

Transportation Asset Management Case Studies

Presented by

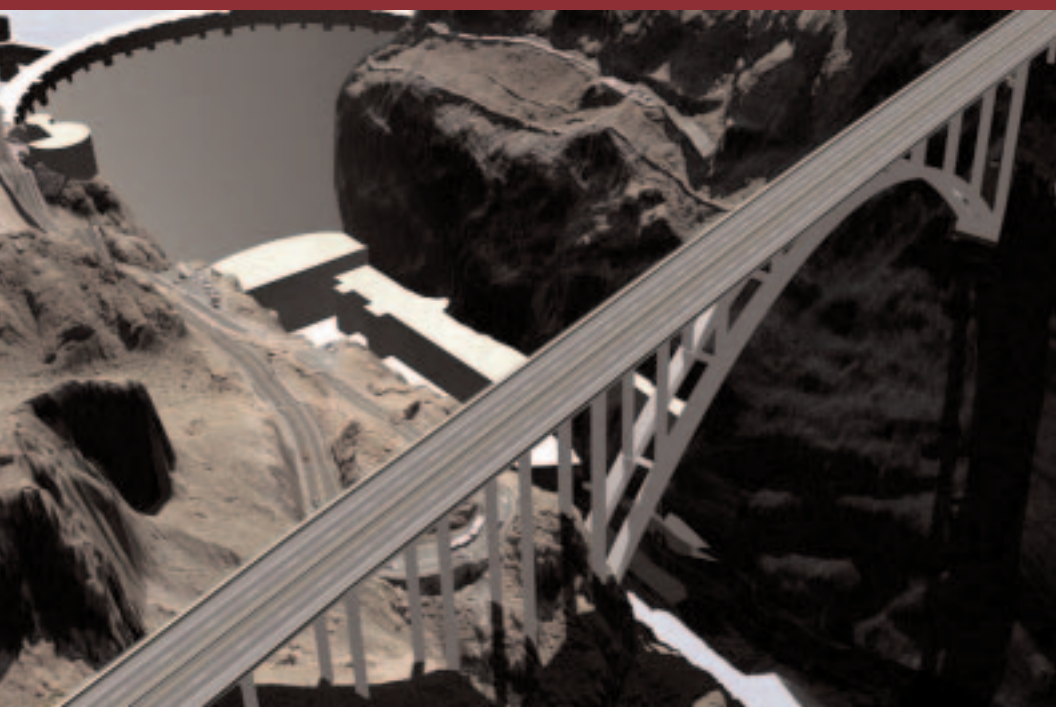


U.S. Department
of Transportation
**Federal Highway
Administration**

D A T A I N T E G R A T I O N

The Arizona Experience





Note From the Director

The Federal Highway Administration Office of Asset Management is aggressively promoting a different way for transportation agencies to distribute their resources among alternative investment options. This new way of doing business, referred to as "Asset Management," is a strategic approach to maximizing the benefits resulting from the expenditure of agency resources.

For any transportation agency, the progression toward effective Asset Management practices will involve a range of activities. These endeavors will differ from State to State. For example, some agencies will pursue a data integration strategy in order to ensure comparable data for the evaluation of investment alternatives across different asset classes. Others will move to deploy economic analysis tools to generate fact-based information for decision-makers. Still others will want to integrate new inventory assessment methods into their decisionmaking processes.

Much can be learned from those who are readying their organizations for Asset Management. To spark the exchange of information, we initiated a series of case studies last year, focused on agencies that are leading the way. The series involves four tracks: data integration, economics in Asset Management, the Highway Economic Requirements System–State Version, and life-cycle cost analysis. Through the years, we will add new State reports to each of the tracks and create new tracks addressing other facets of Asset Management, such as change management and performance measurement.

On behalf of the Office of Asset Management, I am pleased to add this case study on data integration to the series. We believe the case studies will help agencies meet the challenges of implementing Asset Management programs.



David R. Geiger
Director, Office of Asset Management
May 2004

Note to the Reader

The Transportation Asset Management Case Study Series is the result of a partnership between State departments of transportation and the Federal Highway Administration (FHWA) Office of Asset Management. FHWA provides the forum in which to share information, and the individual States provide the details of their experiences. For each case study report, FHWA interviewed State transportation staff, and the resulting material was approved by the State. As such, the reports rely on the agencies' own assessment of their experience. Readers should note that the reported results may or may not be reproducible in other organizations. ■



SR 69 approaching Prescott

Executive Summary

Arizona is one of the fastest growing States in the country. This rapid population growth is driving an ever-increasing demand for transportation infrastructure and services. In response, the Arizona Department of Transportation (ADOT) undertook several initiatives to improve its business practices. ADOT knew that an integrated information system would be critical to fully implement the improvements—a system that would enable agency staff to assemble and analyze data from multiple sources in seconds.

