Alabama Bridge Management System Plus (ABIMS+): Phase 1 Final Report

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16. Abstract

The Federal Highway Administration (FHWA) requires funding allocation be based on bridge management policies developed in accordance with their guidelines. The American Association of State Highway Transportation Officials (AASHTO) has recommended the following activities be included within all comprehensive bridge management system (BMS):

1. Collect, process, and update condition data
2. Predict deterioration
3. Identify alternative actions
4. Predict costs
5. Determine optimal policies
6. Perform short- and long-term budget forecasting
7. Recommend programs and schedules for implementation with policy and budget constraints.

The current Alabama Bridge Information Management System (ABIMS) was created over a decade ago, prior to more recent guideline updates. ABIMS provided a means of collecting, processing, and updating condition data, but did not provide automated support for the remaining major tasks. Support for the remaining six activities becomes more critical as the state's bridge inventory ages and the backlog of bridges due for maintenance continues to grow, thus increasing the urgency behind the rehabilitation and replacement of bridges. Supporting these additional tasks will allow for effective utilization of federal and state budgets and a standard repeatable process to determine the bridges in most need of preventative maintenance, rehabilitation, or replacement.

An extension to ABIMS, referred to as ABIMS+, is the next step in fulfilling AASHTOs recommendations.

ABIMS+ generates Network Prioritization Reports and Target Condition Reports that:

- Within a selected geographic area, identifies a ranked list of bridges in need of rehabilitation, and/or replacement.
- Estimates the cost to restore a set of bridges to a target condition state for the current year
- Estimates the overall achievable condition state of bridges given a limited budget.

Benefits derived from this project include:

- Improved decision-making process to enhance the management of the bridge maintenance backlog.
- Enhanced support for the determination of the relationships among the network condition states and funding needs, given specific maintenance actions for the current year.
- Enhanced support for current year budget allocation decisions between replacement & rehabilitation alternatives
- Compliance with FHWA funding guidelines and provision of information necessary to facility consistent, effective funding allocation decisions for bridge maintenance.
- Development of a stable foundation for future functionality that will achieve ALDOT's objective of meeting AASHTO's *guidelines for a comprehensive bridge management system.*

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Executive Summary

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- Development of a stable foundation for future functionality that will achieve ALDOT's objective of meeting AASHTO's *guidelines for a comprehensive BMS*

1.0 Background

The Alabama Department of Transportation (ALDOT) is charged with the effective management of the state's transportation assets. In addition, ALDOT must allocate federal funding in accordance with federal guidelines and on increasingly formalized decision-making and project selection procedures.

A. Project Drivers: Given the current environment for ALDOT, there are several drivers for this project. These drivers include: compliance with federal guidelines for a bridge management system, funding constraints and the formalization of maintenance budgeting.

***Compliance with Federal Guidelines**:* The Federal Highway Administration (FHWA) requires funding allocation be based on bridge management policies developed in accordance with specific guidelines. To facilitate effective bridge management, the American Association of State Highway and Transportation Officials (AASHTO) recommends the following activities be included within a comprehensive bridge management system:

1. Collect, process, and update condition data
2. Predict deterioration
3. Identify alternative actions
4. Predict costs
5. Determine optimal policies
6. Perform short- and long-term budget forecasting
7. Recommend programs and schedules for implementation with policy and budget constraints

At the initiation of the project, the Alabama Bridge Information Management System (ABIMS) was in place. The ABIMS system provided the collection, processing, and the updating of bridge condition data, but did not provide automated support for the remaining activities recommended for a comprehensive bridge management system by AASHTO.

Funding Constraints: The ABIMS system was created prior to the GASB 34 mandate by the Financial Accounting Standards Board. The establishment of GASB 34 required ALDOT to set preservation levels associated with alternative condition targets and estimate the spending levels required to achieve these targets. This information provides the basis from which to establish attainable goals and evaluate the ongoing the effective utilization of funds. Continuing federal and state budget pressures are placing constraints on the availability of funds and increasing accountability for the effective utilization of these funds. Consequently, ALDOT must now do more with less and is in need of decision support tools capable of assessing the trade-offs between alternative investment strategies and effectively communicating the alternatives to

various stakeholder groups.

Budget Forecasting: The development and implementation of a robust decision tool (ABIMS+) integrated into ALDOT's existing bridge management system is a planned three phase project. Phase 1 of this three phase project conceptualized, designed, constructed and deployed an asset management system that put bridge information in the hands of state officials by identifying bridges in most need of replacement or rehabilitation for the next year based on current bridge condition rating data and current cost data. Phase 2 of the project will provide the ability to evaluate various scenarios to prioritize bridge maintenance activities for a seven year budget forecast period and determine the budget and resultant condition state for each of these scenarios. Phase 3 of the project will provide extended budget forecasting and maintenance activities given the structural deterioration and changing functional demands of bridges over time.

There are several metrics used to rate bridges and determine those in need of replacement or rehabilitation. One of these metrics is the bridge sufficiency rating, which is based on a 100-point scale. The bridge sufficiency metric consists of both functional and structural ratings of a bridge. The structural rating is associated with the deterioration of bridge components. The functional rating addresses the ability of a bridge to serve the type and volume of traffic on, above or below the structure. A second metric used to rate and prioritize bridge maintenance is ALDOT's deficiency rating. Deficiency ratings includes both structural and functional factors as associated with the sufficiency metric, but the deficiency metric will also include additional factors such as safety and economic factors. In this context, the deficiency rating may enhance the priority of a bridge for a maintenance action relative to other bridges with similar structural and functional ratings.

B. Stakeholders: The utilization of the ABIMS+ application has several primary stakeholder groups associated with the support for bridge maintenance decisions. These stakeholders include specific members of ALDOT's Maintenance Bureau, Divisions, the Office Engineer, the Office Engineer, Chief Engineer and the Director.

2.0 Project Value

There are several ways in which ALDOT will benefit from the completion and integration of this project into its work processes:

- Improved decision-making process to enhance the management of the bridge maintenance backlog.
- Enhanced support for the determination of the relationships among the network condition states and funding needs given specific maintenance actions for the current year.
- Enhanced support for budget allocation decisions between replacement and rehabilitation alternatives for the current year.
- Compliance with FHWA funding guidelines, and provision of information necessary for project justification.
- Integration of a stable foundation for future functionality that will achieve ALDOT's objective of meeting AASHTO's guidelines for a comprehensive bridge maintenance system.

The system makes bridge information readily available to the bridge maintenance management committee by providing a new, web-enabled tool for generating reports and allowing access to existing bridge information. It raises the quality of bridge data and provides support for funding allocation decisions. The project applies research results directly to the ALDOT bridge management system and funding allocation systems.

This project also improves the management of the state's bridge maintenance backlog by creating a standard, repeatable process for identifying and prioritizing bridges in need of maintenance. In doing so, the system supports budget allocation decisions by providing ALDOT with more information about benefits derived from spending on preventative maintenance, replacement, and rehabilitation. The system also ensures compliance with FHWA funding guidelines and provides information necessary for bridge replacement or rehabilitation projects.

In summary, the ABIMS+ accomplishes the following objectives:

- The Network Prioritization Report lists the bridges with the lowest or highest sufficiency/deficiency rating, within a specified network bounded by specific constraints.
- The Target Condition Report (TCR) estimates the amount of funding required to bring a specific network (or the entire network) of bridges up to a desired sufficiency, deficiency, or GASB rating.
- The TCR report can generate a list of bridges across the entire state, filtered by geographic and network constraints, to determine where a specified funding amount can be used most effectively.

3.0 Development Process

To provide optimal quality and to ensure the delivery of a highly valuable tool, the ABIMS+ system was developed according to a rigorous repeatable software development methodology.

The goal of ABIMS+ is to provide ALDOT with a standard repeatable method of prioritizing bridges for budget forecasting. During Phase 1, focus was placed on delivering current-year bridge prioritization by sufficiency and deficiency. Current-year bridge prioritization is to be used to deliver two reports: a Network Prioritization Report displaying a ranked list of bridges within a user-defined network of bridges, and the Target Condition Report showing the results (funding required or condition rating achieved) of simulated bridge maintenance actions within a user-defined network of bridges.

Due to the existing information system architecture and requirements placed on the system, ABIMS+ was designed using a three-tier architecture. ALDOT's ABIMS Oracle 9i database was used as the data layer. A Microsoft IIS server was used for the business logic and data access layers, along with some presentation layer capabilities. On the client side, a web browser is used as a partial presentation layer.

