4: Assess performance requirements of asset based on criticality to the customer
  - ASP5: Establish asset lifecycle strategy to achieve performance requirements
  - ASP6: Establish and document operating protocols
  - ASP7: Develop contingency plans for maintaining operational requirements in event of failure
  - ASP8: Establish resources required to deliver asset management service
  - ASP9: Complete asset management activities
  - ASP10: Establish leading & lagging measurement framework for asset
  - ASP11: Conduct Plan, Do, Reviews assessing asset effectiveness to drive value improvement
  - ASP12: Monitor instances of asset abuse
  - ASP13: Monitor asset safety records
  - ASP14: Monitor asset permit to works
  - ASP15: Monitor asset change control
  - ASP16: Monitor asset usage against original design requirements
  - ASP17: Annual governance improvement review by asset group/location; asset health check and improvement objectives (remove? repair? restore? replace?)
  - ASP18: Update asset replacement plan
  - ASP19: Airport asset governance review

Renewal and Decommissioning Planning	Hierarchical enterprise renewal modeling including asset performance, regulatory compliance impact assessments for various renewal methods and timing	Condition and remaining life assessments	Age- and design-life-based assessment
Large/Medium Hub	x		
Small/Non-Hub, General Aviation	x	x	

Best Practices

- The GTAA facilities asset management system supports the overall capital planning process by providing a technically prioritized listing of required restoration requirements for all fixed assets. It accomplishes this by warehousing data related to the age, type, and condition of all systems and equipment.
- A high-level planning and capital expenditure tool is used to understand the condition of the airport's physical assets, their replacement costs, lifecycle costs, and the implication of deferred investments. Each major asset type has its own inventory and condition monitoring tools (e.g., baggage handling and people mover equipment, buildings, bridges, pavements, etc. with information from these systems feeding a commercial software application called Renewal Capital Asset Planning Process (ReCAPP). ReCAPP includes a fixed asset ledger, asset valuation and condition deterioration and weighting tools, minimum condition thresholds and requirements, and financial reporting to assist in programming asset renewal.
- Assets are classified into four major groups—buildings, structures, pavements, and utility systems—which are then divided into subgroups (e.g., under pavements, air trafficked pavements, shoulders, aprons, airside roadways, groundside roadways, etc.). Each asset is further broken into its main component parts and information with respect to its installation date, expected useful life, and replacement value are tracked.
- Commencing in 2010, individuals responsible for a particular asset type perform regular formal condition assessments to establish performance models for the assets.
- The performance data is used to determine investment needs, which are then fed into GTAA's 5-year capital restoration plan.

Information Systems	Equipment/asset inventory and condition assessment data management and reporting	Work order processing including scheduling, cost accounting, and reporting	Defect coding and failure history analysis	Integration with financial and GIS systems	Integration with investment decision support and capital planning tools
Large/Medium Hub	x	X	x	x	x
Small/Non-Hub, General Aviation	x	X	x	x	

Best Practices

- Gatwick Airport uses an integrated security system to assist with energy conservation strategies. Energy savings are achieved by enabling specific equipment only when they are needed (e.g., by using a gate room reader to sense arrivals and enable lifts and escalators for arriving passengers). When the gate room is not in use, these systems are shut down, therefore conserving energy.

- Gatwick Airport is implementing an SAP Enterprise Resource Planning (ERP) system to replace 140 legacy IT systems with the following modules: capital planning, an aero billing solution called SKY-Billing (this software determines passenger numbers and generates bills for airlines), Primavera for capital project management, and property management.
- Miami International Airport is introducing a detailed cost accounting structure to enable typing costs to the provision of a service (e.g., linking facility management costs to the user of a leased space within the airport terminal). This also enables the identification of preventive maintenance that is appropriately cost justified.
- Denver International Airport is implementing an Enterprise GIS and notes three elements critical to the success of new information systems roll out—communication, training, and incentives. Denver is also using Maximo's route capability as a means to improving productivity by avoiding missed PMs and ensuring that all assets are managed.

Data and Knowledge	Advanced asset attribute information recorded, failure history – defects and MTBF, lifecycle costs	Basic asset attribute information recorded for all assets (installation date, material, size, manufacturer name plate information, useful life)	Complete inventory of assets owned by the airport, hierarchically arranged to the Maintenance Management Item (MMI) level	Tools
Large/Medium Hub	x	x	x	EAMS integrated with other airport business systems, or EAMS as part of enterprise resource planning (ERP)
Small/Non-Hub, General Aviation	x	x	X	EAMS integrated with finance and GIS tools and other airport business systems Some very small airports may use standalone CMMS

Best Practices

- GTAA has a fairly advanced system in place for information management. The airport has recently gone through a major development program replacing two of the three original terminals, adding a new runway, central deicing facility, and associated taxiway and apron development. The asset inventory is managed using Oracle Spatial and CAD, and good standards are in place to maintain this information.
- GTAA uses ProjectWise software for content management and collaboration with all parties requiring access to asset data. Data records are nearly 100 percent complete for all recent development and about 75 to 80 percent for much older assets where information is only available in hard copy.