At the heart of the agency's data integration initiative is the ADOT Information Data Warehouse (AIDW). ADOT believes that the data warehouse concept is the fastest and least expensive way to integrate data from its existing systems. Existing management systems and databases will continue to be the agency's official data sources. However, the data in these systems will be extracted periodically, referenced using a common geographic referencing system, and stored in the AIDW. Users will access the integrated data using online tools.

The data integration effort has faced technical, cultural, and business process challenges. Pulling data from many sources into one repository exposes quality issues that must be resolved and data disconnects that must be fixed at the source. To solve these problems, ADOT's overall approach addresses cultural and process issues concurrently with technological change.

The data warehouse is critical to future infrastructure management practices: improving the availability of timely and accurate information will help ADOT offset the loss of experienced transportation personnel that is predicted to occur over the next few years. As younger staff are tasked with meeting the demands of a growing population, information and technology will replace experience and precedent as the bases for important decisions.

ADOT has already added several types of data to the AIDW, including pavement and bridge data, project expenditures, photo logs, accident data, and as-built engineering drawings. Over the next several years, ADOT plans to add a new data source every three to four months. This incremental approach will enable ADOT to produce results and benefits quickly and often. ■

ADOT believes that the data warehouse concept represents the fastest and cheapest way to integrate data from its existing management systems.

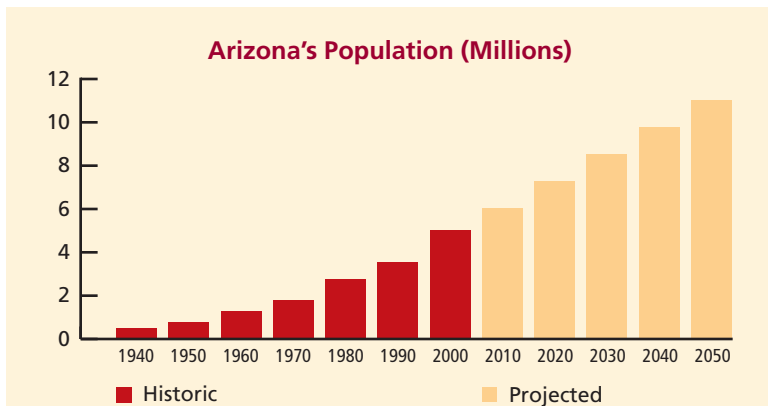
AGENCY FACTS

Arizona's transportation needs are shaped largely by its rapid growth: it is one of the fastest growing States in the country. Population grew from 250,000 in 1950 to more than 5 million in 2000, and is expected to exceed 10 million by 2040. Growth has been supported by strong economic conditions, with more than 70,000 new jobs created annually between 1990 and 2000.

The transportation network supporting this growth consists of these facilities:

- 58,000 miles of roadway (12 percent owned by ADOT)
- 6,474 bridges (67 percent owned by ADOT)
- 4 urban public transportation systems
- 1,909 route-miles of railroad track
- 83 public-use airports
- More than 2,000 miles of State highways suitable for bicycle travel
- 10 major highway-to-rail intermodal freight facilities
- 6 ports of entry from Mexico

Arizona's dry and mild climate has aided ADOT's efforts to maintain the condition of its existing assets. Ninety-nine percent of the interstate system and 79 percent of all state-owned roads are in good or excellent condition. Optimal preservation strategies, such as preventive maintenance, are difficult to sell politically when little deterioration is evident and



Source: U.S. Census Bureau and *MoveAZ Plan Phase I Report* (Cambridge Systematics, Inc., Lima & Associates, et. al., 2002).

capacity needs are perceived to be more pressing. Nearly 65 percent of ADOT's annual construction budget of roughly \$570 million is allocated to system improvement projects.

Almost two-thirds of Arizona's population live in metropolitan Phoenix, with more than 70 percent of jobs in the metropolitan area and 15 percent in metropolitan Tucson. This urban concentration creates pressure for ADOT to address "fair share" issues when attempting to consider rural needs and maintain a statewide transportation perspective.

