WASHINGTON INTEGRATED NETWORKED GEO-BASED SYSTEM (WINGS) USER REQUIREMENTS AND CONCEPTUAL DESIGN

WA-RD 364.1

Final Technical Report
November 1994

Washington State Department of Transportation

Washington State Transportation Commission
Aviation Division
Planning and Programming Service Center

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. WA-RD 364.1	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
4. TITLE AND SUBTITLE Washington-Integrated Networked Geo-Based System (WINGS) User Requirements and Conceptual Design		5. REPORT DATE November 1994 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Roy F. Weston, INC. in association with Jeppesen Sandersen, Inc. Lee Anne Walker, Inc. Reid Middleton, Inc.		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Roy F. Weston, INC. Suite 5700 700 Fifth Avenue Seattle, Washington 98104-5057		10. WORK UNIT NO. 11. CONTRACT OR GRANT NO. DP00162
12. SPONSORING AGENCY NAME AND ADDRESS Washington State Department of Transportation Transportation Building, MS 7370 Olympia, Washington 98504-7370		13. TYPE OF REPORT AND PERIOD COVERED Technical Report 14. SPONSORING AGENCY CODE
15. SUPPLEMENTARY NOTES		

16. ABSTRACT

Abstract:

The purpose of this study was to provide the Washington State Department of Transportation, Aviation Division (WSDOT/AD) with the broad-based vision needed to apply new and emerging technology in geographic information systems (GIS) to aviation planning and reporting systems. It develops a conceptual design for sharing geographic information pertaining to Washington's airports with airport sponsors, the Federal Aviation Administration (FAA), and other WSDOT divisions based on user requirements.

The potential users of the system were identified and interviewed to establish data and application priorities. The consultant team conducted user interviews with WSDOT staff in the Aviation Division, Management Information Systems (MIS), the Planning and Programming Service Center (P&PSC), and the local office of the FAA. The interviews set the framework to develop GIS data priorities and applications. In addition, a conceptual database design was prepared.

The benefits of this shared system would be its ability to accommodate regular and timely data updates, analyze large and varied data sets, evaluate alternatives, present graphic and/or tabular outputs, as well as providing for changes in technology that could make a more efficient system. The system could accommodate spatial relationships of aviation facilities as well as other transportation systems across the state. The data could be accessed through desk-top computing power from various locations and be easy to operate for novice users.

17. KEY WORDS Key words: (1) geographic information systems, (2) GIS, (3) WINGS, (4) aviation planning, (5) user needs analysis, (6) conceptual design	18. DISTRIBUTION STATEMENT No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22616

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
None	None	50	

Technical Report

Research Project DP00162

WASHINGTON INTEGRATED NETWORKED GEO-BASED SYSTEM (WINGS)

USER REQUIREMENTS AND CONCEPTUAL DESIGN

by

Roy F. Weston, Inc.
Suite 5700
700 Fifth Avenue
Seattle, WA. 98104-5057

in association with

Jeppesen Sandersen, Inc.
Lee Anne Walker, Inc.
Reid Middleton, Inc.

Washington State Department of Transportation
Technical Monitor
Amy Arnis
Policy Development
Branch Manager

Prepared for

Washington State Transportation Commission
Department of Transportation
Aviation Division
Planning and Programming Service Center

November 1994

DISCLAIMER

TABLE OF CONTENTS

TABLE OF CONTENTS *(continued)*

LIST OF EXHIBITS

LIST OF TABLES

SECTION 1

INTRODUCTION

1.1 PURPOSE

The purpose of this study is to provide the Washington State Department of Transportation, Aviation Division (WSDOT/AD) with the broad-based vision needed to apply new and emerging technology in geographic information systems (GIS) to aviation planning and reporting systems. This is the first of two reports. It develops a conceptual design for sharing geographic information pertaining to Washington's airports with airport sponsors, the Federal Aviation Administration (FAA), and other WSDOT divisions based on user requirements. The second report will provide an implementation plan.

1.2 GEOGRAPHIC INFORMATION SYSTEMS (GIS)

Simply defined, a GIS is an automated system for managing information with geographic features. Specifically, a GIS is a collection of hardware, software, digital data, and procedures functioning together to capture, manage, analyze, model, and display information that has spatial reference. Information has a spatial reference if it can somehow be tied to a location or area on a map. This applies to approximately 80 percent of WSDOT's information.

A well-designed GIS can answer the following five generic questions:

- **Location - What is at a given location?**

  Data management is simplified when the user can quickly find out what exists at a particular location such as airport name, county, airport reference point (ARP) or by pointing to the feature on a computer screen.

- **Condition - What is the condition of features that meet a specific criteria?**

  Instead of identifying what exists at a given location, the user finds locations where certain conditions are satisfied. For example, show all the airports that have only beacons as navigation aids.

- **Trends - What has changed over time?**

  This question can involve either of the first two generic questions and seeks to find the difference over time. For example, tracking aircraft operations or air cargo activity on a yearly basis could be used to formulate landing fees or air cargo entitlement.

- **Patterns - What spatial patterns exist?**

  These types of questions can get very sophisticated. For example, showing the distribution of airport users relative to the existing and proposed intermodal transportation routes can be easily accomplished. Also, Runway Protection Zone (RPZ) dimensions could be overlaid with land uses and zoning to optimize the size and location of the RPZs. Finally, the flight tracks, noise contours, land use, zoning, and demographic data (census data) could be combined to quantify the size and characteristics of the noise impacts.

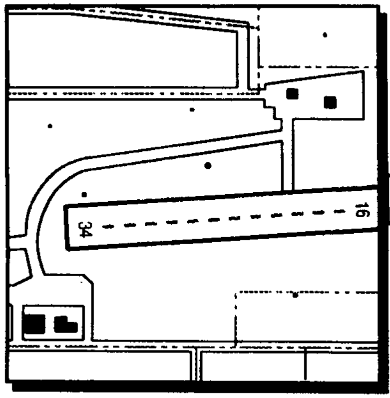
- **Modeling - What if ...?**

  These types of questions are posed to predict the consequences of proposed changes. Examples include the evaluation of changing a service at a particular airport, analyzing the impacts of siting a new airport or closing an airport, evaluating regional impacts, or analyzing the juxtaposition of various modes of transportation (road, rail, sea, and air).

To answer the above questions, graphic and tabular attribute data must have an internal linkage that is managed by the GIS software. Nongraphic data can be queried by inspecting the graphic display and entering a request for tabular data. Exhibit 1-1 illustrates the linkage between graphic and non-graphic data. In this exhibit, runway number 16/34 is displayed with two non-graphic attribute tables. The pavement condition index associated with the runway is illustrated.

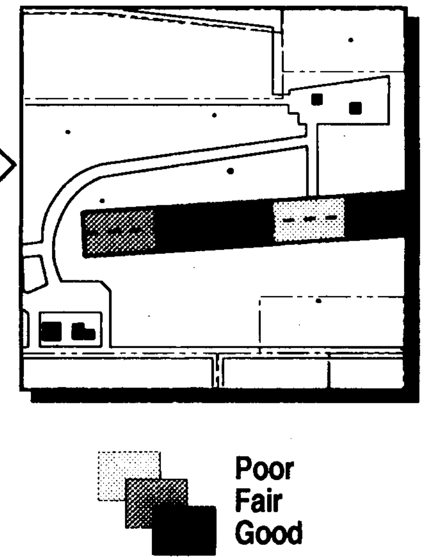
1.3 BACKGROUND

The use of new and emerging technologies like GIS and global positioning systems (GPS) is dramatically changing the aviation industry. These changes affect all levels of the industry and must be integrated to achieve the required cost savings and safety improvements. Although this study is focused on aviation planning and reporting systems, it needs to be analyzed in the context of GIS capabilities and the related changes taking place in the aviation industry. These trends include future air navigation systems and airport-specific GISs.



PRIMARY ATTRIBUTES			
Runway Number	Runway Length	Runway Width	Runway Surface Type
7/25	3840	60	Asphalt
16/34	3997	100	Asphalt
	4000	75	Asphalt
	3800	60	Gravel

PAVEMENT CONDITION			
Runway Number	Surface Condition	Beginning Index	Ending Index
16/34	Good	0	1114
	Poor	1114	2025
	Good	2025	3015
	Fair	3015	3997



Graphic and Nongraphic Data Relationship

EXHIBIT
1-1

WESTON® MANAGERS DESIGNERS/CONSULTANTS

10564-01-01-0002
October 1994

Future Air Navigation System

Today's air traffic control system does not meet the demands of its user, nor is it properly structured to meet tomorrow's challenges. The current system relies on ground-based radar and voice radio to maintain aircraft separation. It also forces multiple aircraft to fly identical, congested, often indirect routes resulting in excessive fuel consumption and additional delays on the ground. Furthermore, the current system is near capacity, while the total available airspace remains vastly underutilized. The Air Transport Association (ATA) estimates its member airlines are currently losing $3.5 billion per year because of limitations in the air traffic control system.

In 1991, the International Civil Aviation Organization (ICAO) and the International Air Transport Association (IATA) endorsed the Future Air Navigation System (FANS) concept as a new world standard. FANS is based upon the rapid advancements in communications, navigation, and surveillance (CNS) technologies expected before the turn of the 21st century. Significant improvements in worldwide air traffic management, aircraft operational efficiencies, and overall flight safety will be possible with major architectural improvements to the airspace system.

"Three primary ingredients of the recommended architecture are:

(1) an airborne computer and associated databases,
(2) a digital, computer-to-computer, communications environment, and
(3) a global, precise, navigation environment." [1]

The availability and intelligent use of digital geo-spatial data is critical to making this vision a reality. The FANS concept relies on highly accurate, real-time, three-dimensional aircraft positioning derived from satellite-based GPS. A discussion of GPS is included in Appendix A. All aircraft will eventually broadcast and receive position reports to and from the ground and other aircraft. Using this technology, pilots will be able to locate nearby aircraft whether on the ground or in the air.

In the air, traffic density on congested routes will be replaced by a new free-flight concept. Once airborne, aircraft will simply fly the best route to its destination based on sophisticated GIS data combined with current weather. Other aircraft will be monitored from each cockpit as well as from the ground. Since aircraft will be scattered rather than concentrated, today's air traffic controllers can assume the role of managers and will be capable of identifying and resolving the remaining conflicts much more efficiently.

[1] Blackburn, Albert W. and George C. McKinney, "A Distributed, Message-based Airspace Environment," Institute of Navigation Conference—GPS 1991.

On the ground, GPS will provide controllers, flight dispatchers, and pilots with a real-time aircraft positioning system capable of efficient and safe surface movement operations in zero-visibility weather conditions. The world's worst air transport disaster, involving the 1977 collision of two B-747s at Tenerife, Canary Islands, could have been avoided with such a system.

Initial implementation of FANS concepts has already begun. On June 2, 1994, FAA Administrator David Hinson canceled FAA's existing contracts to further develop the ICAO-approved ground-based microwave landing system (MLS). Less than a week later, the FAA issued a request for proposal to develop a GPS-based wide-area augmentation system (WAAS). "Hinson called the move to WAAS very significant and praised GPS overall as the single most important advance in the history of navigation."[2]

Scheduled to be implemented by 1997, WAAS is estimated to be a $500 million, six-year program which will include 24 to 30 ground-reference stations and four geostationary satellites. The system will provide a satellite-based navigation system nationwide, essentially free of ground control. For air carriers, airport managers, and aviation planners this will mean a rapid increase in the number of aircraft capable of landing at almost any airport in the United States when minimums are down to 200 feet and 0.75 mile of visibility. In addition, the FAA continues to pursue an active differential GPS research program to demonstrate even lower landing minimums and is working closely with civil aviation authorities throughout the world to ensure a phased transition to space based navigation systems.

Meanwhile, individual airlines throughout the world are conducting pilot programs of their own to prove the cost efficiencies of the FANS concept. For example, Northwest and United airlines have already outfitted revenue service aircraft with various FANS-compliant GPS and satellite communication capabilities. Testing is continuing with data collection and evaluation of the latest CNS technology applications. Information derived from these test flights will be used to justify the financial investments required to retrofit existing aircraft fleets. Only then will airlines begin to realize substantial cost reductions through enhanced operation efficiencies.

This technology is cost-effective and can be used at any airport regardless of size. However, an obstruction survey resulting in a FAA-certified database would be required.

Future Airport Geographic Information Systems

Linking air traffic to a ground location is critical to the efficiency and safety of the overall FANS concept. To reduce ground delays and safely monitor surface traffic at major airports, highly accurate electronic map displays of runways, taxiways, buildings, gate locations, and

[2] *GPS World*. July 1994, p. 16.

other infrastructure is required. Initial studies indicate much of the source information required for these displays is either not of sufficient accuracy or has simply not been collected. Accurate airport data must be obtained either through existing engineering drawings or new surveys.

GIS has already proven itself as an important tool for airport planners and facility managers in organizing, storing, and displaying traditional public utilities information. A 1993 study at the University of Texas at Austin surveyed the 172 busiest airports about their current and planned use of GIS. With a 47 percent response rate, over 58 percent of all major airports indicated that they either actually use GIS or plan to use GIS within 36 months. This study was in support of a future Ph.D. dissertation titled "The Use of Geographic Information Systems for Airport Engineering and Management." [3]

These initial airport applications are providing the necessary geo-spatial data and experience upon which to build new and exciting concepts. For example, at Boston's Logan International Airport and Hanscom Field, the Massachusetts Port Authority (MPA) recently modified its manual airport property management system by adding a PC-based GIS component. The pilot project for a large passenger terminal was completed in January 1992 and concluded:

> "The benefits of the pilot project are accurate billing, accurate information used for rental rate calculations, efficiently produced lease exhibit drawings, more productive business negotiations, better space planning and effective presentation material." [4]

The system is now being expanded to track the remaining operating agreements on facilities totaling 500 leases representing over 12 million square feet of space.