- London Airport Gatwick (LAG) groups assets into related systems. The asset functional code and name is one of the key classifications around which the whole structure of document management, work planning, maintenance reporting, hand-over deliverables, and information cataloging has been built.
- LAG uses a hierarchical system where asset functional codes (AFC) Level 1 is an independent system, with AFC 2 and AFC 3 being dependent systems. For example, within the 200 series (building, structure, fabric), AFC 217 (lightning protection) has dependent subcomponents such as an arrestor (182) and the arrestor has a dependent subcomponent such as a spike (345).

Organization and People Issues	All assets have a defined owner, strategy manager and service provider	Executive leadership is in place for a continuous improvement asset management process	Cross-functional teams engage in the investment and strategy decision-making process	Skills and competencies for asset management are recognized and training plans are in place
Large/Medium Hub, Small/Non-Hub, General Aviation	**x**	**x**	**x**	**x**

Best Practices

- GAL has implemented a system of asset stewardship to assure the ongoing safety and performance expectations of customers and stakeholders, focusing on the prevention of any unacceptable incidents due to asset failure.
- The system of asset stewardship is based around processes to ensure sustainable management of assets focusing on integrity, performance, and condition.
- Business-unit-level asset stewards have been assigned.
- The asset stewardship team is responsible for managing legacy assets and setting up a continuous improvement cycle.
- Capital project/maintenance integrators are responsible for operational and maintenance integration of new projects.
- Planners and facility managers are responsible for planning, execution, measurement, and improvement of maintenance activities.
- At GAL, there has been a change in the way the business is driven, with operations taking a much more significant role in contributing to setting the direction for asset management decisions that ultimately support service delivery. There is the recognition that operations is the final service delivery interface with the customer, and the business is entirely dependent upon retaining customers.
- The responsibility for implementing the asset management system rests with the chief operating officer (COO). The head of asset management supports the COO and is responsible for project definition, providing maintenance, operations, and integration services for the full project lifecycle. The COO signs off on these projects.
- The COO attends daily 15- to 30-minute meetings with operations where issues are reviewed in respect to customer interfaces, other service providers, and contractors. This feeds back to the planning process and is an important element in project definition to ensure solutions will address identified problems. The projects then pass through a development and delivery process until they are handed over to maintenance and operations, with training

and all supporting material. Importantly, this is not a hand over so much as an acceptance by maintenance and operations based on the need established at the project definition stage. This is quite different to the previous regime in which projects were delivered as corporate solutions and not as service solutions for the specific situation.

Commercial Tactics	Development and use of performance-based contracts	Inclusion of asset preservation and performance service levels in operating contracts	Active consideration of risk and lifecycle cost management in outsourcing decisions
Large/Medium Hub, Small/Non-Hub, General Aviation	**x**	**x**	**x**

Best Practices

- Some airports are using performance-based contracts. For example, GTAA uses payment factors for its baggage handling system operation and maintenance contract. The baggage system availability is evaluated on a daily basis, and a monthly contract payment factor is determined and applied to contractor invoices.

Asset Management Planning	Document and maintain asset management plans for creation, utilization, maintenance, decommissioning/disposal of assets	Maintain a risk registry and implement controls to actively manage those risks	Asset management plans include tasks and activities required to optimize costs, risks, and performance of assets	Responsibilities and authorities for the implementation of asset management plan actions, including the means and time scales for achieving these actions
Large/Medium Hub, Small, Non-Hub, General Aviation	**x**	**x**	**x**	**x**

Best Practices

- GTAA uses the "Three Lines of Defense" model with respect to audit processes for their assets. The first line of defense is at the operational management level. This group has ownership, responsibility, and accountability for assessing, controlling, and ensuring the cost-effective function of the assets. The types and current value of the assets are reflected on the airport's balance sheet and in their financial statements. A quality management program is in place to provide a detailed and proactive approach to work planning and execution and to provide measurable compliance with key performance indicators.
- The second line of defense is the risk management and compliance group, which facilitates and monitors the implementation of risk management practices with respect to asset performance. The third line of defense is through internal (and external) audit processes, which provide assurance to the board of directors regarding the accuracy and appropriateness of the risk management framework.

APPENDIX D

Asset Management in Other Sectors

Examples of Other Sector Asset Management Application

1. U.S. Electricity Sector

Drivers: Deregulation of the electricity market in the United States introduced competition in the generation businesses, which resulted in the disaggregation of vertically integrated utilities and a change to an asset management business structure for many businesses, in order to deliver cost and service-level efficiencies.