SETTING THE STAGE

What Does ADOT Have?

ADOT has made significant information technology (IT) investments in data, systems, and related infrastructure. It has eight key types of IT systems:

- Highway performance monitoring system
- Pavement management system
- Bridge inventory and bridge management systems
- Suite of maintenance management tools
- Suite of safety management systems
- Construction management system
- Project and resource management systems
- Financial management systems

These systems have been developed largely independently of one another, using a variety of software platforms and in the absence of agency-wide standards. ADOT staff have augmented this suite of IT tools with several personal files, such as databases and spreadsheets.

ADOT's systems and databases are populated with a wide range of data collected through its day-to-day operations. Recent studies have found that additional data items are not required. Rather, ADOT's greatest needs are to fix existing data, bring them together, and better disseminate integrated information. For example, data residing in personal files are often not readily available to other staff. Also, combining data from incompatible systems often requires significant data manipulation. Therefore, locating, requesting, formatting, and assembling data from different systems can take days, weeks, or even months. Even after all of these efforts, data inaccuracies diminish confidence in the results.

What Does ADOT Want?

ADOT has recently undertaken several initiatives to improve its business practices. The objectives of these efforts include showing accountability for the stewardship of public funds, basing more decisions on performance, and improving the efficiency, effectiveness, and alignment of all DOT operations.

- **Long-range planning process.** ADOT is updating its long-range planning process, making it performance-based to address issues across modes. This effort will produce an updated, multimodal transportation plan; several items that support other resource allocation processes, such as performance measures and targets; and documented linkages with ADOT's capital programming process.
- **Improved capital programming process.** Although identified as a priority, comprehensive improvements to ADOT's capital programming process are unlikely in the near future. However, to stay current with its improved long-range planning process, the department has developed an interim process for selecting projects and building capital programs.
- **Transportation Asset Management.** ADOT has developed an implementation plan for a Transportation Infrastructure Asset Management System. The plan provides recommendations for improving current business practices through the application of Asset Management principles (e.g., policy-driven, performance-based, long-term view, tradeoff analyses, availability of quality data). Together with ongoing planning and programming initiatives, this plan provides a unique opportunity for ADOT to refocus its entire resource allocation process on a consistent, integrated performance basis.
- **Governmental Accounting Standards Board Statement 34 (GASB 34).** ADOT has successfully undertaken the modified approach to GASB 34 reporting. The modified approach requires agencies to define performance measures and tie performance expectations to anticipated funding levels. The department's work in this area provides a model for developing policy objectives and performance targets through its broader Asset Management initiatives.

ADOT's greatest data needs are to fix existing data, bring them together, and better disseminate integrated information.

- **Program delivery.** ADOT is evaluating its project budgeting, accounting, and program delivery processes. This evaluation complements ADOT's resource allocation initiatives by focusing on improvements to the transparency of program commitments and expenditures, financial accountability, and the availability of financial information.

ADOT has long realized that an integrated information system is critical for full implementation of the improved business practices. Such a system would become a one-stop shop for providing accurate information to all internal and external decisionmakers. The system would enable staff to assemble and analyze data from multiple sources quickly.

HOW IS ADOT GETTING THERE?

Overall Approach

The challenges faced during ADOT's data integration efforts have come equally from three areas: technical, cultural, and business process. Simply pulling data from many sources into one repository does not work—quality issues must be addressed and data disconnects must be fixed at the source. To address these root problems, ADOT's overall approach to data integration contains elements in each of three areas.

- **Technical.** ADOT's vision of data integration is a one-stop shop that makes reliable information available to all data customers, internal and external. The agency believes that the data warehouse concept represents the fastest and cheapest way to achieve this vision, as opposed to rewriting existing management systems. In its system development, ADOT is focusing on incremental steps that show results and benefits quickly and often.
- **Cultural.** By adopting the principles of information resource management, ADOT is working to establish an agency-wide data culture. This cultural view is that data are valuable and that strategic resources need to be managed in the same fashion as human resources and capital assets. It stresses that data needs must be driven by business process needs. Clear ownership of data items must be assigned, and owners must be fully accountable for meeting data standards. Adequate financial and human resources must be allocated for data collection and management. In this context, the ADOT Information Data

Users will be able to obtain information from the data warehouse using an online interface or geographic information system tools.

Warehouse (AIDW) is viewed as one tool under the information resource management umbrella.