In addition to larger complex airport applications, airport GIS concepts are also being successfully employed at smaller non-hub commercial airports. A good example is John Wayne Airport (JWA) in Orange County, California. In May 1986, JWA began a $310 million modernization program which included a new terminal, air carrier ramps, additional general aviation tie-downs and taxiways, parking structures, roadways, and other infrastructure upgrades. The project was completed and opened in September 1990. An evaluation of this project concludes:

---

[3] McNerney, Michael, "The Use of Geographic Information Systems at U.S. Airports," URISA Proceedings, August 1994, pp. 680-688.

[4] "Automating Airport Property Management," *Aviation Informatics*, Jul/Aug/Sept 1994, p. 22.

> "The building from scratch of a new terminal and its adjacent buildings and facilities, the new roadways, and the upgrade of the infrastructure presented JWA with a opportunity to capture a great deal of the resulting 40,000 drawings in a 'CAD' format."[5]

Much of the digital geo-spatial airport information collected for the above purposes will also be required to meet many of the challenges proposed in the FANS implementation. These examples represent just the beginning of how the creative use geo-spatial data will help airport managers, planners, dispatchers, and pilots improve flight safety and increase productivity. Multiple use of these data will also lower initial investment costs for data conversion and software development, while increasing the return on investment for integrated airport GIS development activities.

Statewide Airport Planning

These dramatic changes occurring in the use of geo-spatial data to support air navigation and airport operations has significant implications for statewide airport planning systems. The statewide aviation planning efforts require data from both the national air navigation system and individual airport GISs that are being developed. In addition, these related activities will require the timely use of airport planning information in a compatible and integrated format. In fact, ten states have developed airport information management systems using GIS technology.

In Washington, the Washington Integrated Networked Geo-based System (WINGS) is envisioned as a management and planning GIS that will improve the overall efficiency of the state activities and the aviation industry.

The consultant team has interviewed project participants to develop an application-driven database design. This study phase of the WINGS project will set the priorities for data and applications development to support aviation planning and management activities.

1.4 REPORT ORGANIZATION

This report documents the interviews and analysis supporting a strategic plan for the implementation of the *Washington Integrated Networked Geo-based System* (WINGS). A second report will provide the actual implementation plan.

[5] Dedischew, John D., "Building and Running an Airport with AM/FM/GIS," URISA Proceedings 1992, pp. 146-159.

The following sections are included in this report:

Section 2—Washington State Aviation Planning. This section briefly describes the Washington State Continuous Airport System Plan (WSCASP) along with its mission, procedure, and envisioned goals for WINGS.

Section 3—User Requirements. This section documents the results of the user interviews by major work groups and identifies the organizational interactions relative to WINGS. Based on this information, the data and application requirements are identified and prioritized.

Section 4—Generalized Conceptual Design. This section outlines the design considerations and presents the WINGS conceptual model based upon the user applications and the data required to support those applications.

Section 5—System Development Issues. This section provides system development, data management, hardware, and software considerations.

SECTION 2

WASHINGTON STATE AVIATION PLANNING

This section briefly describes the WSCASP along with its mission, procedure, and envisioned goals for WINGS.

2.1 Washington State Continuous Airport System Plan (WSCASP)

In 1970, the Federal Airport and Airway Development Act was enacted. The federal funding available from this legislation provides the FAA with up to 90 percent of funding for preparing and updating state aviation plans. Since 1975, the FAA has promoted continuous airport system planning as the most efficient method of state-level planning.

The WSCASP is a series of independent but inter-related aviation planning studies. Although the nature of the individual studies varies from year to year, the plan provides a vehicle to carry out research, data collection, and planning projects for the state of Washington on an ongoing basis.

The WSCASP studies are generally grouped in three-year cycles to provide a measure of continuity from year to year. Some studies, such as the Inventory, Forecasts, and Recommended Facility Plan, are updated regularly. Other studies, such as a report on the status of GPS in aviation or an Airport Layout Plan (ALP) for a low-activity, general-aviation airport are done on an "as-needed" basis. The nature and description of the studies to be undertaken in the upcoming year is defined as part of the prior year's scope of work.

The mission of the WSCASP is to provide systematic planning for airports in the state. This broad statement gives the WSDOT an extraordinarily flexible structure for collecting and disseminating aviation-related information. The WSCASP provides the vehicle for collecting a large amount of statistical and operational data about the state's airports. The collected data are published and available to interested parties. This information provides a basis for comparison of similar facilities to airport managers, owners, and other professionals offering services such as appraisals or planning to the aviation community. In addition, this program can be used to provide otherwise unobtainable planning services such as an ALP for some of the small but important airports in the state. Without an FAA-approved ALP, these airports would not be eligible for federal assistance in their capital improvement projects such as the installation of improved lighting and navigational aids. Surveys of rates and charges and technical financial planning documents have also been included in the WSCASP.

The WSCASP also provides a vehicle to test new ideas and projects. For example, the WSCASP has included a float plane study and also the layout design and development of Airport Facility Inventory Drawings (AFIDs) for small, low-activity airports which can't justify the expense of a full ALP.

Because of this broad mission, the selection of the projects to be included in the WSCASP for any particular year or cycle is an immense task. As in any planning project, defining the scope of the project can be a lengthy and time-consuming process taking as much as a year to complete. Once the WSCASP projects are defined, they are completed within the given time limit. However, due to the length of time required to define the project, implement it, and produce the final documents, often the original participants and promoters of the project are no longer involved. While these studies may, in every way, meet or even exceed the scope of the project, the new participants may not have the same interest and "ownership" in them. Equally important is the influence of changing political, legislative, and environmental issues which also effect project participants expectations.

The WSCASP planning process will be greatly enhanced by incorporating the traditional hard-copy maps and tabular reports into a comprehensive GIS that can be shared and readily accessed by WSDOT Aviation staff, the FAA, the individual airport managers, and the general aviation community.

2.2 WASHINGTON INTEGRATED NETWORKED GEO-BASED SYSTEM (WINGS)

The benefits of this shared system would be its ability to accommodate regular and timely data updates, analyze large and varied data sets, evaluate alternatives, present graphic and/or tabular outputs, as well as providing for changes in technology that could make a more efficient system. The system could accommodate spatial relationships of aviation facilities as well as other transportation systems across the state. The data could be accessed through desk-top computing power from various locations and be easy to operate for novice users.

The primary goal of the WINGS project is to design and eventually develop a database available to planners and other interested parties. One definition of this availability is to provide universal access to the information. This means the information should be available via electronic link, usable on various different hardware platforms, and require no special training to access the data.

The WINGS database should be to able to store and retrieve data in many different ways. Queries for comprehensive information about an individual airport should be as easily accommodated as requests for a single item of information such as runway length on all airports. Allowing for multiple selection criteria of database information would further enhance the system benefits.

The second goal of this overall project is to create a structure flexible enough to accommodate new information not defined in the original scope. As the aviation industry changes, information which has not been relevant in the past can assume new importance. Entirely new data are developed and need to be made available for analysis. The WINGS database should be able to accommodate not only new information, but also historical information which is re-evaluated and deemed of importance.

The third goal of WINGS is to streamline the process of updating the planning information for all airports within the state. Currently, the data included in the Inventory section of the WSCASP are gleaned from many diverse sources. Locating the source material, extracting the relevant data, ensuring that the new data are consistent with prior years and entering the data into an electronic format is an extremely labor-intensive task. More and more of the source material will become available in an electronic format. By designing WINGS in such a way as to take advantage of this and include it as part of the project, the data management aspect of the system becomes a more manageable task.

Upon completion, the WINGS will be an integral part of the aviation community's transition to automated geo-spatial information systems. This project will create and maintain a common, computerized reference source for aviation planning data gathered in Washington state. By creating this graphically based, computerized resource, planning information can be standardized and distributed more widely.

SECTION 3

USER REQUIREMENTS

The potential users of the system were identified and interviewed to establish data and application priorities. The consultant team conducted user interviews with WSDOT staff in the Aviation Division, Management Information Systems (MIS), the Planning and Programming Service Center (P&PSC), the local office of the FAA, and the current WSCASP contractor. This section documents the results of the user interviews by major work group. A tabulation of the individual surveys is included in Appendix B. Organizational interactions are then reviewed before presenting an analysis of the data and application requirements for WINGS.

3.1 SUMMARY OF INTERVIEWS

Interviews with the project participants were performed over the course of two months. A complete list is included in Appendix C. Most interviewees were excited about the prospects of WINGS as an integrated and shared planning tool. Interview forms were delivered to the project participants who were asked to fill out the forms prior to being interviewed. Personal interviews were then conducted to expand upon the appropriate questions and complete the interview forms. The results of the interviews by major work group are outlined below.

Aviation Division

The Aviation Division of the Department of Transportation is charged with promoting aviation within the state. Implementation of this mission has included support to small airports who are not eligible for FAA assistance for capital improvement projects, coordination and management of the search and rescue program, and various other training, safety, and assistance programs.

The Aviation Division is service-oriented, providing grants and technical assistance for the maintenance and enhancements of publicly owned airports through its Local Airport Aid program. This program monitors and provides funding for airport planning and construction grants and represents the Division's major form of financial assistance to publicly owned airport operators. Grants for projects such as airport master plans or airport improvements are typically funded at 50 percent of the local cost by the Division. In addition, the state has an airport construction and maintenance program which covers the costs associated with operating and maintaining the 16 state-owned and/or operated landing facilities.

The Aviation Division receives grants from several federal agencies, including the FAA and the Economic Development Administration to conduct aviation planning studies. Some of the projects addressed involve issues of long-range "statewide interest" system planning, land use legislation, broad policy issues and incorporation of aviation as a part of Washington's total transportation system. Planning studies such as the WSCASP, the Tiltrotor Feasibility Study, the Puget Sound Heliport System Plan, and the Guide for General Aviation Airport/Economic Development Strategic Planning are examples of the Division's planning work.

Since much of the Aviation Division's planning activity is generally related to airport inventories and complying with FAA requirements, a database would allow the creation of maps and reports with greater efficiency. The aviation staff receive numerous calls daily requesting information regarding current airport conditions and construction projects. Most requests are answered by accessing hard-copy files or through the local knowledge of staff. Many of the plans on file are out of date, requiring a site visit to verify existing conditions.

An ideal result of the WINGS project would be to have all inventory and planning data in a digital format that could be, at a minimum, accessed by the FAA as well as WSDOT. In addition, the ability to display background data (i.e., photobase) would add further value. As part of completing an ALP, a large-scale digital orthophotograph would be ideal to present the photo base and also would be registered to the spatial coordinate framework of a statewide database.

The ideal WINGS data set would include airport drawings, noise contours, and the area surrounding the airports. Inventory data that are currently collected in a tabular database would be integrated with the graphics in a GIS. Eventually, the Aviation Division would require that a complete data set be developed that includes all airports within the state. The data would need to be in a format that is accessed in a read-only format by the FAA and other WSDOT divisions. Local municipalities and the general aviation community would also benefit from access to the system.

Management Information Services (MIS)

Management Information Services (MIS) is responsible for corporate computer systems within WSDOT. They set strategies and directions for the implementation of information technology as necessary to support the business objectives of WSDOT. MIS provides hardware and software infrastructure and manages the communications network. MIS currently has approximately 5,000 computers with an inventory that includes, but is not limited to, PCs, Macintosh, Unix-based workstations, Intergraph and IBM mainframes. There are a number of peripheral devices (i.e., plotters, printers, digitizing tablets) in most state offices. All WSDOT offices are connected through a local area network (LAN). TCP/IP is the state standard for network protocol. Access to a wide-area network (WAN) and Internet are currently available using file transfer protocol (FTP).

MIS has the ongoing task of providing better communication services between WSDOT divisions and service centers while also developing standard hardware and software configurations for a diverse user group. Future directions include WAN improvements that include expansion to all state offices and supporting business requirements using GIS and other graphic information. They will continue to support the client/server environment to accommodate increasingly complex data sets and applications.

Many Washington state agencies have endorsed and incorporated GIS technology using ARC/INFO, including the Department of Natural Resources (DNR), the Department of Ecology and the Department of Wildlife. The use of GIS technology was endorsed in December 1993 by the WSDOT Executive Committee to support the mission, goals, and objectives of the Department. In March 1994, WSDOT prepared an Information Technology (I/T) Strategic Plan that concluded that "*GIS will have a profound impact on the ability of WSDOT to meet its business objectives*."

A specific project was defined to be completed from March 1994 to June 1995 to develop a "base map" to which a variety of databases could be linked and displayed. The first phase of the project was defined in cooperation with Environmental Systems Research Institute (ESRI) and International Business Machines (IBM). During the project, ARC/INFO was evaluated for its ability to incorporate existing WSDOT Intergraph transportation maps at a statewide scale of 1:500,000 and Olympic Region maps at a scale of 1:24,000. Within the Olympic Region, state route milepost data has been developed for pavement management applications, accident reporting, and highway project inventories. At the conclusion of the project, WSDOT will develop a recommendation concerning the use of ARC/INFO for future GIS applications. MIS will be responsible to develop standards and guidelines for GIS implementation. They see their role to establish a statewide base map and to establish detailed data specifications for each division to develop and maintain their own GIS data.

Planning and Programming Service Center (P&PSC)

The P&PSC within WSDOT plans, coordinates, and implements transportation facilities of all kinds within the state, including aviation. Appropriately, this group appears to represent the more broadly based, coordination and policy-oriented interests. They have dealt with such questions as how the airports in the state interact with ground-based transportation and what the future role and impact the airports, large and small, will have in an overall transportation system.

This Service Center assists the Transportation Commission in developing statewide transportation policy and planning alternatives. This includes recommendations for aviation. Service Center staff regularly access the WSCASP hard-copy volumes for aviation planning information or work directly with the Aviation Division staff to obtain more current information.