The user inputs all network constraints and other scenario-specific variables in the user interface. The business logic layer creates an SQL query that filters bridges according to user input, and insures that network constraints follow a logical flow (you cannot set the 'state' variable, and then choose a county outside of that state). The data access layer connects to the database, issues queries for execution and receives the results, returning the results to the application. The database stores all of ABIMS bridge information, a subset of which is used in ABIMS+.

During requirements specification, it was determined that an on-line application developed in ASP.NET 2.0 and Visual Basic.NET 2005 was the best solution for ABIMS+. It was also determined that due to its advanced de-bugging features Visual Studio 2005 would be used as the integrated development environment for this system.

The process to develop a 2-plus-tier architecture included:

- **Requirements Gathering**: The ABIMS database structure and the data contained therein was thoroughly studied to specify the data needed to deliver the NPR and TCR reports and the relationships between that data. The process and criteria ALDOT uses to define a bridge network was studied, and related items were added to requirements. Requirements, once specified, were presented and verified by ALDOT in both verbal and written format.

- **Business Rule (Class) Design**: A class structure allowing for modular phase upgrades to ABIMS+ was developed.
- **User Interface Design**: A user interface adhering to best business practices and ALDOT's normal standards for interface design was developed.
- **Data Access Design**: A data access layer that would most efficiently communicate with ALDOT's database was developed. This data access layer fully implements the advanced features of ADO.NET, which allows for optimal performance and advanced error handling.
- **Verify and Validate**: The information provided in the NPR and TCR reports was verified and validated against the information stored in the ABIMS database.

To facilitate the required functionality of the ABIMS+ Phase I tool, additions and modifications were made by ALDOT to the ABIMS database. These changes and the reasons they were implemented can be seen in Appendix B.

4.0 System Capabilities

ALDOT uses both the Target Condition Report (TCR) and the Network Prioritization Report (NPR) to support their funding allocation needs.

- The TCR is used to either estimate what the rating for a network of bridges will be after maintenance has been performed, or it can generate a list of bridges across the state where funding can be used most effectively.
- The NPR takes in user-specified constraints and generates a list of bridges within the specified network to show the lowest or highest sufficiency/deficiency rated bridges and cost to perform maintenance actions (see Figure 4-1).

ABIMS+ allows the user to determine the type of maintenance action (replacement or rehabilitation alternatives) to be performed on a network of bridges as well as provide a comparison of costs based on different maintenance actions.

To see a complete list of the functional capabilities, please refer to Appendix D.

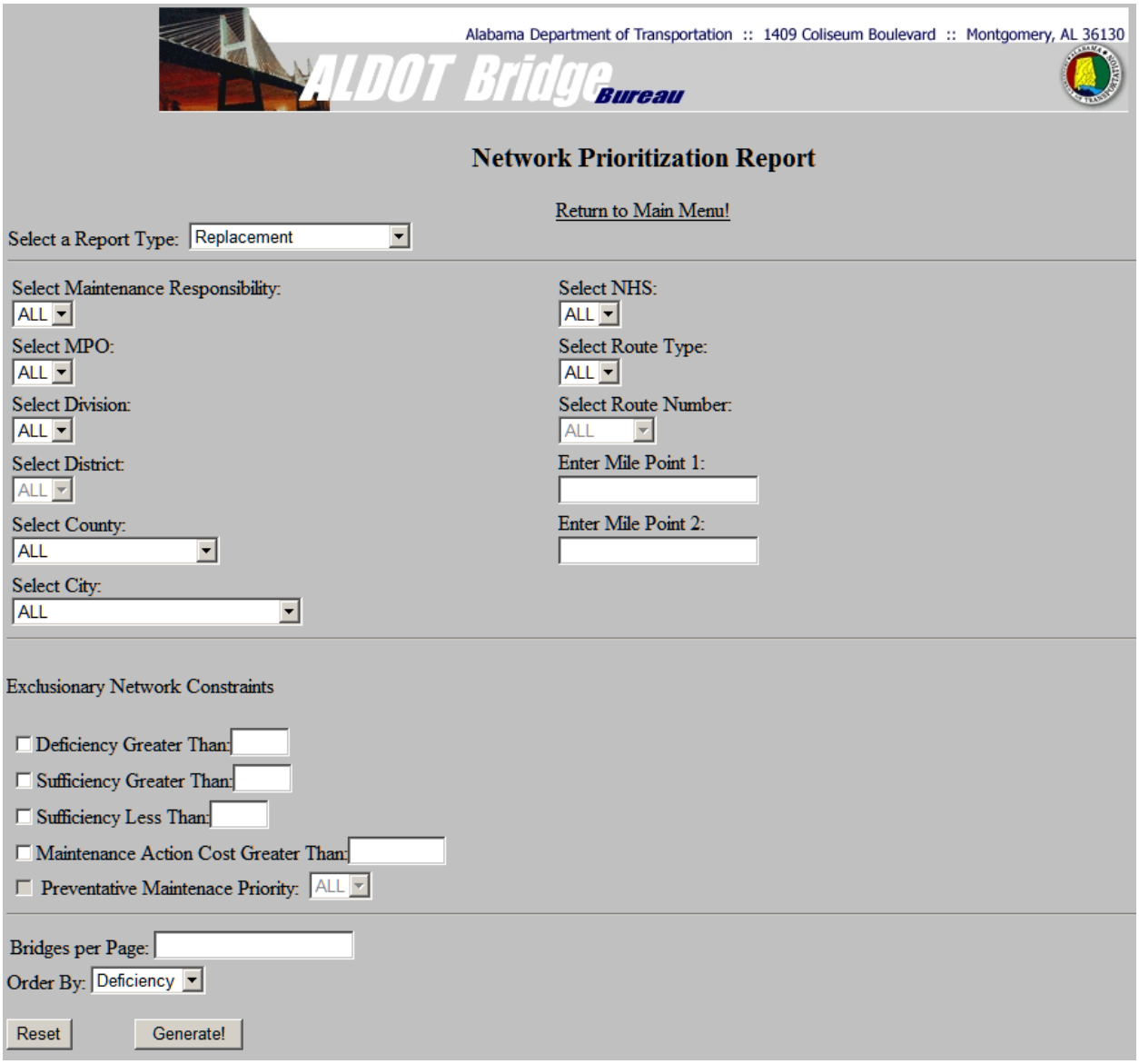

Figure 4-1. Network prioritization report

The network prioritization report consists of four report types: replacement, rehabilitation, preventative maintenance, and all. To select a report type, the user must select the one he or she wishes to generate from the report type dropdown menu (see Figure 4-2).

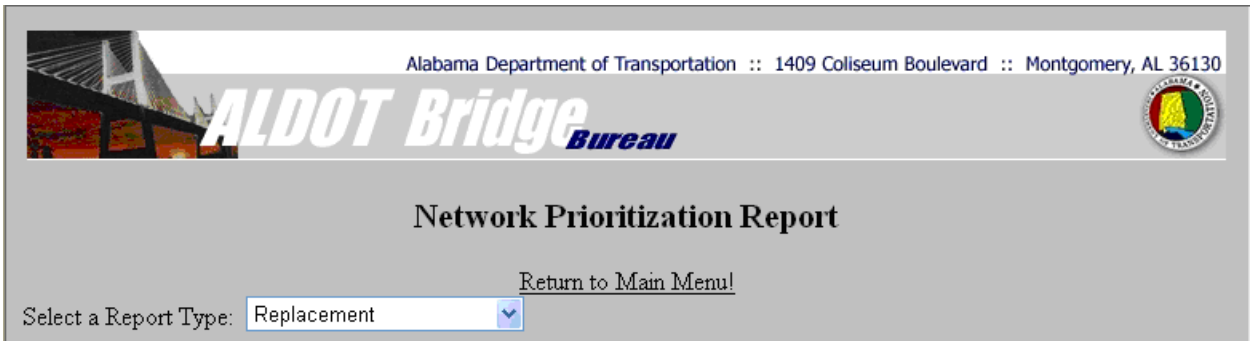

Figure 4-2. Selecting a report type: NPR

The **replacement** network prioritization report presents a prioritized list of operational bridges within a defined geographical network and within certain defined constraints that are eligible for replacement (Item 281 being equal to 1). Among other information given for each bridge, the cost to replace each bridge is presented in this report.

Likewise, the **rehabilitation** network prioritization report presents a prioritized list of operational bridges within a defined geographical network and within certain defined constraints that are eligible for rehabilitation (Item 281 being equal to 2). Presented in this report, among other information, is the cost to replace and the cost to rehabilitate each bridge.

The **preventative maintenance** network prioritization report presents a prioritized list of operational bridges within a defined geographical network and within certain defined constraints that are currently flagged to receive preventative maintenance actions. Among other information given for each bridge, the total preventative maintenance cost for each bridge is presented in this report.

The **all** network prioritization report presents a prioritized list of operational bridges within a defined geographical network and within certain defined operational constraints that are eligible for replacement, rehabilitation, or that are flagged to receive preventative maintenance actions. In the all network prioritization report a bridge will appear for each of the previous three report types it would have been included in; e.g. if a bridge is eligible for replacement and has been flagged for preventative maintenance actions that bridge will appear twice in the all network prioritization report. (Bridges are grouped together on the report to provide for easy discovery.) Among other information given for an occurrence of a bridge in the report, the action type a bridge is eligible for (e.g. replacement, rehabilitation, or preventative maintenance) along with its associated cost is presented.

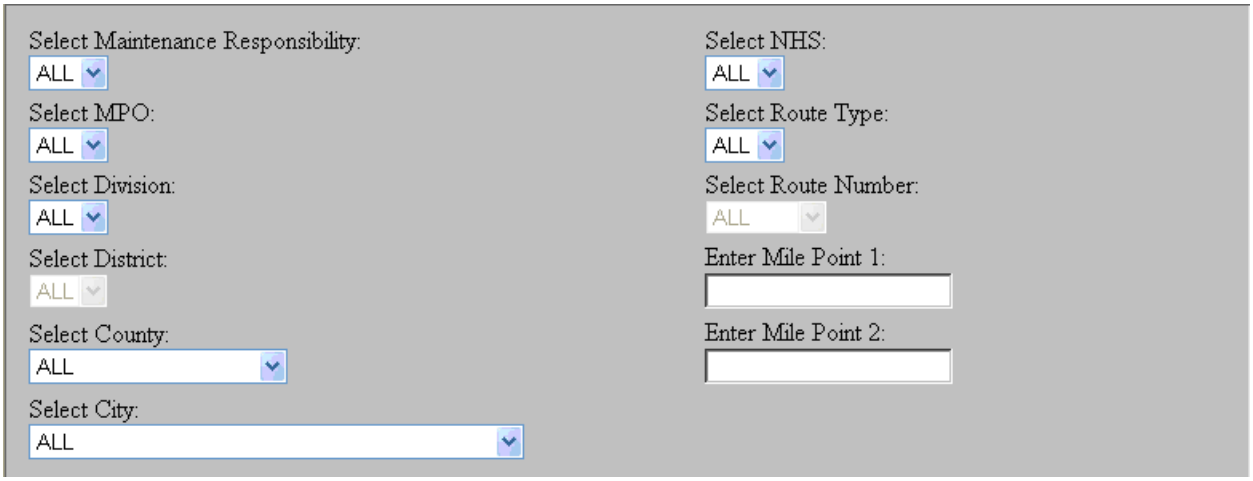

Figure 4-3. Selecting a geographic network of bridges: NPR

The following hierarchy and ordering (known as the **cascade effect**) will be used when selecting a geographic network of bridges to be considered in the analysis.

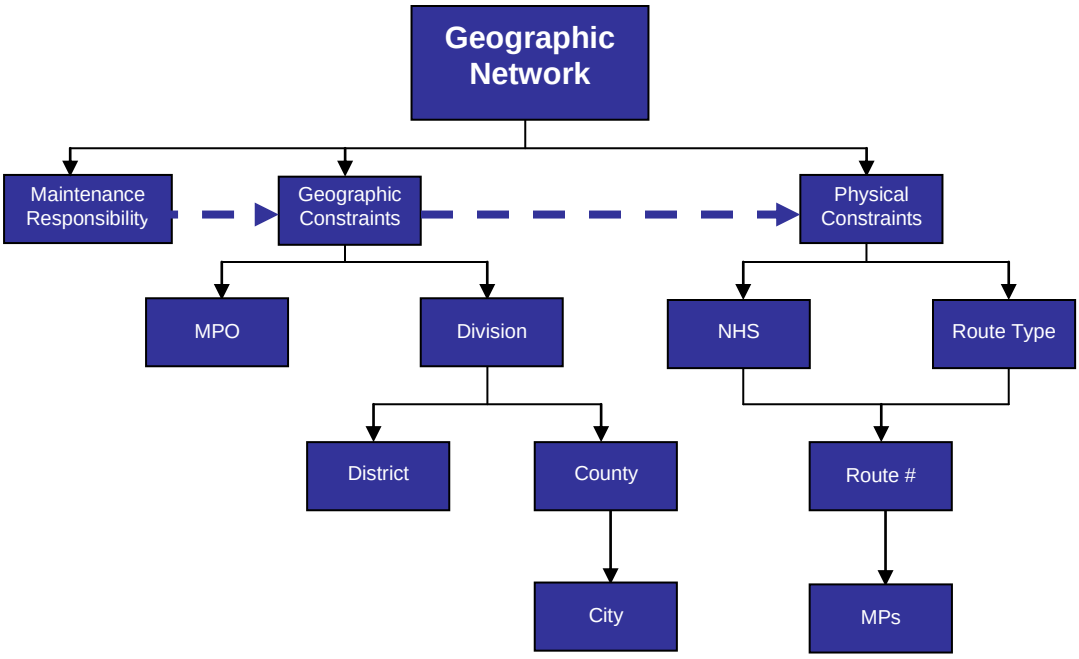

Figure 4-4. Geographic network hierarchy: NPR

The geographic network hierarchy has three branches (see Figure 4-4): maintenance responsibility, geographic constraints, and physical constraints. The branches flow downwards and once a user has reached a forced end of a branch (in the geographic constraints branch: MPO, district, and city) or an elected end of a branch (in the geographic constraints branch: division or county) then the user may choose to move to any branch right of the current branch to

make further selections. (If the user were currently in the geographic constraints branch then he or she could elect to continue to the physical constraints branch.)

A user may initiate the selection of a geographic network at any point within the hierarchy, but once the selection process (a cascade as illustrated by Figure 4-5) has begun all criteria on the same level or above the selection will no longer be modifiable. For each criterion in the geographic network hierarchy the default value is all; e.g. all divisions, all MPOs, all route types, etc. Thus, no geographic network selection is required to generate a valid report.

Figure 4-5. Cascade sequence: NPR

In the above example when a maintenance responsibility was selected from the maintenance responsibility dropdown menu a cascade action was called. According to the geographic network selection hierarchy this means that route types must be constrained; e.g. only route types within the selected maintenance responsibility should be displayed in the route type dropdown menu.

The next cascade action in the example is the selection of a division from the division dropdown menu. The hierarchy requires two events upon the selection of a division. First, all criteria on the same level or above division will now no longer be modifiable. This means that the user will no longer be able to make modifications (new selections) to the MPO or maintenance responsibility dropdown menus. Any selection made previous to selecting a division will continue to be stored; except it will not be modifiable. Second -- as per the geographic network hierarchy -- districts, counties, cities, and route types must be constrained; e.g. only districts, counties, cities, and route types within the selected division should be displayed in their respective dropdown menus.

Finally, a route type is selected from the route type dropdown menu. This event will cause the route number dropdown menu to fill with all the various route numbers within that route type and the above constraints (in this example within the selected maintenance responsibility and division). As with the other criteria, route number is set to default, which is all route numbers within the chosen route type and the defined constraints.

Figure 4-6. Selecting network constraints: NPR

Network Constraints allow the user to exclude bridges from appearing on the network prioritization report. Where *n* equals any positive non-zero integer, the user is allowed to constrain the results of the network prioritization report by **excluding** bridges with:

- a deficiency less than *n*
- and/or a sufficiency greater than *n*
- and/or a sufficiency less than *n*
- and/or a maintenance action cost (the cost to perform a replacement, rehabilitation, and/or preventative maintenance action) greater than *n*
- and/or (when the preventative maintenance report type has been selected) a selected preventative maintenance priority

For all deficiency and sufficiency constraint fields the integer entered must be a whole number (e.g. no decimal values). For maintenance action cost the integer should not include a leading dollar sign or commas, but may include a decimal point followed by two digits (e.g. $1,200,968.59 would be incorrectly formatted whereas 1200968.59 would be an accepted value).

The user will not be able to enter a network constraint until he or she has selected the check box next to the network constraint he or she wishes to enter. When selecting network constraints, simultaneous constraints can be selected. Unchecking a check box will clear the text box associated with that network constraint.

Figure 4-7. Selecting an ordering scheme: NPR

The bridges presented in the network prioritization report can be ordered according to two different ordering schemes. The first, and default, is ordering the bridges in ascending order according to their sufficiency score (e.g. 1, 25, 35, etc.). The second is ordering the bridges in descending order according to their deficiency score (e.g. 90, 86, 35, etc.). These choices are shown in Figure 4-7.

For a user to select an ordering scheme, he or she should simply click on the radio button next to the desired ordering scheme.

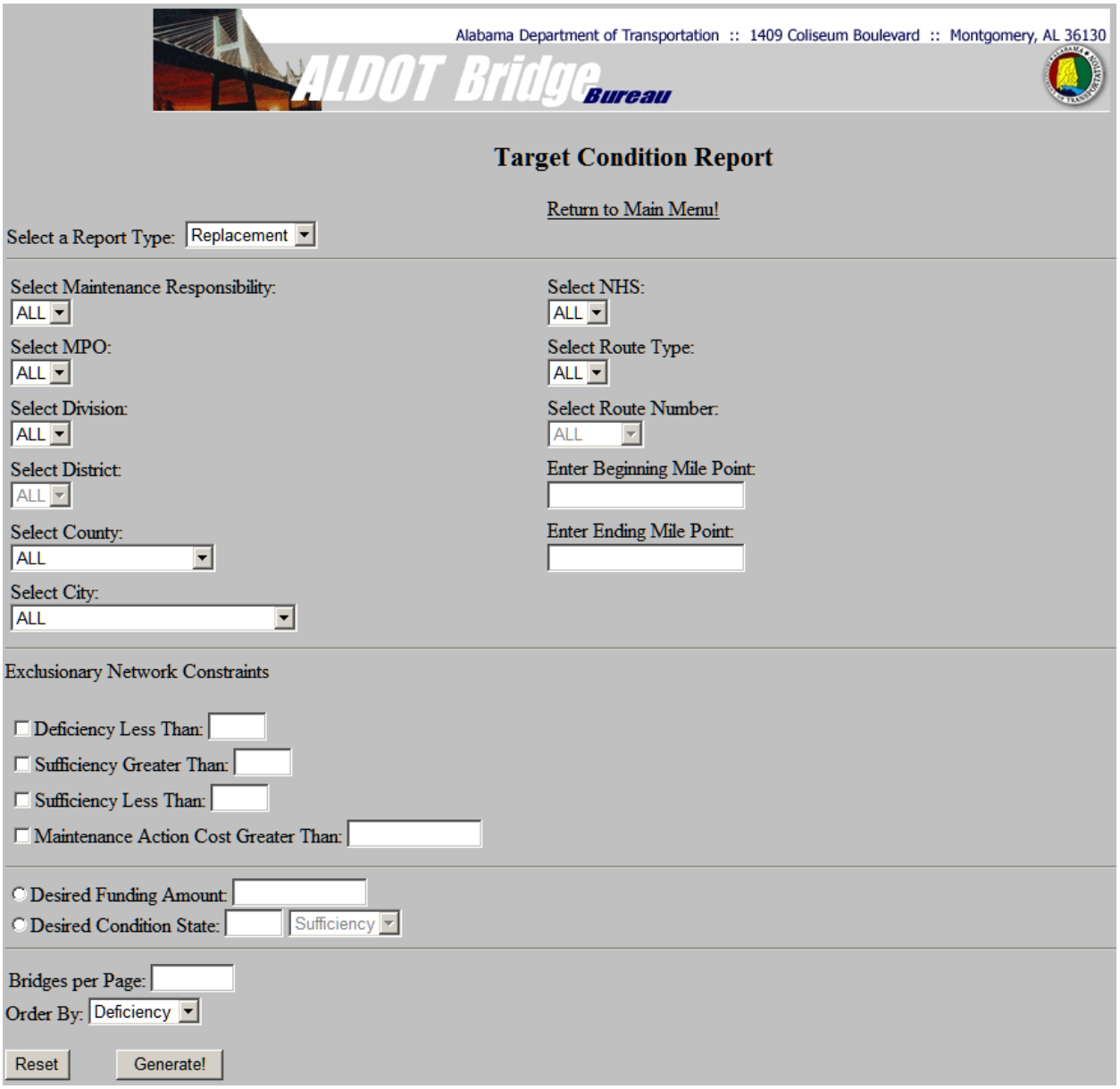

Figure 4-8. Target condition report

The target condition report (see Figure 4-8) consists of four report types: required funding for replacement, resulting network condition state after replacement, required funding for rehabilitation and resulting network condition state after rehabilitation.

Note: When defining the geographic and network constraints, the NPR and TCR reports are almost identical. The only difference between the NPR and TCR reports is the definition of the desired funding amount and desired condition state on the TCR report. This capability is not found on the NPR report.

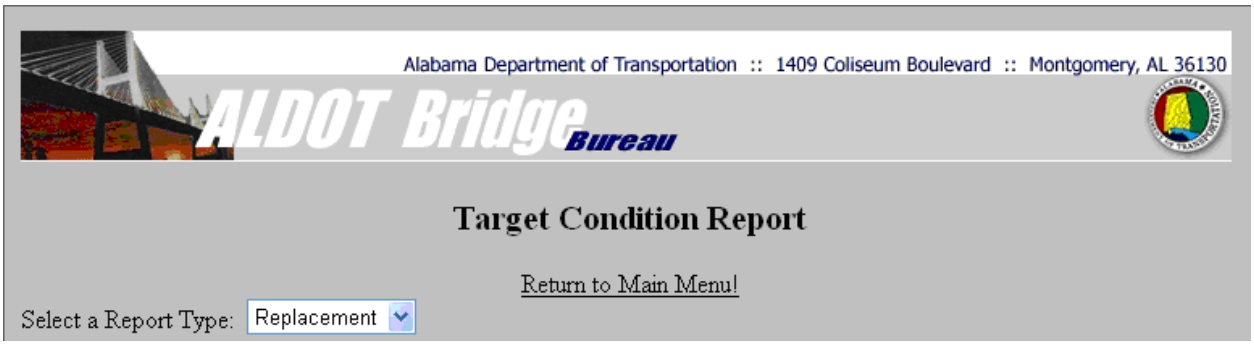

Figure 4-9. Selecting a report type: TCR

To select a report type, the user must select the type of report he or she wishes to generate from the report type dropdown menu at the top of the query form and then must enter either a desired network condition state or a desired funding amount in the appropriate text box near the bottom of the query form. To enter either a condition state or a funding amount into the appropriate text box, the user must first select the radio button next to the constraint the user wishes to enter. The selection screen is shown in Figure 4-9.

The **required funding** for **replacement** target condition report presents a prioritized list of operational bridges within a defined geographical network and within certain defined constraints that are eligible for replacement. In this report, the required funding needed to replace bridges until the user-entered network rating is achieved is presented, along with other information for each bridge in the network.

The **resulting network condition state** after **replacement** target condition report presents a prioritized list of operational bridges within a defined geographical network and within certain defined constraints that are eligible for replacement. In this report, the network condition state achieved after replacing bridges until the user-entered funds are exhausted is presented, along with other information for each bridge in the network.

The **required funding** for **rehabilitation** target condition report presents a prioritized list of operational bridges within a defined geographical network and within certain defined constraints that are eligible for rehabilitation. In this report, the required funding needed to rehabilitate bridges until the user-entered network condition state is achieved is presented, along with other information for each bridge in the network.

The **resulting network condition state** after **rehabilitation** target condition report presents a prioritized list of operational bridges within a defined geographical network and within certain defined constraints that are eligible for rehabilitation. The network condition state achieved after rehabilitating bridges until the user-entered funds are exhausted is presented, along with other information for each bridge in the network, in this report.

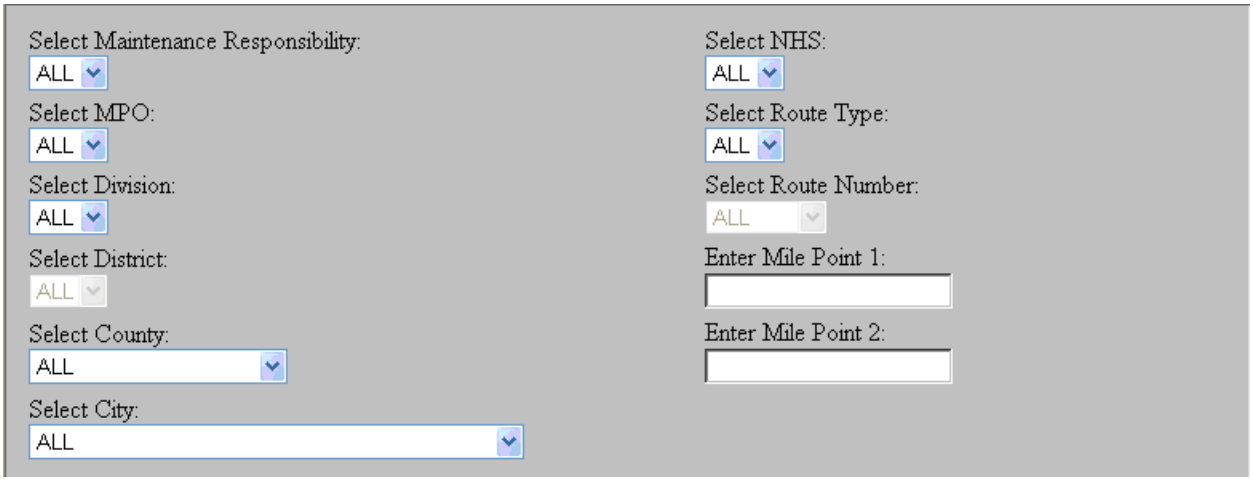

Figure 4-10. Selecting a geographic network of bridges: TCR

The following hierarchy and ordering (known as the **cascade effect**) shown in Figure 4-11 will be used when selecting a geographic network of bridges to be considered in the analysis.

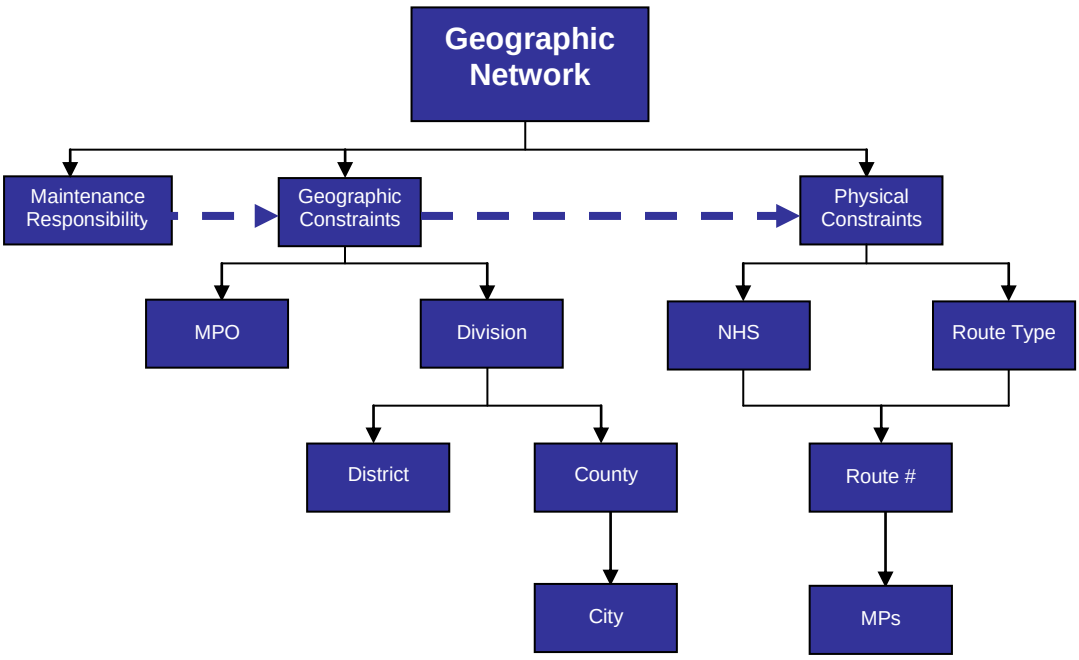

Figure 4-11. Geographic network hierarchy: TCR

The geographic network hierarchy has three branches: maintenance responsibility, geographic constraints, and physical constraints. The branches flow downwards and once a user has reached a forced end of a branch (in the geographic constraints branch: MPO, district, and city) or an elected end of a branch (in the geographic constraints branch: division or county) then the user may choose to move to any branch right of the current branch to make further selections. (If the user were currently in the geographic constraints branch, then he or she could elect to continue to the physical constraints branch, as shown in Figure 4-12).

A user may initiate the selection of a geographic network at any point within the hierarchy, but once the selection process (a cascade) has begun all criteria on the same level or above the selection can no longer be modified. For each criterion in the geographic network hierarchy the default value is all; e.g. all divisions, all MPOs, all route types, etc. Thus, no geographic network selection is required to generate a valid report.

Figure 4-12. Example of a valid cascade sequence: TCR

In the above example, when a maintenance responsibility was selected from the maintenance responsibility dropdown menu a cascade action was called. According to the geographic network selection hierarchy, this means that route types must be constrained; e.g. only route types within the selected maintenance responsibility should be displayed in the route type dropdown menu.

The next cascade action in the example is the selection of a division from the division dropdown menu. The hierarchy requires two events upon the selection of a division. First, all criteria on the same level or above division can no longer be modified. This means that the user will no longer be able to make modifications (new selections) to the MPO or maintenance responsibility dropdown menus. Any selection made previous to selecting a division will continue to be stored; it just will not be modifiable. Second -- as per the geographic network hierarchy -- districts, counties, cities, and route types must be constrained; e.g. only districts, counties, cities, and route types within the selected division should be displayed in their respective dropdown menus.

Finally, a route type is selected from the route type dropdown menu. This event will cause the route number dropdown menu to fill with all the various route numbers within that route type and the above constraints (in this example within the selected maintenance responsibility and division). As with the other criteria, route number is set to default as all route numbers within the chosen route type and the defined constraints.

Figure 4-13. Selecting network constraints: TCR

Network Constraints (see Figure 4-13) allow the user to exclude bridges from appearing on the target condition report. Where *n* equals any positive non-zero integer, the user is allowed to constrain the results of the target condition report by **excluding** bridges with:

- a deficiency less than *n*
- and/or a sufficiency greater than *n*,
- and/or a sufficiency less than *n*
- and/or a maintenance action cost (the cost to perform a replacement, rehabilitation, and/or preventative maintenance action) greater than *n*

For all deficiency and sufficiency constraint fields, the integer entered must be a whole number (e.g. no decimal values). For maintenance action cost the integer should not include a leading dollar sign or commas, but may include a decimal point followed by two digits (e.g. $1,200,968.59 would be incorrectly formatted whereas 1200968.59 would be an accepted value).

The user will not be able to enter a network constraint until he or she has selected the check box next to the network constraint he or she wishes to enter. Unchecking a check box will clear the text box associated with that network constraint.

Figure 4-14. Selecting an ordering scheme: TCR

The bridges presented in the target condition report can be ordered according to two different ordering schemes. The first, and default, is ordering the bridges in ascending order according to their sufficiency score (e.g. 1, 25, 35, etc.). The second is ordering the bridges in descending order according to their deficiency score (e.g. 90, 86, 35, etc.).

For a user to select an ordering scheme he or she should simply click on the radio button next to the desired ordering scheme.

5.0 Technical System Documentation

Technical System Overview (Phase 1)

The ABIMS+ system was developed using a three-tier architecture with a client/server approach. The server side of the system is housed in an ORACLE 9i database instance. The server handles all of the data storage, and the application handles the business logic, user interface, and report generation. The client piece was developed in Visual Basic .Net with an ASP .Net 2.0 front-end. The client-side receives all user inputs, processes all system inputs, calculates all algorithms, and handles most of the data validation.

The major function of this application is to support the user decisions for executing bridge projects and allocating bridge maintenance funding. This decision-supporting function is embodied as a reporting tool that generates a list of bridges in Alabama with some associated cost of maintenance action. There are four major reports that cover each maintenance action:

- Replacement
- Rehabilitation
- Preventative Maintenance
- ALL

To generate these reports, the system requests a set of user inputs to form a query that is sent to the Oracle database. When the Oracle database receives the query, the information regarding bridges, maintenance actions, and costs is retrieved. Once the information has been retrieved, it is sent back through the application and displayed on the screen. The user then has the option to export the bridge list to Microsoft Excel.

When ABIMS+ is launched, the user is automatically directed towards BAMS.aspx, the ABIMS+ homepage. From this screen the user can choose to either transfer towards the Network Prioritization Report (NPR) network selection screen (NPR.aspx) or the Target Condition Report (TCR) network selection screen (TCR.aspx). The user is transferred to either of these pages via a page redirect from the ABIMS+ homepage. This is graphically displayed in Figure 5-1.

At both the NPR and TCR network selection screens, the user will select or enter his or her desired geographic network, certain network constraints, and other required information to generate a NPR or TCR. As the user is making selections, the Master_Array storing these selections is passed back and forth between the webform and the cascade class. When the Master_Array is passed to the cascade class, the cascade class modifies the values stored in certain dropdown lists to mirror the cascade logic. For example, if Madison County has been

selected in the counties dropdown list, then the cities dropdown list would be repopulated with only cities residing within Madison County. Once the user had made his or her selections, he or she will click the "Generate" button.

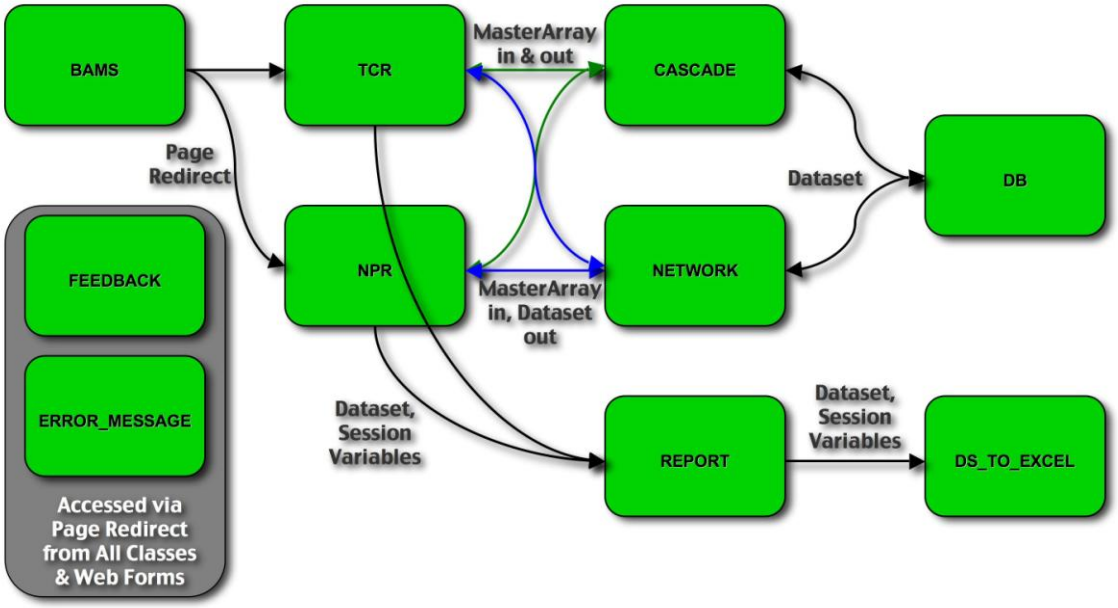

Figure 5-1. ABIMS+ class interactions and flows

When the "Generate" button is clicked, the Master_Array is sent to the network class. Using the information stored in the Master_Array the network class generates a SQL query and submits that query as a string to the database through the DB class. The DB class sends the query to the ABIMS database, stores the results into a DataSet, and then returns that DataSet to the network class. The network class then returns this DataSet to the NPR or TCR network selection webforms. In the case of the TCR network selections webform, the DataSet will be resent to the network class along with either the desired condition state or the required funding amount for additional computation. Finally, the DataSet and selections made by the user on the network selection screen are passed to the report webform (report.aspx) via session variables and a page redirect.

At the report webform the user has the option of generating an Excel document containing the information displayed on the report. When the user clicks this button the DataSet is passed to the ds_to_excel class which generates an Excel file and saves this file to the server.

At any point during the ABIMS+ workflow, the user has the option of transferring to a feedback submission form (feedback.aspx) or back to the ABIMS+ homepage (BAMS.aspx). Also, upon the occurrence of most common errors the user will be transferred, via a page redirect, to the error page (error_message.aspx).

Linking a VB .NET application to an Oracle 9i Database

In the web.config file, the following modifications must be made for ABIMS+ to properly function:

- <identity impersonate=”true” username=”administrator” password=”douseme” /> must be added
- <assemblies><add assembly="System.Data.OracleClient, Version=2.0.0.0, Culture=neutral, PublicKeyToken=B77A5C561934E089"/></assemblies> must be added

Within ABIMS+, the data access class (db.vb) connects to the Oracle 9i database using the ADO .NET object System.Data.OracleClient. The connection string for this object to connect to the ABIMS+ database is: "DataSource=BRIDGEDB;User ID=HDBMPROD;Password=bridge;"

Recommended Minimum Server Configuration Settings

Server System Requirements

Operating System: Windows Server 2003
User Computer: Windows XP Professional
Database: Oracle 9i
Database Version: 9.2
Programming Language: ASP.NET 2.0 (Visual Studio 2005)
Browser: Microsoft Internet Explorer (default)
Browser Version: Version 6.0.29
Internet Information Service (IIS): IIS 6.0

Installation Pre-Requisites

Internet Information Server (IIS) needs to be installed
Oracle9i Release 2 (9.2)

- Important: When installing, complete the Administrator Setup when prompted

Installing an ASP 2.0 application when ASP 1.1 applications are already in use with IIS 6.0

1. Install MS .Net Framework 2.0
    a. Go to the Microsoft Update site and update the computer
        i. http://www.update.microsoft.com/microsoftupdate/v6/default.aspx?ln=en-us
2. Open up IIS 6.0
    a. Click the plus sign beside “Internet Information Services”
    b. Click the plus sign beside “Application Pools”
    c. Right click “Application Pools” and select New -> Application Pool
    d. Name the Application Pool
    e. Click the plus sign beside “Web Sites”
    f. Right click “Web Sites” and select New -> Web Sites

g. Go through the setup process to start a new website
h. Right click the new website and select properties
i. Change the port used to a port not currently used on the server (Default is 80, use some high number like 5000)
j. Give the website an alias
k. Change the website's application pool to the new one you created
l. Copy the website into another folder (other than the inetpub/wwwroot folder, because this automatically creates a website in the default web sites folder, which will break the ASP 1.1 applications)
m. Change the permissions on the folder you just created to allow "Everyone" to read the folder
n. Go back to your website's properties and direct the website to the folder you just created on the server
o. Click the ASP .Net tab in the properties dialog and select 2.0 (Default is 1.1)

Troubleshooting Guide

The purpose of this guide is to provide possible insight into errors that a developer might encounter. It should be understood that these are the most probable error types, but not all the errors that could occur with an application of this type. Furthermore, this guide is intended to provide insight into what might be causing a problem in the application, NOT to actually solve the problem.

Database Errors

If the error appears at this line of code (which is located in the NPR.aspx.vb and TCR.aspx.vb classes):

"Session("Count") = Report_DS.Tables(0).Rows.Count"

There are several possible errors that could cause the application to have this specific type of problem:

- The database table connected to the application is not the specific database the application is expecting. If the tables are not consistent, no rows will be returned, and it will again return this error as this line of code. Errors of this type often result from changes to the database to which the application interfaces.

- The query sent to the database has returned no rows. The cascade functionality (which is the concept of drop-down list options being dynamically populated per user selection) is designed to prevent this error from occurring; however, this error still may be possible.

IIS Errors

Many of the errors that occurred with the IIS configuration during initial development had to do with ASP .NET 2.0 versus ASP .NET 1.1 application integration. The steps to avoid most to all of these integration errors can be found in an earlier part of this guide in the section entitled "Installing an ASP 2.0 application when ASP 1.1 applications are already in use with IIS 6.0" located on page 10.

Many of the applications located on the server are likely in the Default Website Folder shown in Figure 5-2.