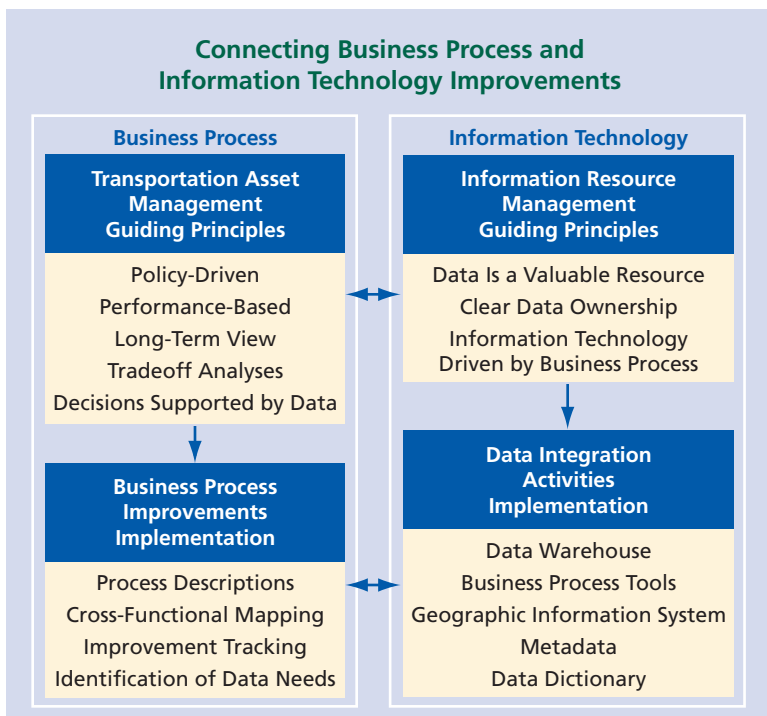
- **Business process.** Data disconnects are symptoms of business processes that are less than optimal. Streamlined business

processes uplift an organization's performance and result in good information flow. In pursuit of this goal, ADOT is completing a six-month business process improvement project. The project objective is to map the existing business processes from planning to maintenance. The project will address project scoping, priority programming, five-year plan update, design and pre-construction, construction, maintenance, program budgeting, project accounting, and contract accounting. For each process, ADOT is developing a process description, a linear flow-chart, a cross-functional chart, and an information-use matrix. The matrix, which will map information use across business processes, will serve as the basis for data enhancements.

The success of ADOT's data integration efforts will be measured by the ability of IT resources to support improved business practices. As illustrated on page 9, ADOT has formally established the relationship between business process and IT improvements at both the strategic and tactical levels.

Technical Approach

ADOT will continue to collect, store, and manage core data sets with various management systems and databases throughout the agency. These systems will continue to be the official sources of agency data, and system administrators will continue to be the data "owners." Periodically data from the systems will be extracted, referenced using a common geographic referencing system, and stored in a series of operational data stores. Data stores are databases that contain processed data that can be fed back to other management systems or to a series of data marts. Data marts are subsets of the database. They differ from data stores in that they are structured for queries, what-if analysis, and analytical processing. Data marts also share the same architecture so that users can "drill across" them and access and analyze data from multiple marts (see sidebar, page 10).