All interviewed staff reiterated that WSCASP data in hard-copy volumes or existing computer format do not serve their long-term needs. The data are only tabular and do not support the ability to produce maps for meetings, presentations, or reports. The ability to perform on-line spatial queries of current WSCASP data and other WSDOT transportation-related data would allow P&PSC staff to make better, more timely recommendations on aviation planning to the Commission. The project participants within P&PSC reiterated the importance of WINGS in supporting the capital improvement programs (CIP) and the allocation of funds.

Management staff within P&PSC indicated that WSDOT is taking a cautious approach to GIS implementation. Based on available funding and past GIS project track records, they would like to start small, with just a few objectives, and build data layers as applications are defined. The first layer would be a "smart map" of basic statewide data including roads, county boundaries, and airport locations. Other layers would be built upon the base map layers. P&PSC staff need a system that could access data from the various transportation divisions and run on desk-top computers enabling managers to view data from their offices.

Federal Aviation Administration (FAA)

The FAA represents the U.S. Government in aviation matters. As a nationally based organization established to regulate air traffic and promote nationwide air safety, their emphasis is in assisting aviation facilities to meet federal safety standards. In addition, the FAA is a principal funding agency for airport improvements through the administration of the Aviation Trust Fund.

The Seattle Airport Districts Office (ADO) works closely with WSDOT/AD to fund and implement the Airport Improvement Program for sixty-five airports that have national importance and are included in the National Plan of Integrated Airport Systems (NPIAS) within the state of Washington. The FAA provides up to 90 percent of the funding for these airports.

The FAA requires that ALPs be updated every five years. An airport must have a current ALP on file if it is to receive financial assistance from the FAA for projects. An ALP consists of the following report and maps:

- Narrative report
- Airport layout drawing
- Airport airspace drawing
- Runway protection zone drawing
- Terminal area drawing
- Land use drawing
- Airport property map

Airport master plans are also updated every five years by the FAA and are more comprehensive than an ALP. The data required to prepare a master plan include complete documentation of the individual planning process at a specific airport and map products.

The FAA requires a user-friendly interface to WINGS to access data in a read-only manner. They do not perceive any data management or maintenance function. The system must be oriented for managers and planners that comprise a large user base to justify the resulting costs of implementation. The FAA would like access to digital maps instead of hanging files of hard-copy maps. The ability to visually select an airport using a computer screen and retrieve both maps and tabular data would greatly improve staff efficiency.

WSCASP Contractor

The WSDOT Aviation Division typically contracts for consultant services to assist in statewide aviation planning. The WSCASP has been contracted to a consultant and has been implemented in three cycles. The first cycle was completed in 1987-1989 and resulted in defining thirteen elements that were defined to support aviation planning. The 1990-1992 cycle resulted in a computer database that brought together, in a much more organized and accessible format, baseline inventory and forecast information of airports throughout the state. During the current planning cycle, the scope of work includes the preparation of nine AFIDs and four ALPs.

3.2 ORGANIZATION INTERACTIONS

The four major stakeholders in WINGS (WSDOT/AD, MIS, P&PSC, and the FAA) present opportunities for six organizational interactions. The extent and type of interactions are used as a basis for weighting the data and applications priorities in the User Needs Analysis.

The major interaction is between the Aviation Division and the FAA for aviation-related issues and planning. The FAA provides funding, regulatory requirements, and plan review. The Aviation Division submits the ALPs and AFIDs to the FAA for approval, manages the funding mechanics for CIPs, and also manages the contractors who assist the Aviation Division.

The second important WSDOT relationship necessary for the development of WINGS is between the Aviation Division and MIS. Aviation Division staff indicated during the interviews that they perceive that they will be the data custodians responsible for data development and future maintenance. They will rely upon MIS to set standard procedures and guidelines for data development and to provide hardware and software support.

Other lesser important interactions include those between the Aviation Division and P&PSC. The Aviation Division will continue to provide P&PSC staff with current information to develop intermodal policies. In addition, the future interaction between the FAA and MIS will be to develop a mutually agreeable database design, storage structure, compatible hardware and software, and an operational communications network that protects proprietary data sets and allows read-only access by the FAA.

The interaction between P&PSC and MIS is perceived to be minimal with MIS being responsible for computer support. There will be minimal direct interaction between the P&PSC and the FAA.

3.3 NEEDS ANALYSIS

The individual survey and interview forms were tabulated and ranked to establish priority applications and supporting data. The process of developing a needs analysis is a multi-step process that begins with direct input from the users. Generally, it was easier for the users to identify the data they required rather than how they would use the data for GIS applications (i.e. maps, queries, or reports). Therefore, data and application requirements were collected separately and then later compared to ensure that the two are consistent. This process supports an application-driven design. Consistency between data and applications is required for the conceptual design presented in Section 4 of this report.

Users View—Data

During the study phase of this project, a survey form was prepared. Participants were individually asked to rate the relative importance of potential data items required to support their aviation planning applications. Data priorities were established; required data items were given a value of "3," additional items deemed important enough to fund were given a value of "2," and desirable items were given a value of "1." All other data were given a value of "0."

A composite score for each data group was calculated. Appendix B presents the individual survey results and priority ranking scores. Exhibit 3-1 presents the survey summary results in high, medium, and low priorities by project participant work group.

Most high priority data is that which is accessed on a regular basis. These data are primarily airport related. Most of the medium priority data is not accessed on a regular basis, but the users would like to have it accessible in a digital format.

LEGEND

- ■ High Priority
- ◪ Medium Priority
- □ Low Priority

DATA LAYERS

	Survey Control			Landing/ Navaids			Land Ownership				Topographic				General Boundaries			Infrastructure					Buildings/ Structures			
	Horizontal Control	Vertical Control	Airport Reference Point	Air Traffic Control Tower	Approach Lighting	Instrument Approach	Rights-of-Way	Easements	Lots/Parcels	Public Land Survey	Contours	Hydrology	Vegetation	Soils/Geology	Airport/Airspace Boundaries	Administrative Boundaries	Zoning	On-Airport Transportation	Off-Airport Transportation	Utilities	Water/Sewer Systems	Stormwater Systems	Aviation Obstructions	Emergency Facilities	Aviation Facilities	Miscellaneous
Aviation	■	■	■	■	■	■	■	■	◪	◪	■	■	■	◪	■	■	■	■	■	◪	◪	◪	■	■	■	◪
P&PSC			□	□	□	□				□	□				□	□	□	□	□	□			□		◪	□
MIS																□	□	□	□	□	□	□	□		□	□
FAA			■	■	■	■	□	□			■	■	■	■	■	■	■	◪	◪	◪	◪	◪	■	■	■	■
Overall Priority	□	□	◪	◪	◪	◪	□	□	□	□	◪	◪	◪	□	◪	◪	◪	◪	◪	◪	□	□	◪	◪	■	◪

Washington Integrated Networked Geo-based System
WINGS

User View of Data Layers

EXHIBIT
3-1

WESTON MANAGERS DESIGNERS/CONSULTANTS

JOB NUMBER: 10564-001-001-0002 DATE: October 1994

Users View—Applications

GIS applications were more difficult for potential users to define. The survey form defined many potential applications that the project participants were asked to rank. A methodology and priority ranking was also developed for GIS applications which have been grouped into functional categories. The generic software categories listed below compromise a toolbox of functions that have been used to perform user-defined applications analyses. The applications built on these functions consist of procedures that can be performed by trained staff or may be programmed in a command language and made accessible through a menu-driven user interface for staff with less technical experience.

Data Entry and Edit

Data entry and edit provides the ability to enter both tabular and graphic data and make edits to the database.

Spatial Query

The most often used functions of a GIS, spatial query programs allow the user to find and display features as well as the attribute data describing the features on the map (such as an airport).

Report Generation

The ability to build tabular reports of attribute data is common to all GIS software. Reports are often the end result of spatial query or many of the more complex analytical functions. Reporting can often be combined with map products with tabular data plotted as well as printed.

Map Product Plotting

The ability to plot maps that are working drawings can be used for internal operations and to produce custom maps that can be considered final products.

Geo-Processing

These functions provide an automated means to add geographic identifiers to the attribute data of features at particular points or along lines at specific locations.

Proximal Analysis

Another powerful tool is the process of selecting features having certain attribute values and then identifying other features within a specified distance. For example, show all the airports within 100 miles of Spokane.

Dot-Density Mapping

Dot-density mapping allows the automatic display of symbols at the location of features that have certain user-defined characteristics. Dot-density maps of airplane accidents, airplane basing statistics, and airport usage data are examples of this GIS function.

Nearest-Neighbor

Nearest-neighbor capabilities allow the identification of a feature that is closest to another feature. An application could be the identification of the closest airport for an emergency landing that can accommodate specific aircraft.

Network Analysis

The topological data structure of a GIS provides the capability to "follow" lines along an interconnected network and then process attribute data associated with those lines along the network. For example, routing emergency vehicles is accomplished by identifying street segments (lines) that connect the starting point (fire station) to the destination (airport). When more than one route is possible, optimum path analysis programs use the attributes of the street segment lines to compute and select the shortest distance or travel time between two points.

Dynamic Segmentation

Dynamic Segmentation allows the association of multiple sets of attributes to any segment of a linear feature without changing the description of the feature. Attributes are assigned using a route-measure format. Location is determined by measuring along the linear feature rather than as a discrete x,y coordinate. Pavement management applications are often performed using this technique.

Polygon Processing

Polygon processing is a term applied to the creation of polygons from existing discrete data, as opposed to the creation of polygon boundaries by digitizing the boundaries. Polygonization can occur when certain spatial criteria are identified by the user. Generic examples of polygonization are:

- Spatial Aggregation that generates polygon boundaries from the results of spatial clustering as displayed on dot-density maps.
- Buffering that forms a polygon around another feature or groups of features at a user-defined distance or other quantitative measurement from the feature.

Document Imaging

Document imaging is a process of digitally capturing an image of a document, storing it on a computer, and retrieving it later for display or reproduction. It is based on the integration of several technologies, most notable scanning, optical disks, image monitors, and laser printers.

Exhibit 3-2 presents the users priorities for aviation planning applications built upon the above general GIS functions. It is noted that many of the standard software functions are required by the project participants. However, spatial query is considered the most important generic software function for aviation-related applications.

Data Priorities

The setting of applications and data priorities is based upon the user interviews by assigning a weighting factor to the raw scores. The raw user scores for each project participant have been weighted by the organizational and data interactions that will be established when the project is implemented. A weighting factor for key project participants has been given a value of 1.0; a weighting factor of 0.5 has been given for other participants that will be in a support role to the overall project. Therefore, the survey results of the prominent users of WINGS are given more weight than WSDOT staff acting in a support role. The following recommended priority data types reflect the individual user requirements based on the application priorities and the subjective evaluation of the consultant team. The specific priority ratings and rankings are provided in Appendix B.

The primary interest of the project participants is to assign a geographic location to the existing aviation data. Each feature in WINGS will be assigned a geographic location and thus can be analyzed or viewed in spatial relationships to surrounding features. There are two levels of data that will be required to support this project. The first level is a statewide database of spatial registration (survey control) and shared graphic features between WSDOT and other state agencies. These GIS data layers are county boundaries, public roads, surface hydrology. These data layers currently exist in other state-owned GIS databases and should be considered for inclusion in the WSDOT "smart map." The cost to incorporate existing data will be much less than developing new data. The second level of data is that surrounding each specific airport which includes the site of the airport and the surrounding planning area.

LEGEND
- ■ High Priority
- ◩ Medium Priority
- □ Low Priority

	Map Production						Data Query										Analysis						Modeling		
	Land Ownership/Planning	Locational	Transportation	Aviation Facilities	Environmental Areas	Topographic Maps	Engineering Facilities	Environmental Areas	Airspace Classification	Airport Inventory	Utilities	Emergency Facilities	Public Land Survey	Stormwater Data	Demographics	Noise Exposure	Airport Usage	Transportation Analysis	Demographic Analysis	Economic Development	Airport Facilities	Emergency Management	Long Range Planning	Noise Quality	External Modeling
Aviation	High	High	Medium	High	Medium	High	High	Medium	High	High	Medium	High	Medium	Medium	Medium	High	High	Low	Medium	Medium	High	High	High	High	Low
P&PSC	High	High	High	Low	Low	Low	Low	Medium	Low	Low	Low	Low	High	Low	Low	Low	Low				Low	Low	Low		
MIS	Medium	Medium	Medium	Low	Medium	Medium	High	Medium	Low	Low	High	Low	High	High	Low	Low	Low						Low		
FAA	High	Medium	Low	High	High	Medium	High	High	High	High	Low	High	Low	Low	High	Medium	Low			Medium	High	Medium	High	Medium	High
Overall Priority	High	High	Medium	Medium	Medium	Medium	High	High	Medium	Medium	Medium	Medium	High	Medium	Medium	Medium	Medium	Low	Low	Medium	Medium	Medium	Medium	Medium	Low

Washington Integrated Networked Geo-based System
WINGS

User View of Applications

EXHIBIT
3-2

WESTON MANAGERS DESIGNERS/CONSULTANTS

JOB NUMBER: 10564-001-001-0002 DATE: October 1994

Table 3-1—Recommended Data Priorities

	Statewide	Local
High Priority		
Horizontal Survey Control		X
Airport/Airspace Boundaries	X	X
Aviation Facilities		X
Aviation Obstructions		X
Landing/Navigation Aids		X
Noise Contours		X
Medium Priority		
Stormwater Systems		X
Water/Sewer Systems		X
On-Airport Transportation		X
Administrative Boundaries	X	X
Demographic Data		X
Other Utilities		X
Zoning		X
Lots/Parcels		X
Emergency Facilities		X
Public Land Survey		X
Low Priority		
Off-Airport Transportation	X	X
Vertical Survey Control		X
Elevation Contours		X
Hydrology	X	X
Vegetation		X
Soils/Geology		X
Rights-of-Way		X
Easements		X

The digital conversion of data into a GIS can require up to 70 percent of the total budget. Therefore, it is recommended that WSDOT implement those data layers that support the priority applications and allow WSDOT to rapidly realize the benefits of WINGS early in the project life-cycle. The recommended priority data types presented in Table 3-1 emphasize the development of a data set that would support FAA and WSDOT priority applications. An indication is presented whether the data layer would be statewide, local to an airport, or both.