- Organization Structure and Function
  - Separated the definition of the work required from the delivery of work.
    - Creation of an asset management function
    - Service delivery function
    - Service level agreements between asset management and other business units or organization functional groups (e.g., IT, finance, operations)
    - Performance-based remuneration for executive managers in charge of functional groups, based on service level agreement signed, performance measures, targets, rewards, and penalties
    - Emergence of VP asset management roles in electricity distribution organizations
- Lifecycle Processes and Practices
  - Reviews of maintenance and operations performance—cost and performance benchmarking
  - Capital spend reviews and justifications and prioritization based on strategic objectives, risk, revenue, service-level performance
  - Review of outsourcing strategies, development of more comprehensive contractor performance evaluation criteria and processes
  - Risk assessments, risk registers, risk mitigation plans

2. U.S. Water Sector

Drivers: Long-lived civil infrastructure constructed in the post-war growth period is coming due for renewal or replacement. Federal funding for water projects is becoming more difficult to obtain, risk exposure associated with large buried infrastructure is considerable in some instances. Water businesses are being pushed toward preparing for financial self-sufficiency. This means that they need to better understand the true cost of provision of water and wastewater services so that funding strategies can be determined and negotiated with customers for a corresponding level of service, and within legislative requirements.

- Organization Structure and Function
  - Develop corporate asset management group to drive asset management improvements across service businesses (water and wastewater); ensure consistency in the evaluation of risks and capital priorities, as well as consistency with the corporate asset management policy
  - Asset owner, strategy manager, and service provider roles set up within the business with asset owner responsible for setting objectives and goals, asset strategy manager responsible for determining what needs to be done to meet the goals and objectives, and service providers doing what needs to be done to meet the goals and objectives
  - Establishment of corporate or enterprise levels of service statements or agreements that drive the development of asset strategies
- Lifecycle Processes and Practices
  - Compete asset registers represented in hierarchy from the network level down to maintenance managed items (level at which work orders are recorded)
  - Integration between maintenance management system, GIS, and financial systems
  - Maintenance strategy reviews undertaken to ensure that critical assets are managed with interventions undertaken at the optimal point in terms of repair/replace cost and risk exposure, and not run to failure
  - Asset hand-over procedures ensure that contractors/engineers provide all required asset lifecycle attribute data necessary for managing the asset from commissioning through renewal/disposal
  - Engineering records, standards and specifications reviewed and maintained so that assets are fully documented, an approved equipment list is in place to ensure that poor performing equipment is not approved for installation, and that standards and specifications are continually updated in terms of reliability and maintainability requirements
  - Processes are in place to monitor asset configuration (e.g., pumps are operated within their design range, and should circumstances arise where they are required to operate outside design range, mitigations are put in place to manage any increased risk exposure, additional maintenance requirements, and any change in asset remaining life is managed through strategic planning process for renewal
  - Risk and service levels are managed by understanding what the organization's tolerance is to risk—tolerable risk limits are determined quantitatively either using a score or dollar values, and any risks that exceed the tolerable limit are mitigated through the implementation of controls such as redesign, redundancy, renewal, replacement with a different asset, or emergency response plans to reduce the consequence of failure

3. Rail Sector (United Kingdom/Australia)

Drivers: Improvement in safety, on-time performance, and cost of service in the face of increasing demand (in many cases) and aging infrastructure.

- Organization
  - Restructuring to include an asset management function to develop and oversee the application of asset strategies across the business. London Underground reorganized during the privatization and PPP period to include asset management function to ensure preservation of assets and performance, and seamless interfaces between London Underground and partners
- Processes and Practices
  - Improvement programs determined using maturity assessments to identify areas of weakness that can be improved to gain the greatest improvement in performance
  - Review business processes and practices and maintenance management system functionality to identify system improvements to enhance monitoring and maintenance decisions such as defect coding, analysis, and workflows to capture defect information

  - Use regular condition assessment techniques to identify cracks, misalignment, and other defects on rails to enhance proactive maintenance
  - Use decision support systems to predict future asset condition as an input to strategic renewal planning
  - Use integrated decision support systems, with maintenance management systems (e.g., Maximo and Optram) to enhance decision making and timeliness of work to improve performance

4. Gas Sector

Drivers: Safety and pipeline integrity legislation. Safety is given the most importance as a driver for asset management while environmental issues are given the least. In regimes based on incentive regulation it is indicated that issues related to response to customers increase importance compared to cost-based regimes. This can be explained by the need to meet specific customer service level standards, which are set as an objective in incentive regulation regimes.

- Organization
  - Recent research team surveys indicate that around 20 percent of gas businesses worldwide claim to have a well-developed, holistic approach to asset management
  - Most gas companies have a branch/group/division dedicated to asset management and have sufficient executive support to implement change where necessary
- Processes and Practices
  - Majority of gas businesses have complete asset registers
    - Remote operational control is used by the majority of the companies and has consistently been the most common method of implementing maintenance and control of the gas networks; before 1995 almost 60 percent of companies had implemented this, with a prediction of 85 percent by 2010
    - Not more than 60 percent of the companies will have implemented risk-based maintenance, gas leakage search programs, and smart metering by 2011
    - Utilization of remote data access from field was very low at under 20 percent pre-1995, but was recorded as nearly 70 percent in 2007 and is predicted to increase a little more by 2011
    - Renewal and replacement planning is typically undertaken on a 10-year planning horizon, with asset strategies applying for longer time periods

Abbreviations and acronyms used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation