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Decision Support Framework Implementation of the Web-Based Environmental Decision Analysis Application DASEES: Decision Analysis for a Sustainable Environment, Economy, and Society

U.S. EPA Office of Research and Development Ecosystem Services Research Program (ESRP)

Notice

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Foreword

The U.S. Environmental Protection Agency (EPA) is charged by Congress with protecting the Nation’s land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA’s research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory (NRMRL) is the Agency’s center for investigation of technological and management approaches for preventing and reducing risks from pollution that threaten human health and the environment. The focus of the Laboratory’s research program is on methods and their cost-effectiveness for prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites, sediments, and ground water; prevention and control of indoor air pollution; and restoration of ecosystems. NRMRL collaborates with both public and private sector partners to foster technologies that reduce the cost of compliance and to anticipate emerging problems. NRMRL’s research provides solutions to environmental problems by: developing and promoting technologies that protect and improve the environment; advancing scientific and engineering information to support regulatory and policy decisions; and providing the technical support and information transfer to ensure implementation of environmental regulations and strategies at the national, state, and community levels.

This publication has been produced as part of the Laboratory’s strategic long-term research plan. It is published and made available by EPA’s Office of Research and Development to assist the user community and to link researchers with their clients.

Cynthia Sonich-Mullin, Director
National Risk Management Research Laboratory

Table of Contents

List of Figures

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Note to Readers

The information in this report is intended for web-based application developers and those interested in open source web-design. As such, the greater part of this report is of a technical nature. For those finding the terminology unfamiliar, a glossary is included at the end of this report.

1 Introduction

1.1 Environmental Applications Research

Pervasive environmental challenges such as climate change, coastal eutrophication, habitat and species' loss are rarely the result of natural processes solely, but linked to human activities and their resource management behaviors (Shultz, 2011). The implication of this is that solutions will not always have a straightforward, "tame" application of science-based actions, but are often "wicked" problems. "Wicked" problems (Balint, et al., 2011) are large-scale environmental policy questions where environmental concerns, economic constraints, and societal values conflict causing seemingly intractable political situations.

Over the last few decades, advances in information technology have enabled the environmental sciences to evolve from relatively distinct scientific disciplines, e.g., geology, meteorology, hydrology, etc., to a more inter-related systems-based science. When human behavior is factored, the analysis of complex phenomena, such as climate change becomes more feasible (Dozier and Gail, 2009). Dozier and Gail (2009) argue that these analyses drive the need for research into the development of environmental applications that use systems approaches and decision science to enable society to make decisions that address "wicked' problems.

1.2 Decision Support Framework (DSF)

The EPA Science Advisory Board (SAB) recommended that the EPA (U.S. Environmental Protection Agency, 2000) should develop a decision-making framework for addressing such complex multi-faceted problems. They specified that this framework should focus on the interaction between analytic and deliberative processes in decision-making and be capable of assessing cumulative risk, evaluating competing management options, including societal values, and clarifying potential tradeoffs (United States, 1997, National Research Council, 1996). In response, the Decision Support Framework (DSF) team developed a research implementation plan (U. S. Environmental Protection Agency, 2009), with the goal of creating a flexible decision framework for structuring complex problems that helps decision-makers and stakeholders transparently evaluate scientific and technical analyses within an economic and societal values context.

1.2.1 Conceptual Model

The DSF conceptual model envisions a five-step decision process of defining context, identifying objectives, formulating alternatives, evaluating and deciding among alternatives, and implementation (Fig. 1). Solicited advice from decision experts and review of literature identified four key overarching ideas that were considered important in developing a successful decision-making model.

1. The framework should support a process that follows the concepts of behavioral decision theory and decision analysis (French et al., 2009; Gregory and Keeney, 2002) to ensure all the necessary elements are considered for making an informed decision.

2. The framework should use analytic-deliberation (National Research Council, 1996), which combines rigorous, scientific approaches with an emphasis on communication to facilitate mutual understanding among stakeholders.

3. The framework should encourage adaptive management as a strategy for managing complex environmental systems having uncertainty (Williams, 2001).

4. The framework should use an accepted conceptual approach for establishing decision context and problem framing. The Drivers-Pressures-States-Impacts-Response (DPSIR) conceptual model (UNEP, 2007) is a widely recognized approach and was adopted for the DSF.