Applications Priorities

Table 3-2 presents the priority GIS applications from the user view and refined by the subjective analysis. The overwhelming emphasis is centered upon determining what is at a given location and what is the current condition of features that meet a specific criteria. In addition, the users expressed the need to produce map products.

High-priority applications are those that would replace existing manual activities that are done on a regular basis. These activities are generally labor- and time-intensive requiring data to be retrieved from many sources.

Medium-priority applications are those that either already exist as stand-alone software solutions or the current access to the application is not done frequently enough to warrant a high priority.

Low-priority applications would require building data sets that could be used in the applications. Data for these applications could be developed as the need arises and as funding becomes available.

Table 3-2—Application Priorities

High Priority	
Mapping:	Aviation Facilities/Locations Land Ownership Locations Transportation
Data Query:	Airport Inventory Airspace Classifications
Analysis:	Airport Facilities Airport Usage Noise Exposure
Modeling:	None
Medium Priority	
Mapping:	Environmental Areas Transportation Facilities Topographic Contours
Data Query:	Environmental Areas Stormwater Runoff Engineering Facilities Utility Locations Demographics Emergency Facilities
Analysis:	Economic Development Demographics
Modeling:	Long Range Planning Alternatives Noise Impacts
Low Priority	
Mapping:	None
Data Query:	Public Land Survey/Cadastral
Analysis:	Transportation Alternatives
Modeling:	Off-Airport (External) Modeling Emergency Management

SECTION 4

CONCEPTUAL DESIGN

The previous section establishes the data and application priorities. This section focuses on the data and begins the database design process. The first step in designing a user-oriented database is to prepare a conceptual design which is independent of any commercial software or data storage structure. This section presents the salient database considerations and the recommended WINGS conceptual model. This model is based upon the user applications and the data required to support those applications.

4.1 WINGS DATABASE OVERVIEW

When fully implemented, WSDOT and FAA can use WINGS as a database to support a variety of activities related to airport planning, airport pavement management, emergency response, noise monitoring programs, and environmental management plans. This database will contain both graphic data stored in a common geographic coordinate system and non-graphic data. A database with both graphic and tabular attribute data is commonly termed a GIS. A GIS is not simply a computer system for making maps, although it can create maps as required. A GIS is a management and analysis tool. The distinguishing characteristic of a GIS is that it allows the user to identify spatial relationships between map features, supports user queries, and performs analyses.

Some disagreement exists over the meaning of the term "database." In this report, the term refers to a large collection of data in a computer, organized so that it can be expanded, updated, and retrieved rapidly for various uses. The data may be organized as a single file, or as multiple files, or sets but supports a wide variety of user applications.

The design of the WINGS database considers the type of features that should be grouped or that are maintained by the same division. Consideration is also given to grouping features into design layers based upon the perceived data maintenance roles as the database matures.

4.2 DATA STRUCTURE

The most simple GIS structure consists of "layers," some of which will be specific to the Aviation Division's needs, and others of which will be common to many users throughout the state and the aviation industry. For example, WSDOT has incorporated the state roads network into a GIS. It would, therefore, be inappropriate to redundantly store the roads data in the WINGS GIS.

Each type of feature is included in the GIS database and is assigned to one specific layer. For example, a data layer in WINGS will be airport boundaries. The layers are linked together by a common geographic coordinate.

The principle purpose of the layered digital database is to allow easy access to the most common combinations of information contained within the database while also providing an efficient method of managing potentially large amounts of diverse information. To achieve this balance, each database layer must be defined so that the finest level of detail captured in the layer is quickly retrievable. Once information has been captured in the most elementary form, the process of aggregating data components within a layer to derive new data themes is easily accomplished using GIS software functions.

In addition, the information contained in each layer should be logically related to all other elements within the layer to ensure efficient storage, retrieval, and management techniques. For example, by capturing basic airport locations and state roads as separate layers, they are easily accessed individually and may also be readily retrieved and combined to form the standard WINGS base map.

An option to storing data in layers is to organize simple features into hierarchical complex features, called "objects." An object can be composed of many simple graphic features or "primitives" and their associated attributes. These features can reside on multiple data layers in their simple state. Using GIS software, the user can define the rules to group the single graphic features into objects and assign attributes to the object. An example of an object is a runway which may include the navigational aids associated with the runway, associated lighting, and the painted centerline.

Two salient concepts are noted concerning an object-oriented GIS. The first concept is that simple graphic features can be shared by more than one object. When the graphic configuration or an attribute value is updated, the resulting objects "know" that the change has occurred. The second concept is that the spatial update and maintenance of a mature GIS is less complex using an object-oriented GIS.

Elaborating on the above example of an object, if a more recent survey updates the position of the runway, then all inherent features to that object are adjusted. Without the object-oriented approach, the individual data layers of a GIS composed of simple graphic features would have to be re-registered one layer at a time.

The major disadvantage to an object-oriented GIS is that few commercially available GIS software companies support an object-oriented spatial structure. However, object-based GIS is becoming more popular given the long-term operational and maintenance advantages.

4.3 GIS DATA TYPES

Two basic types of data comprise a GIS: graphic data and the related tabular attribute data. The GIS manages the relationships between graphic and attribute data, thus making the relationships transparent to the user. The graphic features stored in a GIS may be presented in several different formats depending on the user's need for accuracy, content, and coverage. Coordinate values are captured using a digitizing tablet, stereoplotter, coordinate geometry, or an optical scanner. The coordinates are recorded as X and Y (and sometimes Z) values in a geographic coordinate system.

Without tabular attribute data, a GIS is merely a computer graphic. Linking the tabular data with the graphic features of the GIS allows the user to perform analyses of the data and answer the five generic questions that are supported by a GIS. Examples of this tabular attribute data would include existing WSCASP files.

4.4 GIS DATA MANAGEMENT

GIS data must be organized thematically (i.e., by data category) or geographically. A data management system for an area the size and density of Washington state should be based on a data structure that arranges information in both formats. Thematic organization is the same concept as arranging data in layers. To allow a more efficient data storage structure, the thematic data are often partitioned by geographic areas.

Geographic organization is accomplished by defining a common tile or partition structure for the entire database. These are manageable areas that fit together to form a contiguous coverage over the extent of the database. These tiles may be formed on the irregular shapes of administrative or natural boundaries, or may be defined by a regular system of rectangles or polygons such as standard grid units or the areas bounded by lines of latitude and longitude. In any case, the tiling of a data layer is transparent to the user when performing applications. County boundaries would be a logical tiling unit.

4.5 DATA FORMATS

Graphic data that are referenced to geographic coordinates are captured, maintained, and manipulated in a number of different formats. These formats can be split into the two categories of vector and raster data structures. Vector data are built from coordinate values of points or lines that locate or delineate features on the earth. Polygon data are simply a closed loop of lines. Raster, or continuous, data are usually structured as a regular grid or array of cells that represent an area on the earth. Spatial data maintained in either of these formats can be linked to tabular attribute tables that describe the various attributes of interest.

Vector Data

Vector data can be conceptualized as falling into three categories: graphics, attributes, and annotations, described below.

Graphics

Graphics are elements of individual features represented as:

- Points, such as airport reference points;
- Lines, such as roads or flight paths;
- Polygons, such as airport boundaries, land use zones and runway protection zones;
- Nodes occur where a line segment ends, begins, or connects with another line segment. An example would be a runway end.

Graphic elements portray or model the individual physical features and are stored in the database using X and Y coordinates and sometimes a Z (elevation) value. A point or a node is represented by a single coordinate pair, while lines are represented by a string of X and Y coordinate pairs. An area (polygon) is represented by a closed loop of lines. Map features are further identified by functional classification to allow selection and display of similar features. Each graphic data element includes an internal identifier to link with nongraphic attributes which describe the element.

Attributes

Attributes are nongraphic elements describing the graphic features and are stored in a database format that allows them to be linked with their related graphic features. This linkage supports information retrieval through interactive queries of map feature location or associated attribute value content. Attributes may be displayed as text, used as query criteria, or contained in reports. Using attributes, a GIS can retrieve and manipulate graphic elements in either of two ways:

- The operator selects and displays graphic elements on the basis of attribute value(s). The following query is an example of this type of retrieval:

  "Display all the pavement sections which are asphalt and have not been seal-coated in the last five years."

- The second method involves selection and display of graphic elements of attribute contents. The following query is an example of this type of retrieval:

  "Display all general aviation airports within King County and assign symbols based upon the number of 1993 takeoffs and landings."

An important aspect of a GIS database is that the attributes may be external to the GIS. In other words, the attribute database is defined as a standalone database to support many applications, but has been assigned internal indices that are common to both the GIS and other external databases. This linking of many databases allows the external data to be used in GIS displays and analyses.

Annotations

Annotations are graphic text features that may be derived from the tabular attribute of a feature or may be independent of any graphic feature. Independent annotation not associated with any graphic feature is commonly used to produce map products. For example, a north arrow or general notes are not associated with any particular graphic feature.

Raster Data

Raster data structures are used to manage satellite imagery, digital orthophotography, or scanned documents. The ability of a GIS to integrate both raster and vector data sets provides more sophisticated products and analyses available to the users. For example, the recent FAA requirement to present the ALP drawings drafted on an aerial photograph is an excellent application of integrating raster and vector data into a single map product.

The ALP map product could be even more useful if the underlying image were a digital orthophotograph. Orthophotographs (accurate maps that look like photographs) have been used by various planning, engineering, and mapping agencies for years. In raster digital format, they can now be displayed on computer screens and registered to the corresponding vector map data used in many GISs.

4.6 SPATIAL ACCURACY

A successful GIS will grow in size and attract more users. If the information is not reliable, WSDOT's liability will also grow. Attempts to retrofit a mature GIS to one of higher accuracy will encounter significant difficulties associated with base maps and database structures. Therefore, setting standards for spatial and attribute accuracy of the database layers must be designed into the GIS from the beginning.

The National Committee for Digital Cartographic Data Standards defines accuracy as

> *"...the closeness of results of observations, computations, or estimates to the true values accepted as being true."*

For many users, the issue of relative accuracy (i.e., the accuracy of positioning map elements relative to each other) is often more important than absolute accuracy (i.e., accuracy of data element coordinates with respect to a spatial coordinate system). As discussed later in this section, the reliance on relative accuracy in place of absolute accuracy may have negative long-term cost implications, unless properly designed.

The spatial accuracy requirements of organizations vary depending on their mission and the type of data. The benefits derived from a low accuracy system are limited to those organizational units or data types with minimal accuracy requirements. Obviously, the greater the spatial accuracy, the more organizations will find the system useful and the greater the cumulative benefit. For example, a map showing the distribution of airport users by census tract does not require the same spatial accuracy as an airport utility map that may be relied on to authorize excavation at a given location. As long as the marginal increase in cost for each marginal increase in accuracy is exceeded by a corresponding marginal increase in cumulative benefits, the increased accuracy is justified.

Accuracy in excess of minimum requirements has no disadvantages except for the high initial cost and required development time. These initial costs must be balanced against the long-term maintenance and upgrade costs of less accurate systems. Despite the large initial costs associated with higher levels of accuracy, a pure benefit-cost analysis would show that the highest accuracy required by the participating public organizations will usually result in a positive total benefit. This is due to the fact that public data costs are amortized over very long time periods. Practical considerations other than the true long-term economic return of improved accuracy will legitimately influence the final acceptable investment. Therefore, the cost of improved accuracy must be justified based on tangible and intangible benefits with a relatively short payback period. Potential benefits of increased accuracy include the following:

- Increased use of the GIS
- Increased reliability for all users
- Ability to properly overlay separate data layers
- More timely responses to inquiries
- Limitation of state and federal government liability
- Cost avoidance in re-digitizing data
- Cost savings during base map maintenance
- Cost savings when upgrading map accuracies

WINGS will have to be designed to allow for attributes of varying degrees of accuracy. The database design must be done to ensure that data derived from sources with varying scales and accuracies are properly identified. This is accomplished by enforcing the use of metadata (data about data) that will reliably quantify the accuracy of the individual features.

Two levels of spatial accuracy are recommended for the implementation of WINGS. Statewide data should, at a minimum, be spatially accurate to 200 feet. A mapping scale of 1:100,000 supports this level of accuracy. Airport-specific data would be spatially accurate insets in the statewide system. Airport-specific data should, at a minimum, be accurate to 2 feet. A mapping scale of 1:1,200 supports this level of accuracy.

4.7 BASE MAP CONSIDERATIONS

The digital base map is the foundation and standard framework for all data layers in the GIS. These fundamental data contain the controls for all other sources of spatial data that are added to the GIS database. Following standard GIS database design theory, the components of the base map and associated base map layers are derived from the needs of the users. For example, if WSDOT has an established priority for surface water management at each airport, then the base map layers should contain topography and impervious surfaces. Regardless of the priority applications, the WINGS GIS must contain the geodetic control network as a primary data layer. An accurate GIS base layer is important for the following reasons:

- The base map provides the necessary control for a GIS that spans the entire state.
- The established control points of an accurate base map provide the foundation for future updates of other layers in the GIS.
- The ability to tie to other data layers that may not be created by the Aviation Division but would be useful data sources.

Statewide base map data layers for WINGS should be derived from a number of existing sources. For example, the DNR has existing statewide coverage of Public Land Survey System (PLSS) section corners that have been derived from 1:24,000-scale U.S. Geologic Survey (USGS) quadrangle maps. In addition, WSDOT has an existing digital coverage of roads. Additional base map data available from the Federal Government includes census tracts, hydrography, transportation networks, and county/administrative boundaries. The federal government also administers the National Aerial Photography Program (NAPP) for 1:40,000-scale color infrared photography that is scanned for 1:12,000 digital orthophotograph production.

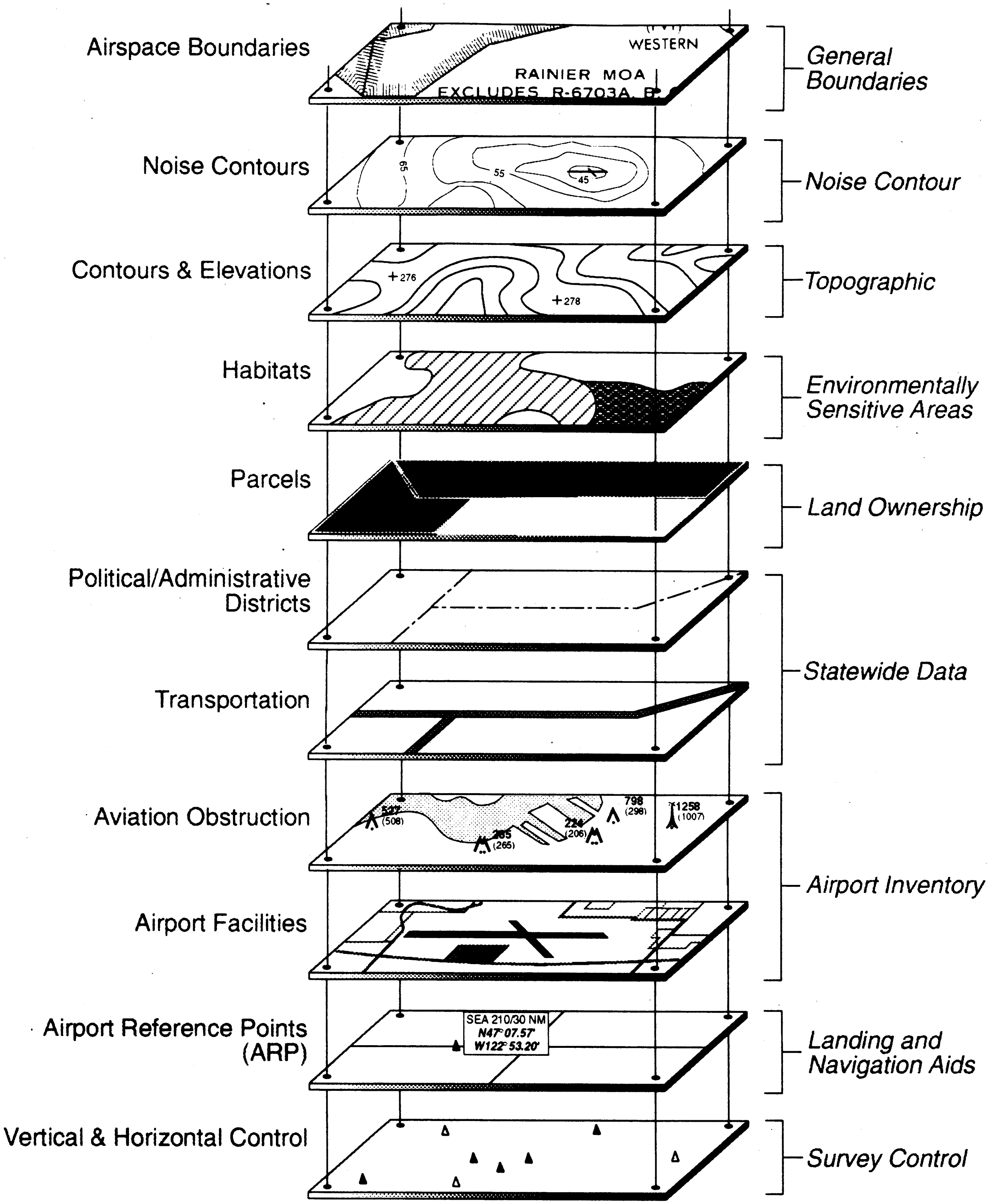
4.8 WINGS LOGICAL DESIGN

The WINGS database is conceived as special purpose data layers that are built upon a statewide multi-purpose GIS. It simply is not cost-effective for the WINGS database to replicate existing statewide digital GIS data.

The logical data layers described below serve as a starting point for completing a physical database design that is specifically designed for the selected system GIS software and system configuration. Priority data layers include survey control, landing and navigation aids, airport inventories, and statewide coverage of roads and county boundaries. Other data layers include land ownership surrounding the airports, topography, general boundaries, noise contours, and environmentally sensitive areas. Exhibit 4-1 illustrates the layers in the WINGS logical design.

Statewide Data Layers

Many data sets currently exist for a statewide coverage. At a minimum, the WINGS GIS must contain the roads, county boundaries, major incorporated areas and hydrology. From a cost effectiveness point of view, WINGS should use existing data sources maintained by others through an data sharing agreement. These data can be obtained from state and federal agencies.



Map Database Layering Concept

Exhibit
4-1

WESTON
MANAGERS DESIGNERS/CONSULTANTS

10564-01-01-0002
October 1994

Airport-Specific Data Layers

Survey Control Layer

The geodetic and local survey control will provide registration and spatial reference for all other data layers. Extensive control will be required for the conversion of data from manual to automated format. It must be maintained by a single division with access to information regarding any changes in the locations or status of these data. It is recommended that the statewide control maintained by the DNR be used for generalized control of statewide features.

Airport specific survey control will be required to establish the level of accuracy required by the users. Since all other airport specific layers of WINGS will be built from these features, they must be constructed at a sufficient level of spatial accuracy to support all applications and products. Extensive survey control is required within each airport planning area. The airport-specific control should be a subset of the statewide control.

Landing/Navigation Aid Layer

The landing and navigation aids will provide additional information to tie airports and navigation systems to a common spatial reference system. These aids include the ARPs which have accurate coordinates. The first step would be to tie the ARPs and the airport name to the base map. This would be the foundation for creating all other airport data layers. For NPIAS airports, the FAA is responsible to maintain these data. The state is responsible to maintain these data for non-NPIAS airports.

Airport Inventory Layers

This layer will contain the data specific to each airport. Each airport will have a layer dedicated to information required to develop the ALPs or the AFIDs. The data layer would be geo-referenced to the more accurate survey control specific to the airport. The benefits of this data layer include:

- Satisfying the FAA regulations for submitting data. While not currently required in digital format, having the data in this form would allow for the updates to be more efficiently produced.

- Layers of information could be created for use in the airport master plans. Certain other drawings such as the FAA Form 5010 drawings are required for the FAA and can be derived from a common database. These could be more easily created and manipulated if the technician could start with an existing data set and update the appropriate features. Currently, FAA Form 5010 drawings are created in AutoCAD and are strictly graphic in nature.

Land Ownership Layer

A land ownership layer would include properties within the airport planning areas. This data requires a significant level of effort to create and maintain. Coordination with the individual county assessor's offices is required. Many counties have this data in their GIS and it would be appropriate to develop interlocal agreements for the county staff to maintain the data and WSDOT and the FAA to use the data on a read-only basis. A pertinent addition to this layer is current land use zoning.

Topographic Layer

The topographic layer will include a Digital Terrain Model (DTM), ground-elevation contours and spot elevations. These data can be used in combination with planimetric features in the planning and construction of new facilities. More importantly, knowing the ground elevation, the location of an obstruction, and the height of the obstruction, the intrusion into the federal aviation regulation (FAR) 77 airspace could be calculated.

Existing public agency data are not sufficiently accurate (horizontal and vertical) to incorporate its airport-specific data layers.

General Boundaries

These layers will be used for the planning and administration of facilities and services. These layers include political boundaries, administrative districts and other areas defined by specific agencies. Airspace boundaries are included in this data layer.

In general, these boundaries would be obtained from others; however, some boundaries will have to be digitized and maintained by the Aviation Division.

Noise Contour Layer

The noise layer consists of the 65 and 55 Ldn contours generated by FAA contouring programs in addition to point locations of actual measurements. In addition, if a street network with address ranges as an attribute existed in the database, individual noise complaints could be added to this layer and compared to the theoretical noise contours.

Environmentally Sensitive Areas

The environmental layer may consist of natural features such as wetlands, steep slopes, or wellhead protection areas or habitats. In addition, sensitive habitat areas such as salmon spawning streams or bird rookeries are required to evaluate the aviation impacts.

These data will have to be obtained from state and local governments and maintained by WINGS given the diverse group of data providers. Existing data include Priority Habitat areas mapped by the Department of Wildlife and National Wetlands Inventory data available from the Department of Ecology.

SECTION 5

SYSTEM DEVELOPMENT ISSUES

WINGS will be implemented as a computerized database. Data will be stored in the GIS, and individual data sets will be used to perform the full spectrum of user applications. Central to the design of an efficient system are hardware, software, and data management considerations.

The design and development of WINGS should continue to follow a structured system development methodology in a phased, top-down process. This process will ensure management involvement at critical decision points as successively greater levels of system detail are developed. Management is called on to make one of three decisions at the end of each phase: proceed to the next phase, revise certain parts of the previous phase, or cancel the project. The four major phases are the study phase, the design phase, the development phase and the operational phase. Each is briefly described below.

5.1 STUDY PHASE

This report documents the study phase. During this phase, the needs were identified and the conceptual design developed. Alternatives were recommended concerning design and implementation of the system. The study phase will be completed with an implementation plan which will include general cost estimates.

5.2 DESIGN PHASE

In this phase, specifications are produced based on the design specifications developed in the study phase. Physical database designs and data conversion specifications are completed. If Computer-Aided System Engineering (CASE) tools are employed to develop data flow diagrams in major data and applications development, the total system cost can be reduced.

5.3 DEVELOPMENT PHASE

This phase involves the construction of the new system from the design specifications. The final product of the development phase is the operational system itself.

5.4 OPERATIONAL PHASE

In the operational phase, the old system is replaced by the new or revised system. The system's performance is monitored, and improvements are made as WSDOT and FAA needs change and technology improves.

5.5 HARDWARE ALTERNATIVES

The options for WINGS include a centralized or a distributed hardware system. The intent of this discussion is to provide information which can guide the preparation of a set of reasonable system specifications and implementation procedures.

The system configuration options take into account three major components: communications, processing, and database storage. This section discusses some of the options available and examines the issues associated with their implementation. Only factors that distinguish the options are considered at this point in the analysis.

Centralized Versus Decentralized

The centralization/decentralization issue is a complex one that requires careful deliberation. The placement of information processing capability within the organization is an important and complex consideration when evaluating system options, especially given the advent of improved data communications networks, low-priced small and mid-sized computers with significant processing power and more powerful user-friendly languages.

In the continuing discussion that is almost as old as the computer industry, there are as many reasons for decentralization as for centralization. In contrast to the arguments for centralization, which involve efficiency, the arguments for decentralization involve effectiveness.

The major issues to consider when evaluating centralization versus decentralization include the following:

Economy of Scale

Economy of scale is the most frequently stated reason for operations centralization. It results from several factors:

- Decentralized smaller computers may have unused capacity. Centralization on a large computer can eliminate the cost of such capacity.
- Individual computers may be overloaded, requiring computer upgrades. Centralization on a large computer can enable the central computer department to absorb this overload by drawing on unused capacity.
- Generally a smaller number of support personnel (e.g., operators, system administrators) is needed for a large installation than for multiple small installations.

The economies do not all favor centralized operation. The use of smaller computers in a decentralized environment can provide significant savings under the proper conditions. A single-purpose, small-to-medium-sized computer used for a specific application can be relatively inexpensive. Many times these smaller systems do not require the operator or technical support of larger systems.

Improvements in the processing power and network capabilities of microcomputers have made a microcomputer-based system a viable alternative for consideration.

The Reduced Instruction Set Chip (RISC) has made it possible for hardware manufacturers to build a computer that is small in size, has tremendous processing power relative to its size, operates in an office environment, and is reasonably priced (priced at about $5,000 for a low-end model). GIS software system developers have taken advantage of these hardware platforms.

Sophistication of Applications

Large computers offer advantages beyond economy of scale. Certain applications not feasible on smaller equipment are made practical by their higher internal speed and greater primary storage. Although in some cases it is technically possible to operate an application on a small computer, doing so absorbs a major part of the computer's capacity.

Centralization forces users into a common mold that may be inappropriate for their needs. The specific hardware required for one user may differ from that required by another. These different needs could be satisfied with far less complexity and cost by smaller installations.

The centralized installation also creates contention for machine time among users. Several jobs running concurrently on a single machine may delay response time to users and, invariably, create competition for priority of service. Some GIS operations require significant computer processor time.

Quality and Consistency of Systems Development

Centralization permits the design and use of common databases and common standards for data update and distribution. It can also enhance the ability to utilize development and project control techniques. Some of these benefits include the ability to:

- Evaluate development projects from an overall user perspective, such as establishing priorities and conducting benefit-cost analyses.

- Avoid redundant development of similar systems for different project participants.

- Apply project control techniques. While this management function is not unique to computer system projects, experience with computer project management is helpful.

In addition, substantial differences exist between the abilities of large and small installations to attract and retain highly qualified technical personnel. These technical personnel can require sizable salaries possibly putting a burden on the budgets of individual departments.

A centralized group can more easily hire and retain highly qualified personnel. These personnel can provide a greater range of alternative solutions to problems, resulting in a lower cost of development, operations, and system maintenance.

Proponents of decentralization convincingly argue that local analysts are more attuned to local needs. These analysts acquire an in-depth knowledge of department operations, managerial preferences, and organizational strengths and weaknesses. This enables them to establish requirement specifications and design systems that are most suited for the department. It also helps them to avoid seeking technical solutions to what could be fundamentally business problems. The local analyst can also respond more quickly to the emergencies and changes in priorities.