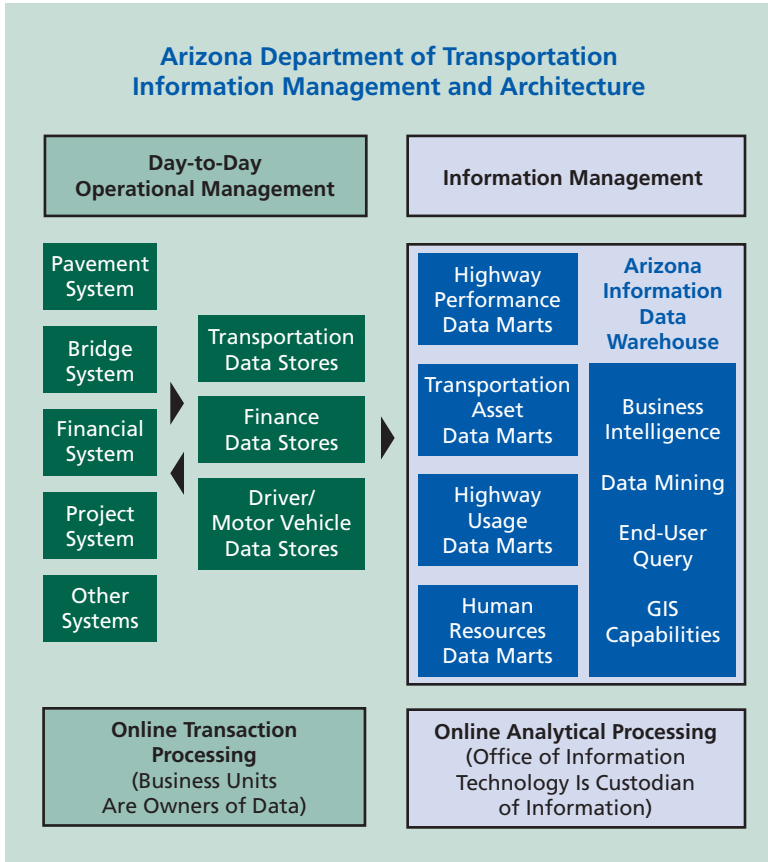


Taken as a whole, the data marts represent the core of the ADOT Information Data Warehouse (AIDW). The AIDW will be an online analytical processing system that serves as a read-only repository of information. The system will use a Windows 2000 Server and SQL Server 2000. Microsoft's Analysis Services and Data Transformation Services (both of which are components of SQL Server 2000) will provide online analytical processing capabilities.

Initially users will have access to the AIDW through ADOT's intranet. ESRI's ArcIMS and ArcSDE (Spatial Database Engine) software will provide an agency-wide geographic information systems (GIS) solution for performing queries and viewing results without requiring users to store large shape files locally.

ADOT is also developing a series of business intelligence tools to enable users with little or no technical training to readily access integrated

data. Users will be able to query data with an online interface or GIS with point-and-click and drag-and-drop query capabilities. Users will be able to retrieve summary data or drill across the data marts to get information on projects, traffic, accidents, features, maintenance history, and other items at any given milepost.



Linear Referencing System

In July 2000, ADOT adopted its Transportation Planning Division's Arizona Transportation Information System as the standard centerline mapping system. This system uses a spatially referenced data layer containing information on 80 percent of all public roads in Arizona. It also uses a location referencing system that enables any data with a latitude and longitude or route and milepost component to be easily mapped. Significant work is still needed to ensure that location is validated for every record in each database. ADOT's data warehouse will use this standard referencing system as the basis for integrating data from various sources.

IS IT WORTH IT?

Improving the availability of timely and accurate information is imperative for ADOT's future infrastructure management practices to offset the staffing shortage that is predicted throughout the agency over the next few years. As younger staff are tasked with meeting the demands of a growing population, experience and precedence will be replaced by information and technology as the bases for important decisions.

The sole purpose of the AIDW is to "deliver the right information in the right amount to the right people at the right time." When fully implemented, the AIDW will provide ADOT, its planning partners, and the Arizona legislature the ability to answer questions like these:

- How much money was spent in a county for pavement preservation in the past two years?
- What was the impact on congestion of opening a major loop segment?
- What was the total cost of widening a corridor?
- What was the total cost of scope changes made during implementation of the capital program?
- How much money has been spent on studies and pre-design work for projects that were not implemented?

The ability to answer these types of questions will enable ADOT to

ADOT's data warehouse will deliver the right information in the right amount to the right person at the right time.

defend transportation budgets and communicate consequences, measure and monitor business practices and proactively address problems, align business practices with agency goals and objectives, and make more efficient and effective resource allocation decisions.

WHAT HAS ADOT LEARNED?

Organizational Lessons

- Data ownership and accountability play a key role in ADOT's data integration efforts. To this end, AIDW staff have worked to help operational units (e.g., planners and engineers) understand that they own the data they collect and are responsible for its integrity. IT staff are merely custodians of the data, and the data warehouse merely a tool with which to access the data.
- Strong partnerships between IT staff and agency practitioners are required for a successful agency-wide IT initiative. In some cases, IT efforts motivate reluctant practitioners to change. In other cases, the practitioners want to move forward quickly and need to be restrained by IT staff to insure consistency with an overall strategy.



Navajo Bridge; US 89-A crossing the Colorado River at Marble Canyon, Coconino County

- A strong mandate for a comprehensive data integration initiative from above is unlikely to happen. Bottom-up desire is usually strong but can be uncoordinated, particularly across divisions, and by itself cannot provide the impetus for moving forward. A critical success factor is a carefully blended mix. Management support is required to ensure that the appropriate tools and resources are available. Bottom-up support is required so that a regression does not occur when the current management leaves.