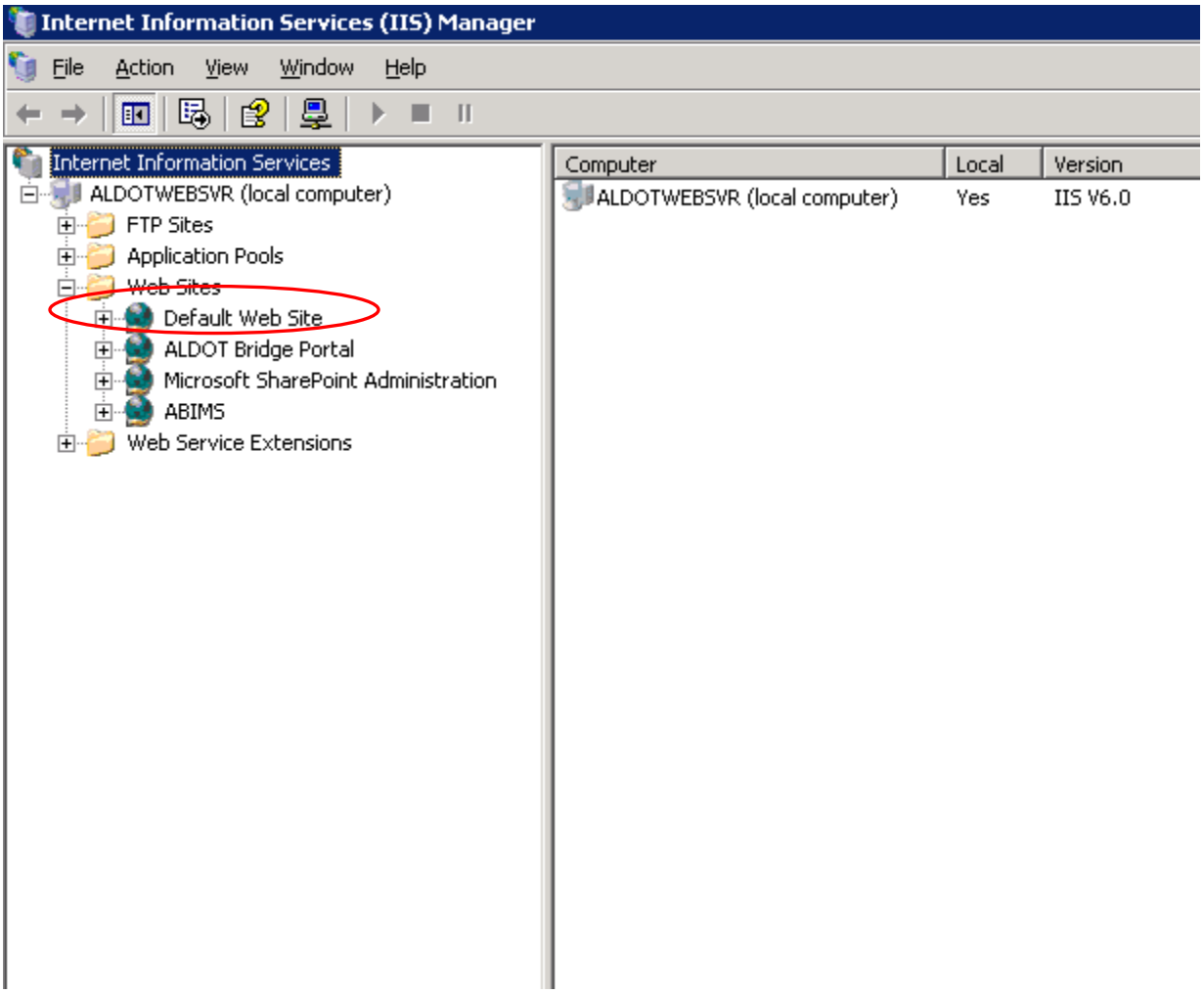

Figure 5-2. IIS default website folder

If an ASP 2.0 application is installed in this folder, none of the ASP 1.1 applications in that folder will work. In addition, if an ASP 2.0 application is installed as a new website outside the default website folder, but its application pool is located inside an application pool with another

ASP 1.1 application (which includes the default application pool), neither application will function. Solution: The ASP 2.0 application needs to have its own application pool. The default application pool is shown inside the bottom circle in Figure 5-3. A new application pool is shown as the top circled area on the figure.

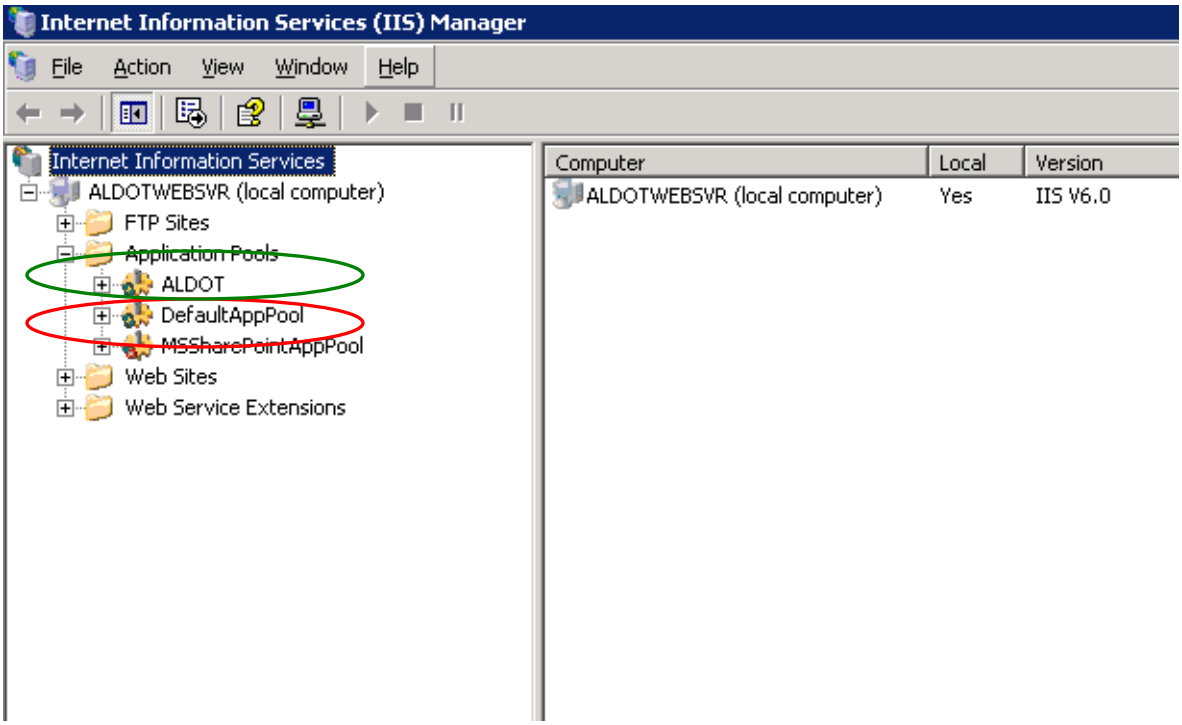

Figure 5-3. IIS default application pool and new ASP 2.0 application location

6.0 Conclusion

The system developed in this project phase provides immediate feedback throughout the bridge asset maintenance management process. It complies with applicable AASHTO guidelines and was developed in collaboration with ALDOT by the Aging Infrastructure Systems Center of Excellence (AISCE) at The University of Alabama.

Beyond providing a standard repeatable process for identifying and prioritizing bridges in need of preventive maintenance, rehabilitation, and replacement, this system is a springboard for future phases. These future phases will enable the system to:

- Utilize forecasting methods to determine the relationships among condition state, timeframe, and funding needs, given a specific maintenance action.

- Employ optimization techniques to assess the budget allocation approaches between preventative maintenance, replacement, and rehabilitation alternatives.

These additional phases will deliver an AASHTO-compliant bridge maintenance management system through the provision of analysis tools to manage future bridge funds. Likewise, this system will provide a standard repeatable process for the generation of evidence that additional funds are necessary to maintain bridges at a desired level of service and safety.

Adding these phases to ABIMS+ will extend the value produced in this project by incorporating bridge component deterioration. The enhancement also will provide a method to determine the bridges most in need of a specific preventative maintenance action. By utilizing this approach, value is added by isolating bridges with the most need of a specific action and utilizing the available funding needs effectively to maintain those specified bridges. It may also be benchmarked to create similar systems to use on other ALDOT processes.

7.0 Acknowledgements

THIS REPORT WAS PREPARED WITH THE COOPERATION AND ASSISTANCE OF REPRESENTATIVES OF THE FOLLOWING AGENCIES AND ORGANIZATIONS:

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8.0 References

Bridge Inspection Manual. Maintenance Bureau, Alabama Department of Transportation, Montgomery, AL.

Code of Federal Regulations, Chapter 23: National Bridge Inspection Standards, Part 650, Subpart C.