The close association between the analyst and user also means that the user becomes better educated concerning the benefits and limitations of the systems.

Data Processing Expense Control

Some reasons for centralization do not fit the general areas previously mentioned. Most of these involve controlling the cost of data processing and include the following:

- Smaller installations often lack sufficient overview to perform adequate advance planning. This may result in unexpected requirements for equipment or development. Capacity planning, for example, can be a complex issue to evaluate.

- Decentralization often obscures administration's view of computer processing costs. It is difficult for top management to apply measures of cost or effectiveness to a decentralized function.

- Decentralization makes it more difficult to see the overall systems need and apply a comprehensive, integrated solution.

A decentralized system is recommended for WINGS implementation. The primary reason is the office locations of the users and their diverse existing computing environment. The FAA office is in Renton, the Aviation Division is at Boeing Field, and the other WSDOT users are in Olympia. The FAA and the Aviation Division have IBM-compatible workstations, P&PSC has existing Macintosh computers, MIS has mainframe and IBM workstations. The GIS group within MIS has Intergraph workstations and a Unix-based workstation on loan from IBM.

In addition, all project participants expressed the requirement to have immediate access to the WINGS database through a microcomputer on their desk. When implemented, they expect to perform their own analyses using a shared database.

A GIS requires specialized hardware components for processing, editing, and display of graphic and nongraphic data. The two alternatives that are viable for WINGS include PC-based workstations (either IBM-compatible or Macintosh computers) and Unix-based workstations. While Unix-based workstations would provide a faster response time for users, PC-based computers are more appropriate for most WINGS users. It is assumed that WSDOT staff within MIS would be responsible for the server and communication network maintenance.

5.6 SOFTWARE ALTERNATIVES

The comprehensive evaluation of software alternatives to support WINGS is beyond the scope of this study. However, some pertinent events have recently occurred:

- WSDOT has recently completed the ARC/INFO demonstration project in conjunction with ESRI and IBM. The results of this project are completed, and WSDOT has made a recommendation to the GIS Committee to adopt ARC/INFO as the WSDOT GIS software. This recommendation was made based on a translation of Intergraph files of road networks and an evaluation of the dynamic segmentation functionality of the ARC/INFO software for managing event tables for road maintenance and accident locations. ARC/INFO, as recommended, would be run on Unix-based workstations and file servers.

- The second recent development is that the FAA Western Region has recently embraced Airport Information Management System (AIMS). AIMS software has been developed by Gregory C. Rigamer (g.c.r.) and Associates, Inc. and has been implemented for ten state agencies. The software has a growing base of state users and is also used by the FAA.

  Development of the AIMS software began in 1985, and most recently, has been enhanced to operate in a Microsoft Windows or a Macintosh micro-computer environment. The software manages a variety of data about each airport including:

  - General airport information
  - Layout drawings
  - Property maps and ownership attributes
  - Small-scale regional maps (i.e., USGS quadrangle maps)
  - FAA Form 5010-1 information
  - Construction and planning grant information

Two salient capabilities of the software include evaluating runway end obstructions and analyzing pavement conditions. Company literature promotes the software as facilitating the development of annual maintenance plans and long-term capital improvement programs. It appears that the software allows for tabular data maintenance, but lacks functionality to maintain graphic features.

The AIMS software displays graphic data using ArcView, a display and query software module from ESRI. Using AIMS software on a PC, the user can directly view and query ARC/INFO data residing on a file server.

A software recommendation is not made at this time; however, the AIMS software should be evaluated and tested by WSDOT given the fact that it is PC-based and works in both a Microsoft Windows and Macintosh computing environment.

APPENDIX A

GLOBAL POSITIONING SYSTEMS

APPENDIX A

GLOBAL POSITIONING SYSTEMS

Global Positioning System (GPS) has been partially responsible for making GIS a cost-effective technology by dramatically reducing the cost of determining the position of mapped objects. It is based on a constellation of Department of Defense (DOD) satellites orbiting the earth at an altitude of 11,000 miles. GPS receivers pinpoint locations by receiving signals from these satellites and applying sophisticated trilateration techniques.

The system was originally designed for military purposes. However, civilian organizations have expanded on the technology, turning it into an industry that is predicted to reach $10 billion by the end of the decade. Most of that activity will be in the navigation market. However, GPS will also supply a significant amount of data for GIS data bases.

GPS was designed to determine positions within 16 meters (spherical probable error) in real-time virtually anywhere on the earth. This is called point positioning. It only requires a single receiver and minimal expertise. Unfortunately, the accuracy of the available satellite data may be degraded by the military to 100 meters without prior notice. However, the accuracy can be significantly improved by employing various techniques that are not significantly affected by DOD actions. Obviously, to accomplish this increase in accuracy there must be a corresponding increase in expertise and cost. The three salient techniques to improve GPS accuracy are:

- Differential techniques requiring two GPS receivers. One receiver must be positioned on a geodetic control point as the other receiver travels to the points where geographic positions are required. The roving receiver can be in a van, boat, airplane, or hand-held. The 3-meter accuracy in three dimensions (X, Y, and Z) can be most easily obtained by postprocessing the data from both receivers. This processing only requires a 386 personal computer (PC). Real-time 3-meter accuracy can be obtained by providing a radio link between the stationary and roving receivers.

- Geodetic techniques developed by the NGS require geodetic quality receivers and must be postprocessed on a 386 PC to obtain centimeter-level (less than an inch) accuracies. To obtain geodetic accuracies over long distances, a surveyor must make simultaneous observations between a known point and other points of interest for 1 to 5 hours.

- Newly developed "kinematic" techniques, also developed by NGS, allow centimeter-level accuracy "on the fly" over short distances of about 10 kilometers (6 miles). The roving receiver can be in a van, boat, airplane, or hand-held. Recently improved techniques called Pseudo-kinematic using the Ambiguity Function Method will result in another dramatic drop in surveying cost.

APPENDIX B

USER SURVEY RESULTS

Work Group	MIS					P&PSC		AD				FAA			
Interviewee	F.A.	D.D.	G.S.	C.K.	R.C.	A.A.	C.S.	B.H.	M.M.	J.M.	N.L	J.C.	**Avg.**	**Wt. Avg.**	**Final Score**
Weighting	0.5	0.5	0.5	0.5	0.5	1	1	1	1	1	1	1			
APPLICATIONS															
Potential Products-Base Map Production															
Land ownership maps	3	0	2	0	3	3	3	2	3	0	3	3	**2.08**	**1.75**	3
Locational maps	3	0	2	0	2	3	3	2	3	0	3	2	**1.92**	**1.63**	3
Noise contour maps	3	0	2	0	1	3	3	1	3	0	3	3	**1.83**	**1.58**	3
Planning maps	3	0	2	0	2	3	3	1	3	0	3	2	**1.83**	**1.54**	3
Transportation maps	3	0	2	0	3	3	3	0	3	0	3	1	**1.75**	**1.42**	3
Aerial photographs	3	0	2	0	2	0	0	3	3	0	3	1	**1.42**	**1.13**	2
Facility maps	3	0	2	0	2	0	0	1	3	0	3	3	**1.42**	**1.13**	2
Topographic maps	3	0	2	0	2	0	0	2	3	0	3	2	**1.42**	**1.13**	2
FAR Part 77 maps	3	0	0	0	1	0	0	2	3	0	3	3	**1.25**	**1.08**	2
Engineering plans	3	0	2	0	2	0	0	0	3	0	3	3	**1.33**	**1.04**	2
Environmental maps	3	0	2	0	2	0	0	0	3	0	3	3	**1.33**	**1.04**	2
Administrative/jurisdictional maps	3	0	2	0	1	0	0	2	3	0	3	1	**1.25**	**1.00**	2
Utility maps	3	0	2	0	3	0	0	1	3	0	3	1	**1.33**	**1.00**	2
Orthophotography	3	0	2	0	2	0	0	0	3	0	3	1	**1.17**	**0.88**	2
Special use maps	0	0	2	0	2	0	0	0	3	0	3	0	**0.83**	**0.67**	2
Roadside inventory maps	0	0	0	0	3	0	0	0	3	0	0	0	**0.50**	**0.38**	1
Construction plan	0	0	0	0	0	0	0	0	0	0	0	3	**0.25**	**0.25**	1
Category Score															**2**
Potential Prods-Inventory															
As-built drawings	3	0	3	3	0	3	0	2	3	2	2	3	**2.00**	**1.63**	3
Environmentally sensitive areas	3	0	0	3	3	3	0	0	3	3	2	3	**1.92**	**1.54**	3
Obstructions	3	0	0	0	0	3	0	3	3	3	2	3	**1.67**	**1.54**	3
Proximity to other airports	3	0	0	3	0	3	0	1	3	3	2	3	**1.75**	**1.50**	3
Airspace classification	3	0	0	0	0	3	0	2	3	3	2	3	**1.58**	**1.46**	3
Engineering designs	3	0	3	3	0	3	0	0	3	2	2	3	**1.83**	**1.46**	3
Runway pavement conditions	3	0	0	0	0	3	0	3	3	2	2	3	**1.58**	**1.46**	3
Apron pavement conditions	3	0	0	0	0	3	0	2	3	2	2	3	**1.50**	**1.38**	3
Apron pavement design	3	0	0	0	0	3	0	2	3	2	2	3	**1.50**	**1.38**	3
Apron size	3	0	0	0	0	3	0	2	3	2	2	3	**1.50**	**1.38**	3
Base aircraft	3	0	0	0	0	3	0	2	3	2	2	3	**1.50**	**1.38**	3
Helicopter landing pad	3	0	0	0	0	3	0	2	3	2	2	3	**1.50**	**1.38**	3
Navigational aids	3	0	0	0	0	3	0	2	3	2	2	3	**1.50**	**1.38**	3
Passenger enplanements	3	0	0	0	0	3	0	1	3	3	2	3	**1.50**	**1.38**	3
Runway approach	3	0	0	0	0	3	0	2	3	2	2	3	**1.50**	**1.38**	3
Runway approach type	3	0	0	0	0	3	0	2	3	2	2	3	**1.50**	**1.38**	3
Runway dimensions	3	0	0	0	0	3	0	2	3	2	2	3	**1.50**	**1.38**	3
Runway lighting	3	0	0	0	0	3	0	2	3	2	2	3	**1.50**	**1.38**	3
Runway numbers	3	0	0	0	0	3	0	2	3	2	2	3	**1.50**	**1.38**	3
Runway pavement design	3	0	0	0	0	3	0	2	3	2	2	3	**1.50**	**1.38**	3
Runway surface	3	0	0	0	0	3	0	2	3	2	2	3	**1.50**	**1.38**	3
Taxiway lighting	3	0	0	0	0	3	0	2	3	2	2	3	**1.50**	**1.38**	3
Taxiway pavement conditions	3	0	0	0	0	3	0	2	3	2	2	3	**1.50**	**1.38**	3
Public land survey system	3	0	3	3	3	3	0	1	3	0	2	1	**1.83**	**1.33**	3
Sewer system expansion plans	3	0	0	3	0	3	0	0	3	3	2	2	**1.58**	**1.33**	3
Water system expansion plans	3	0	0	3	0	3	0	0	3	3	2	2	**1.58**	**1.33**	3
Aircraft limitations	3	0	0	0	0	3	0	2	3	1	2	3	**1.42**	**1.29**	3
Domestic vs. international service	3	0	0	0	0	3	0	0	3	3	2	3	**1.42**	**1.29**	3
Hangar	3	0	0	0	0	3	0	2	3	1	2	3	**1.42**	**1.29**	3
Land use and planning designation	3	0	0	0	0	3	0	1	3	2	2	3	**1.42**	**1.29**	3
Medical facilities	3	0	0	0	0	3	0	0	3	3	2	3	**1.42**	**1.29**	3
Photographs	3	0	0	0	0	3	0	3	3	3	2	0	**1.42**	**1.29**	3
Road construction/maintenance status	3	0	3	3	0	3	0	0	3	1	2	2	**1.67**	**1.29**	3
Runway Protection Zones (RPZ's)	3	0	0	0	0	3	0	1	3	2	2	3	**1.42**	**1.29**	3
Runway signage	3	0	0	0	0	3	0	1	3	2	2	3	**1.42**	**1.29**	3
Safety records	3	0	0	0	0	3	0	2	3	2	2	2	**1.42**	**1.29**	3
Taxiway pavement design	3	0	0	0	0	3	0	1	3	2	2	3	**1.42**	**1.29**	3