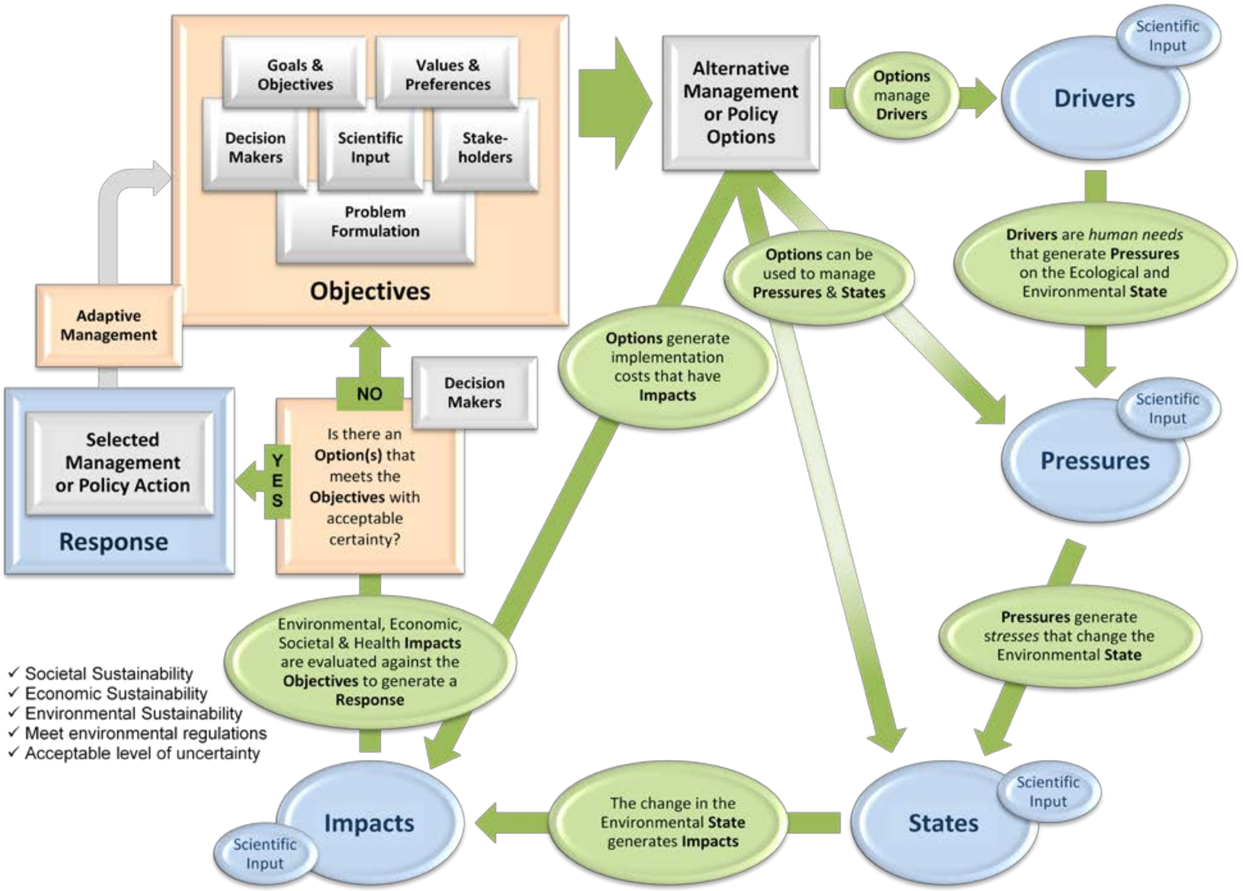

Goals & Objectives
Values & Preferences
Decision Makers
Scientific Input
Stake-holders
Problem Formulation
Objectives
Alternative Management or Policy Options
Options manage Drivers
Scientific Input
Drivers
Adaptive Management
Options can be used to manage Pressures & States
Drivers are human needs that generate Pressures on the Ecological and Environmental State
Options generate implementation costs that have Impacts
NO
Decision Makers
Scientific Input
Pressures
Selected Management or Policy Action
Response
YES
Is there an Option(s) that meets the Objectives with acceptable certainty?
Pressures generate stresses that change the Environmental State
Environmental, Economic, Societal & Health Impacts are evaluated against the Objectives to generate a Response
✓ Societal Sustainability
✓ Economic Sustainability
✓ Environmental Sustainability
✓ Meet environmental regulations
✓ Acceptable level of uncertainty
Impacts
Scientific Input
The change in the Environmental State generates Impacts
States
Scientific Input

Figure 1. DSF Conceptual Model (USEPA, 2009)

1.3 Decision Support Systems (DSS)

Implementing the DSF entails development of a computerized decision support system (DSS). A generic DSS architecture (Fig. 2) must include a knowledge base, analysis tools, and inference engine (Black and Stockton, 2009). Other components such as user interface and stakeholder participation tools greatly improve the DSS function but are not considered fundamental. Specific structures for a DSS are contingent on its intended purpose. An information-based DSS (Black and Stockton, 2009) provides structures that support the intended functions of the DSF conceptual model. Information-based DSSs maintain database architectures such as relational and data types e.g., geographical information systems (GIS), of varying complexity, to provide information appropriate to the DSS needs. They can incorporate a range of analytical tools, e.g., multi-criteria decision analysis (MCDA) to analyze database information.