Process Lessons

- ADOT's success to date is largely due to its focus on delivery. AIDW staff strive to add a data source to the warehouse every three to four months, so they are not seen as only talking about what is possible. It is important to augment a vision and architecture with practical progress.
- When beginning a data integration initiative, there may be a strong urge to build the metadata (data about data) and data dictionary layer first. ADOT has learned that this approach does not bring practical value quickly and may cause people to lose interest. Metadata, though important, is a means and not an end. The identification and documentation of data items should be performed in parallel with development of the analytical tool.
- Another critical success factor is the ability to match the tools to the users. ADOT's vision is to use business intelligence tools already available in the private sector. However, these tools should not be implemented until they match ADOT's organizational maturity. For example, until the culture is transformed to be information-reliant and the skill set is upgraded to ask and answer business questions and what-ifs, business intelligence and data mining tools are extraneous. ADOT's approach has been to ensure that the proper platform is available to "plug and play" new tools as the organization becomes ready to use them. If an agency implements tools prematurely and turns them over to planners and engineers to use, the success of the overall data warehouse initiative may become incorrectly tied to the success of individual tools.

- A solid IT vision and architecture are important, because technology rapidly becomes obsolete, and it is burdensome and inefficient to rewrite code every few years. The IT vision needs to accommodate plug-and-play tools so that the agency does not have to reinvent the wheel. However, it is equally important to be flexible when pulling in data sources, because priorities often shift. Anticipating the next crisis and being ready with the data win every time.

Technical Lessons

- The traditional online analytical process model consists of dimensions and facts. Dimensions are what users slice and dice to answer business questions regarding the facts. This model works well in a sales analysis scenario in private industries. However, it does not work well in a DOT core business, where most data are descriptive (bridge name and type, project description and timeline, etc.) rather than quantitative or additive. For this reason, ADOT uses a mixture of relational (ROLAP) and multidimensional (MOLAP) online analytical processing models.
- Data warehousing and GIS remain two separate worlds in the IT field. When staff with different backgrounds talk about data warehousing, they mean different things. Data warehousing is database-intensive. GIS traditionally is flat-file-based and represents one dimension (geography) in answering business questions. It is only recently that the GIS environment has moved towards the spatial database model, and it will take some time before these two areas converge.
- One key data warehouse principle is not to alter the original data from the source. At ADOT, data “transformation” is limited to little more than geo-coding—cleansing the geographical information (route, mile-post, offset). Much of the data that are not validated at the source end up in “unknown” buckets. ADOT has found that it is critical that data ownership be clear and to build processes that provide feedback on data anomalies to the data owners. It also is critical to create buy-in from data owners so that they understand the importance of changing their systems to validate data at entry.

WHAT'S NEXT?

ADOT began work on its data warehouse in 2001. To date, the following data sources have been integrated into the system:

- Photo log available at the district offices
- Pavement and bridge data
- Project expenditures
- As-built engineering drawings, in PDF format
- Priority programming and Highway Performance Monitoring System data
- Safety/accident data

Additional data sets will be prioritized and brought in one at a time over the next several years. Currently, ADOT is developing a GIS user interface and adding construction data to the AIDW.

ADOT also plans to develop metadata and a data dictionary. This process will include documenting the following items:

- Data policies and standards
- Data characteristics (e.g., intended use, computational methods, required transformations, etc.)
- Data sources and owners
- Data collection, validation, and management processes
- Routines for extracting data from management systems and databases and loading them into the AIDW
- Example queries and use cases

Closing Thoughts

ADOT will soon complete an initial assessment of its current business practices. This project is envisioned to be the launch pad for a comprehensive business process improvement effort that will further solidify the role of the information data warehouse. Both the business process improvement and data warehousing initiatives are gaining traction with support from executive management and operational management.

Further Information

ADOT Web Site

<http://www.dot.state.az.us/>

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Credits and Sources

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———. *Five Year Transportation Facilities Construction Program, FY 2003–2007* (2003).

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Photographs courtesy of the Arizona Department of Transportation

Front cover: Stacked split, I-10 and I-17, in Phoenix

Inside front cover: US 93 crossing the Colorado River at the Hoover Dam (artist's rendition)



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