Work Group	MIS				P&PSC			AD				FAA			
Interviewee	F.A.	D.D.	G.S.	C.K.	R.C.	A.A.	C.S.	B.H.	M.M.	J.M.	N.L	J.C.	**Avg.**	**Wt. Avg.**	**Final Score**
Weighting	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**1**	**1**	**1**	**1**	**1**	**1**	**1**			
Storm water system expansion plans	3	0	0	3	0	3	0	0	3	2	2	2	**1.50**	**1.25**	3
Surface access	3	0	0	3	0	3	0	1	3	3	2	0	**1.50**	**1.25**	3
Apron lighting	3	0	0	0	0	3	0	0	3	2	2	3	**1.33**	**1.21**	3
Economic development potential	3	0	0	0	0	3	0	2	3	2	2	1	**1.33**	**1.21**	3
Electric utility plans	3	0	3	3	0	3	0	0	3	1	2	1	**1.58**	**1.21**	3
Natural gas utility plans	3	0	3	3	0	3	0	0	3	1	2	1	**1.58**	**1.21**	3
Noise exposure	3	0	0	0	0	3	0	2	3	0	2	3	**1.33**	**1.21**	3
Pilot registration	3	0	0	0	0	3	0	1	3	1	2	3	**1.33**	**1.21**	3
Seaplane activities	3	0	0	0	0	3	0	0	3	2	2	3	**1.33**	**1.21**	3
Sewer utility records	3	0	3	3	0	3	0	0	3	1	2	1	**1.58**	**1.21**	3
Storm water data	3	0	3	3	0	3	0	0	3	1	2	1	**1.58**	**1.21**	3
Taxiway signage	3	0	0	0	0	3	0	0	3	2	2	3	**1.33**	**1.21**	3
Telephone utility plans	3	0	3	3	0	3	0	0	3	1	2	1	**1.58**	**1.21**	3
Water utility records	3	0	3	3	0	3	0	0	3	1	2	1	**1.58**	**1.21**	3
Geodetic control	3	0	3	3	3	3	0	0	3	0	2	0	**1.67**	**1.17**	3
Parking	3	0	3	0	0	3	0	2	3	1	2	0	**1.42**	**1.17**	3
Aircraft data	3	0	0	0	0	3	0	2	3	2	2	0	**1.25**	**1.13**	3
Apron tie-downs	3	0	0	0	0	3	0	0	3	1	2	3	**1.25**	**1.13**	3
Demographics	3	0	0	0	0	3	0	0	3	1	2	3	**1.25**	**1.13**	3
Major employers	3	0	0	0	0	3	0	0	3	2	2	2	**1.25**	**1.13**	3
Mean/max temperatures	3	0	0	0	0	3	0	0	3	1	2	3	**1.25**	**1.13**	3
Off-airport property boundaries	3	0	0	0	0	3	0	2	3	2	2	0	**1.25**	**1.13**	3
On-airport leasehold locations	3	0	0	0	0	3	0	0	3	1	2	3	**1.25**	**1.13**	3
On-airport leasehold terms	3	0	0	0	0	3	0	0	3	1	2	3	**1.25**	**1.13**	3
Providers of services (list)	3	0	0	0	0	3	0	2	3	1	2	1	**1.25**	**1.13**	3
Security	3	0	0	0	0	3	0	0	3	1	2	3	**1.25**	**1.13**	3
Terminal	3	0	0	0	0	3	0	2	3	2	2	0	**1.25**	**1.13**	3
Hazardous and toxic materials storage	3	0	0	0	0	3	0	0	3	3	2	0	**1.17**	**1.04**	3
Property management rate/charges	3	0	0	0	0	3	0	0	3	1	2	2	**1.17**	**1.04**	3
Public facilities	3	0	0	0	0	3	0	2	3	1	2	0	**1.17**	**1.04**	3
Airport Signage	0	0	0	0	0	0	0	0	3	0	0	0	**0.25**	**0.25**	1
Photos of approach, obliques, pavement	0	0	0	0	0	0	0	0	0	0	0	2	**0.17**	**0.17**	1
Category Score															3
Potential Products Analysis-Patterns, Trends															
Noise exposure	0	0	3	0	0	3	0	1	3	3	3	2	**1.50**	**1.38**	3
ALPs	0	0	0	0	0	3	0	1	3	2	3	3	**1.25**	**1.25**	3
Average daily traffic	0	0	3	0	0	3	0	0	3	3	3	1	**1.33**	**1.21**	3
Pavement replacement	0	0	3	0	0	3	0	0	3	3	0	0	**1.00**	**0.88**	2
Economic development potential	0	0	0	0	0	0	0	0	3	2	3	2	**0.83**	**0.83**	2
Statewide significance	0	0	0	0	0	0	0	1	3	3	3	0	**0.83**	**0.83**	2
Aircraft registrations	0	0	0	0	0	0	0	1	3	1	3	0	**0.67**	**0.67**	2
National significance	0	0	0	0	0	0	0	0	3	2	3	0	**0.67**	**0.67**	2
Budget / fund distributions	0	0	3	0	0	0	0	0	3	3	0	0	**0.75**	**0.63**	2
Transit ridership	0	0	0	0	0	3	0	0	3	1	0	0	**0.58**	**0.58**	1
Demographic distribution	0	0	0	0	0	0	0	0	3	3	0	0	**0.50**	**0.50**	1
Regulations	0	0	0	0	0	0	0	1	3	2	0	0	**0.50**	**0.50**	1
Routing	0	0	0	0	0	0	0	0	3	3	0	0	**0.50**	**0.50**	1
Maintenance/repair	0	0	0	0	0	0	0	0	3	0	0	2	**0.42**	**0.42**	1
Administrative notification	0	0	0	0	0	0	0	0	3	0	0	1	**0.33**	**0.33**	1
Business licenses	0	0	0	0	0	0	0	0	3	0	0	1	**0.33**	**0.33**	1
Complaints	0	0	0	0	0	0	0	0	3	0	0	1	**0.33**	**0.33**	1
Infrastructure failures	0	0	0	0	0	0	0	0	3	0	0	1	**0.33**	**0.33**	1
International agreements	0	0	0	0	0	0	0	0	3	1	0	0	**0.33**	**0.33**	1
Socio-political distribution	0	0	0	0	0	0	0	0	3	1	0	0	**0.33**	**0.33**	1
Users of public services	0	0	0	0	0	0	0	0	3	0	0	1	**0.33**	**0.33**	1
Compliance AIP	0	0	0	0	0	0	0	0	0	0	0	3	**0.25**	**0.25**	1
Safety areas	0	0	0	0	0	0	0	0	0	0	0	3	**0.25**	**0.25**	1

Work Group	MIS				P&PSC			AD				FAA			
Interviewee	F.A.	D.D.	G.S.	C.K.	R.C.	A.A.	C.S.	B.H.	M.M.	J.M.	N.L	J.C.	**Avg.**	**Wt.**	**Final**
Weighting	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**1**	**1**	**1**	**1**	**1**	**1**	**1**		**Avg.**	**Score**
Scheduling	0	0	0	0	0	0	0	0	3	0	0	0	**0.25**	**0.25**	1
Accidents	0	0	0	3	0	0	0	0	0	0	0	0	**0.25**	**0.13**	1
Bridges	0	0	0	3	0	0	0	0	0	0	0	0	**0.25**	**0.13**	1
Pit sites	0	0	0	3	0	0	0	0	0	0	0	0	**0.25**	**0.13**	1
Projects (construction)	0	0	0	3	0	0	0	0	0	0	0	0	**0.25**	**0.13**	1
Category Score															**1**
Potential Products Analysis-Models															
Emergency management	0	0	0	0	0	3	0	2	3	2	3	2	**1.25**	**1.25**	3
Financing alternatives	0	0	0	0	0	0	0	0	3	3	3	3	**1.00**	**1.00**	2
Population projection impacts	0	0	0	0	0	0	0	1	3	2	3	3	**1.00**	**1.00**	2
Airport expansions	0	0	0	0	0	0	0	1	3	2	3	2	**0.92**	**0.92**	2
Infrastructure financing	0	0	0	0	0	0	0	0	3	2	3	3	**0.92**	**0.92**	2
Noise quality	0	0	0	0	0	0	0	0	3	3	3	2	**0.92**	**0.92**	2
Regional transportation impacts	0	0	0	0	0	0	0	0	3	3	3	2	**0.92**	**0.92**	2
Airport closures	0	0	0	0	0	0	0	1	3	1	3	2	**0.83**	**0.83**	2
Police/fire/ambulance resp routing	0	0	0	0	0	0	0	0	3	2	3	1	**0.75**	**0.75**	2
Suitability analysis	0	0	0	0	0	0	0	0	3	1	3	1	**0.67**	**0.67**	2
Input data for external models	0	0	0	0	0	0	0	0	3	1	0	3	**0.58**	**0.58**	2
Utility system network analysis	0	0	0	0	0	0	0	0	3	1	0	1	**0.42**	**0.42**	2
Balancing of field crew workloads	0	0	0	0	0	0	0	0	3	0	0	1	**0.33**	**0.33**	1
Employment	0	0	0	0	0	0	0	0	3	0	0	1	**0.33**	**0.33**	1
Routing service vehicles/inspectors	0	0	0	0	0	0	0	0	3	0	0	1	**0.33**	**0.33**	1
Priority array	0	0	0	3	0	0	0	0	0	0	0	0	**0.25**	**0.13**	1
Category Score															**2**

Work Group	MIS				P&PSC			AD				FAA			
Interviewee	F.A.	D.D.	G.S.	C.K.	R.C.	A.A.	C.S.	B.H.	M.M.	J.M.	N.L	J.C.	Avg.	Wt. Avg.	Final Score
Weighting	0.5	0.5	0.5	0.5	0.5	1	1	1	1	1	1	1			
GRAPHICAL DATA CONTENT															
Basic Control Data															
ARP (Airport Reference Point)	0	0	0	0	0	3	0	0	3	3	3	3	**1.25**	**1.25**	3
Horizontal geodetic points	0	0	0	0	0	0	0	0	3	3	3	0	**0.75**	**0.75**	2
Local bench marks	0	0	0	0	0	0	0	0	3	3	3	0	**0.75**	**0.75**	2
Local horizontal control point	0	0	0	0	0	0	0	0	3	3	3	0	**0.75**	**0.75**	2
Local horizontal control traverse	0	0	0	0	0	0	0	0	3	3	3	0	**0.75**	**0.75**	2
Vertical geodetic points	0	0	0	0	0	0	0	0	3	3	3	0	**0.75**	**0.75**	2
Category Score															**2**
Landing and Navigation Aids															
Air traffic control tower	0	0	0	0	0	3	0	1	3	3	3	3	**1.33**	**1.33**	3
Approach lighting system	0	0	0	0	0	3	0	1	3	3	3	3	**1.33**	**1.33**	3
Instrument approach	0	0	0	0	0	3	0	2	3	2	3	3	**1.33**	**1.33**	3
Rotating beacon	0	0	0	0	0	3	0	1	3	3	3	3	**1.33**	**1.33**	3
Visual Approach	0	0	0	0	0	3	0	0	0	0	0	3	**0.50**	**0.50**	1
Category Score															**3**
Land Ownership Data															
Right-of-ways	0	0	0	0	0	0	0	2	2	3	3	1	**0.92**	**0.92**	2
Easements	0	0	0	0	0	0	0	1	2	3	3	1	**0.83**	**0.83**	2
Section corners	0	0	0	0	0	3	0	1	2	0	3	0	**0.75**	**0.75**	2
Subdivisions	0	0	0	0	0	0	0	1	2	3	3	0	**0.75**	**0.75**	2
Lots	0	0	0	0	0	0	0	1	2	2	3	0	**0.67**	**0.67**	2
Parcels	0	0	0	0	0	0	0	1	2	2	3	0	**0.67**	**0.67**	2
Quarter section corners	0	0	0	0	0	0	0	1	2	0	3	0	**0.50**	**0.50**	1
Sixteenth section corners	0	0	0	0	0	0	0	1	2	0	3	0	**0.50**	**0.50**	1
Townships	0	0	0	0	0	0	0	1	2	0	3	0	**0.50**	**0.50**	1
Category Score															**2**
Topographic Features															
Contours	0	0	0	0	0	3	0	1	3	3	3	3	**1.33**	**1.33**	3
Spot elevations	0	0	0	0	0	0	0	1	3	3	3	3	**1.08**	**1.08**	3
Wooded areas	0	0	0	0	0	0	0	1	3	3	3	3	**1.08**	**1.08**	3
Rivers, creeks, streams	0	0	0	0	0	0	0	0	3	3	3	3	**1.00**	**1.00**	2
Drainage basins	0	0	0	0	0	0	0	0	3	2	3	3	**0.92**	**0.92**	2
Gravel Pits	0	0	0	0	0	0	0	1	3	1	3	3	**0.92**	**0.92**	2
Wetlands	0	0	0	0	0	0	0	0	3	2	3	3	**0.92**	**0.92**	2
Geology	0	0	0	0	0	0	0	0	3	1	3	3	**0.83**	**0.83**	2
Soils	0	0	0	0	0	0	0	0	3	1	3	3	**0.83**	**0.83**	2
Individual trees	0	0	0	0	0	0	0	0	3	3	3	0	**0.75**	**0.75**	2
Landfills	0	0	0	0	0	0	0	0	0	0	0	3	**0.25**	**0.25**	1
Category Score															**2**
General Boundaries															
Airport boundary	0	0	0	0	0	3	0	2	3	3	3	3	**1.42**	**1.42**	3
Airspace boundaries	0	0	0	0	0	3	0	2	3	3	3	3	**1.42**	**1.42**	3
Land use zones	0	0	2	0	0	3	0	1	3	3	3	3	**1.50**	**1.42**	3
Aircraft altitude (noise) requirements	0	0	0	0	0	3	0	1	3	3	3	3	**1.33**	**1.33**	3
Flood zones	0	0	2	0	0	3	0	0	3	3	3	3	**1.42**	**1.33**	3
City limits	0	0	2	0	0	3	0	0	3	2	3	3	**1.33**	**1.25**	3
County limits	0	0	2	0	0	3	0	0	3	1	3	3	**1.25**	**1.17**	3
Air pollution areas	0	0	0	0	0	0	0	0	3	3	3	3	**1.00**	**1.00**	2
Historic areas	0	0	2	0	0	0	0	0	3	1	3	3	**1.00**	**0.92**	2
City neighborhoods	0	0	0	0	0	0	0	0	3	2	3	2	**0.83**	**0.83**	2
Comprehensive planning areas	0	0	0	0	0	0	0	0	3	3	3	1	**0.83**	**0.83**	2
Park lands	0	0	0	0	0	0	0	0	3	1	3	3	**0.83**	**0.83**	2
School districts	0	0	0	0	0	0	0	0	3	3	3	1	**0.83**	**0.83**	2