Guidelines for Operation. Alabama Department of Transportation, Montgomery, AL.

Recording and Coding Guide for the Structural Inventory and Appraisal of the Nation's Bridges. Publication FHWA-PD-96-001. U. S. Department of Transportation, 1995.

Appendix A: ALDOT Bridge Replacement Procedure Outline

Goal: Implement a standardized repeatable process, compliant with state and federal standards, for use in identifying and prioritizing bridges in need of maintenance action

As an integral part of ALDOT's standard and repeatable process for determining bridges in need of maintenance action within the State of Alabama (Appendix C), ABIMS+ provides further standardization of step 3-A and provides ALDOT with a prioritized list of bridges pulled from the ABIMS database.

Through user-interface controls, ABIMS+ ensures that prioritized lists of bridges are created in a standard and repeatable fashion. To generate a Network Prioritization Report (NPR), a report displaying a ranked list of bridges within a user-defined geographic network, a user must first determine the various geographic and network constraints to be used in generating the prioritized list of bridges. Once the user defines his or her geographic and network constraints, selections are inserted into a standard query template, ensuring uniformity in report generation. Using this standard query, the ABIMS database is queried and the results are formatted into a standardized report. This standardized report displays all the geographic constraints used in determining the list of bridges; which aids in ALDOT's ability to successfully repeat the results of the report.

Through its development of the ABIMS+ Phase I tool, The University of Alabama has fulfilled its agreement to deliver ALDOT a standardized repeatable process, compliant with state and federal standards, for use in identifying and prioritizing bridges in need of maintenance action.

- Bridge replacements to be established for a five-year period.
- Bridge replacement budgets are established for each fiscal year.
    - Office Engineer to provide Maintenance Bureau the funds available each fiscal year of the programmed period.
    - Maintenance Bureau to estimate amount of BR funding needed for Bridge Painting Program for each fiscal year. Currently 5%.
    - Chief Engineer to approve BR funds to be set-aside for Bridge Painting.
    - Remainder of BR funds available for replacement projects.
- A prioritized list of bridges to be replaced is produced by the Maintenance Bureau.
    - Initial list is produced by ABIMS+ with bridges ranked by their deficiency score. Higher numbers represent bridges in worse shape; lower numbers represent bridges in better shape.
    - Bridges are reviewed by the Maintenance Bureau for compliance with HBR eligibility requirements.
    - Initial bridge priorities are reviewed by the Maintenance Bureau and may be adjusted for reasons that include the following:
        - Bridges that have an adverse impact on ALDOT's ability to issue overweight permits are raised in priority.
        - Bridges that can be removed are raised in priority. An example is a bridge that overpasses an abandoned rail line.

        - Bridges that do not meet HBR eligibility are reduced in priority.
    - Maintenance Bureau assigns bridges to each fiscal year.
- Prioritized list from Step 3 is distributed to the Divisions.
    - Divisions are asked to review replacement estimates and develop more refined estimates where appropriate.
    - Each Division is asked to submit comments and recommendations for changes in proposed prioritization.
- Maintenance Bureau and Office Engineer adjust assignment of bridges to fiscal years based on adjusted replacement cost estimates.
- Committee meets.
    - Approves selected Division recommendations for change.
    - Makes own recommendations for changes as needed.
    - Approves prioritized list.
- Maintenance Bureau produces final prioritized list.
    - Bridges for Year 1 through Year 3 are signed off by Chief Engineer and Director
    - Lists for all years are distributed.
    - Changes to Year 1 through Year 3 must be approved by the Committee and signed off by the Chief Engineer and Director.

Appendix B: Additions/Modifications to the ABIMS Database

Cost Additions
As requested in the UA MIS ABIMS+ Project Team's meeting with ALDOT, two additional fields were added to the BMS_ST_INV table in the ABIMS database.

- A replacement cost, ST_TOT_IMPRVT_AM. This is the cost that would be displayed in ABIMS if Item 75 were defined as replacement (31).
- A general rehabilitation cost, ST_TOT_RHAB_AM. This is the cost to generally rehabilitate the bridge, not taking into account the various rehabilitation actions (Item 75 values: 33, 34, 35, & 38).

GASB Additions
Per the UA MIS ABIMS+ Project Team's meeting with ALDOT, a GASB rating for each bridge in the ABIMS database was added; ST_GASB34_PC was added to the BMS_ST_INV table.

Preventative Maintenance Queue Addition
Per conversations during the UA MIS ABIMS+ Project Team's meetings with ALDOT, the tables relating to the preventative maintenance queue (BMS_MN_CITY_COST, BMS_MN_COUNTY_COST, BMS_MN_STATE_COST, BMS_ST_MN_ACTVY_DS, BMS_ST_MN_NEEDED, BMS_ST_MN_NEED_HST) were added to the ABIMS database. These tables are replicated in real-time from the DB2 database where the data is originally stored by the application used to enter preventative maintenance actions on bridges.

Via a meeting with ALDOT, it was learned that in the preventative maintenance cost tables no initial costs were in the city table (because the cities haven't sent that information to ALDOT yet) and that there would only be a few counties' data listed in the county table. When information is not available in either the city or county tables AIBMS+ should default to the state table.

Cities Table Addition
As conversed in meeting with ALDOT, a table containing the FIPS code and narrative name for cities within the state of Alabama (BMS_CITY) was added to the ABIMS database.

Resultant Conditions Table Addition
As discussed, a simple table (BMS_ST_RSULT_CONDS) containing a number change for GASB, sufficiency, and deficiency for each bridge action (Item 75 values: 31, 33, 34, 35, & 38) and for each of the three ownership groups (state, county, and municipal) was developed and added to the ABIMS database.

Appendix C: Data Dictionary

Field Name	Definition	Notes
Report Type	The type of report to run - replacement, rehabilitation, preventative maintenance, all	
MPO	The Metropolitan Planning Organization in which the bridge is located	
Division	The division in which the bridge is located	
District	The district in which the bridge is located	
County	The county in which the bridge is located	
City	The city in which the bridge is located	
NHS	The National Highway System in which the bridge is located	
Route Type	The type of route the bridge is located on - highway, county, federal	
Route Number	The number of the route - ex: 215	
Mile Point 1	The starting mile number	Optional
Mile Point 2	The ending mile number	Optional
Deficiency Greater Than	The deficiency of the bridge is greater than this number	Optional
Sufficiency Greater Than	The sufficiency of the bridge is greater than this number	Optional
Sufficiency Less Than	The sufficiency of the bridge is less than this number	Optional
Maintenance Action Cost Greater Than	The maintenance action cost (cost to perform a replacement, rehabilitation, or preventative maintenance) is greater than this number	No $ sign, 2 decimal places MAX, Optional
Preventative Maintenance Priority	When the preventative maintenance report type has been selected, a selected preventative maintenance priority	Only if Preventative Maintenance Report Type is Selected, Optional
Bridges Per Page	How many bridges per page are listed on the report screen	
Order By	How the report should be ordered - sufficiency or deficiency	
Desired Funding Amount	The desired funding amount is this number - format with no $	No $ sign, 2 decimal places MAX - Choose this or "Desired Condition State"
Desired Condition State	The desired condition state for the number - sufficiency or deficiency	Choose this or "Desired Funding Amount"

Appendix D: ABIMS+ Functional Capabilities

Description	ABIMS+ Description
Action costs	
Inputs: Database	ABIMS+ uses ALDOT's ABIMS Bridge database
Inputs: Bridges to Include	Network geographic constraints
Inputs: Annual Budget Levels	Expected yearly budget with inflation
Inputs: Discount Rate	as percentage
Inputs: Planning Horizon	
Maximum annual budget	
Bridge ID, description, location	Stored in ABIMS database
Characteristics of over and under roadways	
Geometric and structural characteristics	Stored in ABIMS Item numbers
Network Optimization	
Shows economically motivated replacement work that meets structurally/functionality motivated needs	
Includes Culverts in Ratings	
Resulting bridge conditions are rolled forward info the following year and the simulation cycle is restarted	
Effect of projects on bridge conditions is simulated	
Allocates funds to the prioritized list of projects until they are exhausted	
Iterations	
Selects all projects above a threshold value	
Calculates deck, superstructure, and substructure on 0-9 scale	
Sufficiency Rating Considers functional issues	
Determine the optimal set of decisions for a given network of bridges	
FO and SD, it is SD	
Reports (includes maintenance decisions for each year, and resulting improvements in condition ratings)	
Condition assessment of deck, superstructure, substructure	