Work Group	MIS				P&PSC			AD				FAA			
Interviewee	F.A.	D.D.	G.S.	C.K.	R.C.	A.A.	C.S.	B.H.	M.M.	J.M.	N.L	J.C.	**Avg.**	**Wt. Avg.**	**Final Score**
Weighting	0.5	0.5	0.5	0.5	0.5	1	1	1	1	1	1	1			
Utility planning/management areas	0	0	0	0	0	0	0	0	3	3	3	1	0.83	0.83	2
Annexed areas	0	0	0	0	0	0	0	0	3	1	3	2	0.75	0.75	2
Redevelopment districts	0	0	0	0	0	0	0	0	3	1	3	2	0.75	0.75	2
Homeowner's associations	0	0	0	0	0	0	0	0	3	1	3	1	0.67	0.67	2
Special assessment areas	0	0	0	0	0	0	0	0	3	1	3	1	0.67	0.67	2
Utility franchise areas	0	0	2	0	0	0	0	0	3	0	3	1	0.75	0.67	2
Environmental inspection districts	0	0	0	0	0	0	0	0	1	1	3	2	0.58	0.58	2
Park districts	0	0	0	0	0	0	0	0	3	1	3	0	0.58	0.58	2
Utility maintenance districts	0	0	0	0	0	0	0	0	3	0	3	1	0.58	0.58	2
Urban Growth Boundaries	0	0	0	0	0	0	0	0	3	0	0	2	0.42	0.42	1
Category Score															**2**
Transportation															
On-airport															
Heli-pads	0	0	0	0	0	3	0	2	3	3	3	3	1.42	1.42	3
Pavement	0	0	0	0	0	3	0	1	3	3	3	2	1.25	1.25	3
Public right-of-way	0	0	0	0	0	3	0	1	3	3	3	2	1.25	1.25	3
Paint striping	0	0	0	0	0	3	0	1	2	3	3	2	1.17	1.17	3
Parking lots	0	0	0	0	0	3	0	0	2	2	3	3	1.08	1.08	3
Bridges	0	0	0	0	0	0	0	0	2	2	3	3	0.83	0.83	2
Sound barriers	0	0	0	0	0	0	0	0	0	3	3	3	0.75	0.75	2
Traffic signs	0	0	0	0	0	3	0	0	3	1	0	2	0.75	0.75	2
Tunnels	0	0	0	0	0	0	0	0	2	1	3	3	0.75	0.75	2
Bikeways	0	0	0	0	0	0	0	0	2	1	0	2	0.42	0.42	1
Street lights	0	0	0	0	0	0	0	0	2	1	0	2	0.42	0.42	1
Traffic lights	0	0	0	0	0	0	0	0	2	1	0	2	0.42	0.42	1
Category Score															**2**
Off-airport															
Airports	0	0	2	0	0	3	0	2	3	3	2	3	1.50	1.42	3
Heli-pads	0	0	2	0	0	3	0	2	3	3	2	3	1.50	1.42	3
Public right-of-way	0	0	2	0	0	3	0	1	3	3	2	2	1.33	1.25	3
Railroads	0	0	2	0	0	3	0	0	3	2	2	3	1.25	1.17	3
Bus routes	0	0	2	0	0	0	0	0	3	3	2	2	1.00	0.92	2
Billboards	0	0	2	0	0	2	0	0	3	0	2	2	0.92	0.83	2
Commercial signs	0	0	2	0	0	2	0	0	3	0	2	2	0.92	0.83	2
Street lights	0	0	2	0	0	2	0	0	3	0	2	2	0.92	0.83	2
Traffic lights	0	0	2	0	0	2	0	0	3	0	2	2	0.92	0.83	2
Traffic signs	0	0	2	0	0	2	0	0	3	0	2	2	0.92	0.83	2
Bridges	0	0	2	0	0	0	0	0	3	0	2	3	0.83	0.75	2
Sound barriers	0	0	2	0	0	0	0	0	3	3	2	0	0.83	0.75	2
Tunnels	0	0	2	0	0	0	0	0	3	0	2	3	0.83	0.75	2
Bikeways	0	0	2	0	0	0	0	0	3	0	2	2	0.75	0.67	2
Bus stops	0	0	2	0	0	0	0	0	3	0	2	2	0.75	0.67	2
Paint striping	0	0	2	0	0	0	0	0	3	0	2	2	0.75	0.67	2
Parking lots	0	0	2	0	0	0	0	0	3	0	2	2	0.75	0.67	2
Pavement	0	0	2	0	0	0	0	0	3	0	2	2	0.75	0.67	2
Category Score															**2**
Utilities															
Power poles	0	0	2	0	0	2	0	0	3	3	2	3	1.25	1.17	3
Electric lines	0	0	2	0	0	2	0	0	3	3	2	2	1.17	1.08	3
Telephone lines	0	0	2	0	0	2	0	0	3	2	2	2	1.08	1.00	2
Natural gas lines	0	0	2	0	0	0	0	0	3	3	2	2	1.00	0.92	2
Television cable lines	0	0	2	0	0	0	0	0	3	0	2	2	0.75	0.67	2
Category Score															**2**

Water Systems

Work Group	MIS				P&PSC			AD				FAA			
Interviewee	F.A.	D.D.	G.S.	C.K.	R.C.	A.A.	C.S.	B.H.	M.M.	J.M.	N.L	J.C.	**Avg.**	**Wt.**	**Final**
Weighting	0.5	0.5	0.5	0.5	0.5	1	1	1	1	1	1	1		**Avg.**	**Score**
Fire hydrants	0	0	2	0	0	0	0	1	3	3	0	2	**0.92**	**0.83**	2
Water main lines	0	0	2	0	0	0	0	0	3	3	0	2	**0.83**	**0.75**	2
Storage tanks	0	0	2	0	0	0	0	0	3	2	0	2	**0.75**	**0.67**	2
Water service connections	0	0	2	0	0	0	0	0	3	2	0	2	**0.75**	**0.67**	2
Meters	0	0	2	0	0	0	0	0	3	0	0	2	**0.58**	**0.50**	1
Reducers,back-flow devices,blow-offs	0	0	2	0	0	0	0	0	3	0	0	2	**0.58**	**0.50**	1
Reservoirs	0	0	2	0	0	0	0	0	3	0	0	2	**0.58**	**0.50**	1
Standpipes	0	0	2	0	0	0	0	0	3	0	0	2	**0.58**	**0.50**	1
Water treatment facilities	0	0	2	0	0	0	0	0	3	0	0	2	**0.58**	**0.50**	1
Water valves	0	0	2	0	0	0	0	0	3	0	0	2	**0.58**	**0.50**	1
Wells	0	0	2	0	0	0	0	0	3	0	0	2	**0.58**	**0.50**	1
Category Score															**1**
Sewer Systems															
Manholes	0	0	2	0	0	0	0	0	3	3	0	2	**0.83**	**0.75**	2
Risers	0	0	2	0	0	0	0	0	3	3	0	2	**0.83**	**0.75**	2
Sewer laterals	0	0	2	0	0	0	0	0	3	3	0	2	**0.83**	**0.75**	2
Sewer lines	0	0	2	0	0	0	0	0	3	3	0	2	**0.83**	**0.75**	2
Standpipes	0	0	2	0	0	0	0	0	3	3	0	2	**0.83**	**0.75**	2
Clean outs	0	0	2	0	0	0	0	0	3	0	0	2	**0.58**	**0.50**	1
Flush tanks	0	0	2	0	0	0	0	0	3	0	0	2	**0.58**	**0.50**	1
Pump / lift stations	0	0	2	0	0	0	0	0	3	0	0	2	**0.58**	**0.50**	1
Separators	0	0	2	0	0	0	0	0	3	0	0	2	**0.58**	**0.50**	1
Sewer treatment facilities	0	0	2	0	0	0	0	0	3	0	0	2	**0.58**	**0.50**	1
Wyes, tees, reducers	0	0	2	0	0	0	0	0	3	0	0	2	**0.58**	**0.50**	1
Category Score															**1**
Storm Water Systems															
Catch basins	0	0	2	0	0	0	0	0	3	3	2	2	**1.00**	**0.92**	2
Main drain lines	0	0	2	0	0	0	0	0	3	3	2	2	**1.00**	**0.92**	2
Open channels	0	0	2	0	0	0	0	0	3	3	2	2	**1.00**	**0.92**	2
Sand / soil traps	0	0	2	0	0	0	0	0	3	3	2	2	**1.00**	**0.92**	2
Culverts	0	0	2	0	0	0	0	0	3	0	2	2	**0.75**	**0.67**	2
Inlets	0	0	2	0	0	0	0	0	3	0	2	2	**0.75**	**0.67**	2
Manholes	0	0	2	0	0	0	0	0	3	0	2	2	**0.75**	**0.67**	2
Outfalls	0	0	2	0	0	0	0	0	3	0	2	2	**0.75**	**0.67**	2
Category Score															**2**
Buildings and Structures															
Aviation obstructions	0	0	0	0	0	3	0	2	3	3	3	3	**1.42**	**1.42**	3
Radio towers	0	0	0	0	0	3	0	2	3	3	3	3	**1.42**	**1.42**	3
Fences	0	0	0	0	0	3	0	1	3	3	3	3	**1.33**	**1.33**	3
Fuel storage	0	0	0	0	0	3	0	1	3	3	3	3	**1.33**	**1.33**	3
Hangars	0	0	0	0	0	3	0	1	3	3	3	3	**1.33**	**1.33**	3
Terminals	0	0	0	0	0	3	0	1	3	3	3	3	**1.33**	**1.33**	3
Convalescent centers	0	0	0	0	0	0	0	0	3	3	3	3	**1.00**	**1.00**	2
Fire stations	0	0	0	0	0	0	0	0	3	3	3	3	**1.00**	**1.00**	2
Hospitals	0	0	0	0	0	0	0	0	3	3	3	3	**1.00**	**1.00**	2
Schools	0	0	0	0	0	0	0	0	3	3	3	3	**1.00**	**1.00**	2
Churches	0	0	0	0	0	0	0	0	3	2	3	3	**0.92**	**0.92**	2
Convention center, stadium, etc.	0	0	0	0	0	0	0	0	3	2	3	3	**0.92**	**0.92**	2
Industrial buildings	0	0	0	0	0	0	0	0	3	3	3	2	**0.92**	**0.92**	2
Police stations	0	0	0	0	0	0	0	0	3	2	3	3	**0.92**	**0.92**	2
Public buildings	0	0	0	0	0	0	0	0	3	3	3	2	**0.92**	**0.92**	2
Residential buildings	0	0	0	0	0	0	0	0	3	3	3	2	**0.92**	**0.92**	2
Smokestacks	0	0	0	0	0	0	0	0	3	3	3	2	**0.92**	**0.92**	2
Commercial buildings	0	0	0	0	0	0	0	0	3	2	3	2	**0.83**	**0.83**	2
Hotels / motels	0	0	0	0	0	0	0	0	3	2	3	2	**0.83**	**0.83**	2

Work Group	MIS				P&PSC			AD				FAA			
Interviewee	**F.A.**	**D.D.**	**G.S.**	**C.K.**	**R.C.**	**A.A.**	**C.S.**	**B.H.**	**M.M.**	**J.M.**	**N.L**	**J.C.**	**Avg.**	**Wt.**	**Final**
Weighting	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**1**	**1**	**1**	**1**	**1**	**1**	**1**		**Avg.**	**Score**
Shopping centers	0	0	0	0	0	0	0	0	3	2	3	2	**0.83**	**0.83**	2
Breakwaters	0	0	0	0	0	0	0	0	3	0	0	2	**0.42**	**0.42**	1
Bulkheads	0	0	0	0	0	0	0	0	3	0	0	2	**0.42**	**0.42**	1
Intrusions into FAR 77 space	0	0	0	0	0	3	0	0	0	0	0	2	**0.42**	**0.42**	1
Piers	0	0	0	0	0	0	0	0	3	0	0	2	**0.42**	**0.42**	1
Retaining walls	0	0	0	0	0	0	0	0	3	0	0	2	**0.42**	**0.42**	1
Category Score															**2**
Miscellaneous															
Flag poles	0	0	0	0	0	0	0	0	3	3	3	0	**0.75**	**0.75**	2
Rookeries	0	0	0	0	0	0	0	0	3	0	3	3	**0.75**	**0.75**	2
Cemeteries	0	0	0	0	0	0	0	0	3	0	0	3	**0.50**	**0.50**	1
Golf courses	0	0	0	0	0	0	0	0	3	0	0	0	**0.25**	**0.25**	1
Category Score															**2**

APPENDIX C

PROJECT PARTICIPANTS

APPENDIX C

PROJECT PARTICIPANTS

Name	Phone	Interview	Division
Frans Arnold	705-7608	24-May	WSDOT - MIS
Nancy Abraham	705-7606	24-May	WSDOT - MIS
Deea Niemi	705-6817	24-May	WSDOT - MIS
Jane Koura	705-7686	24-May	WSDOT - MIS
David Sheibe	705-7601	24-May	WSDOT - MIS
Brian Holmes	443-4131	Unavailable	WSDOT - AD
Dennis DeFries	705-7707	1-Jun	WSDOT - MIS
George Spencer	705-7612	1-Jun	WSDOT - MIS
Clint Kaku	705-7647	1-Jun	WSDOT - MIS
Ron Cihon	705-7036	3-Jun	WSDOT - P&PSC
Jim Michal	705-7116	3-Jun	WSDOT - P&PSC
Amy Arnis	705-7923	6-Jun	WSDOT - P&PSC
Ralph Roderick	SICK	Sick	WSDOT - P&PSC
Carla Sawyer	705-7972	6-Jun	WSDOT - P&PSC
John Doyle	705-7932	6-Jun	WSDOT - P&PSC
M.J. McIver	443-4131	16-Jun	WSDOT - AD
Julie Mercer	705-7961	16-Jun	WSDOT - AD
Newell Lee	443-4131	16-Jun	WSDOT - AD
John Current	227-2236	30-Jun	FAA
Stan Allison		1-July	W&H Pacific, Inc.