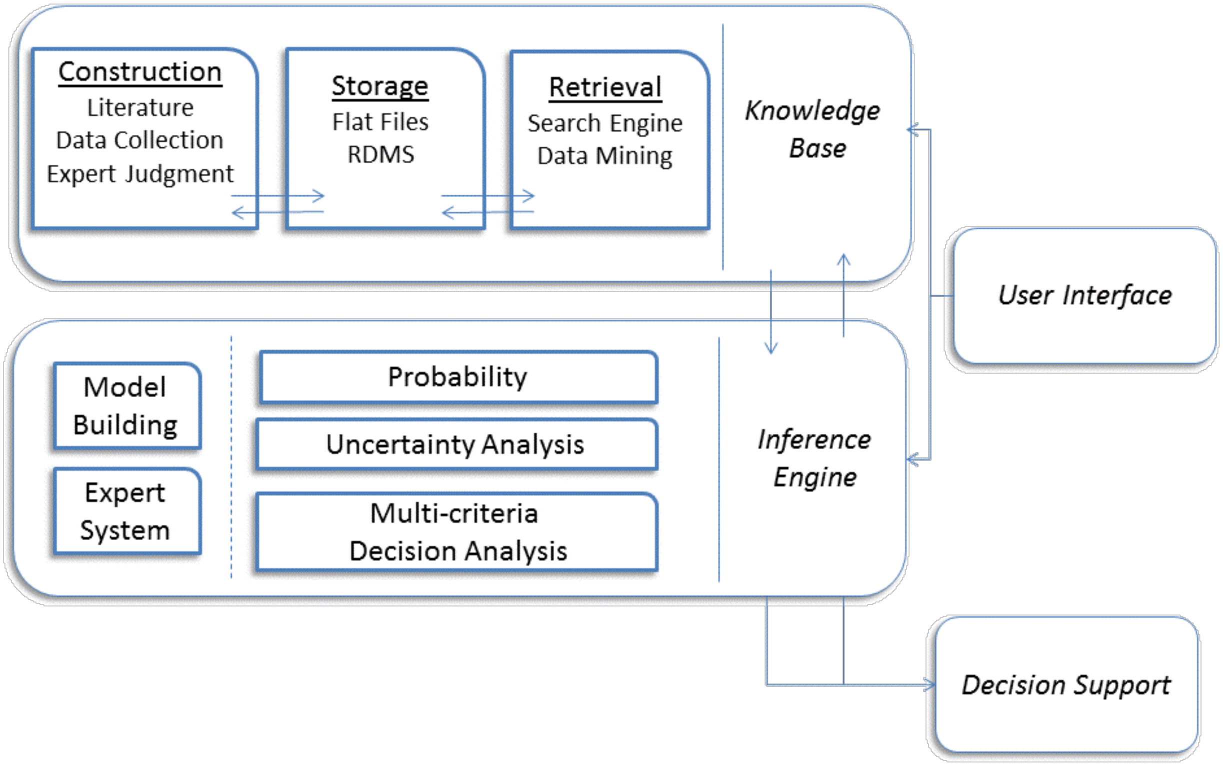


Figure 2. Generic Architecture for a Decision Support System (Adapted from Black and Stockton, 2009)

1.3.1 Web-based Decision Support

From its inception, the implementation of the DSF was envisioned to be a web-based application of the principles and ideas elucidated by the framework conceptual model. The reasons for this are technical and functional. Technically, there is a large and expanding resource pool of software and hardware options for making customizable DSSs and associated tools capable of accessing information on the web (Black and Stockton, 2009). Of particular note is the rise of open source developer options, such as the statistical programming language R (www.r-project.org), that allow an online community of developers to contribute to the continual development and maintenance of web-based decision support systems. Functionally, a web-based DSS supports a key aim of the DSF of promoting stakeholder involvement and participatory decision-making by using community-based deliberative processes to better resolve “wicked” problems (Bayley and French, 2007; Insua et al., 2007; Panagiotopoulos et al., 2010).

1.3.2 Decision Analysis for a Sustainable Environment, Economy, and Society (DASEES)

Web-based decision and statistical analysis tool developers at Neptune and Company, Inc., have facilitated the implementation of the Decision Support Framework through the web-based application DASEES (**D**ecision **A**nalysis for a **S**ustainable **E**nvironment, **E**conomy, and **S**ociety). The following discussion is specific to the platform architecture and software design approaches being taken by the developers.

2 DASEES Web Application Framework

2.1 Functional Design

DASEES is organized in five steps according to the DSF conceptual model:

1. Understand context
2. Define objectives
3. Develop options
4. Evaluate options
5. Take action

At the top level, DASEES will consist of a set of guidance and software tools designed both to educate decision-makers in using this conceptual model and to allow them to create their own decision-specific model using interactive tools that allow them to input data and generate graphs, charts, and statistical analyses. By using these tools, different decision options can be quantified and evaluated in the larger context of the conceptual model. In addition, DASEES will house case studies that demonstrate how the tools and guidance can be applied to specific real-world decisions. The case studies will be used as the building blocks for the upper levels of DASEES.

In terms of site navigation, the structure described above will be implemented as a series of tabs (Fig 3). Each of these top-level tabs will contain sub-tabs housing tools useful in the decision process. The “DASEES steps” will contain an overview tab, which will provide an introduction to the individual steps. Each of these sub-tabs may contain its own sub-tabs, housing guidance or tools.

Requirements for each tab and sub-tab will depend on whether they contain guidance or house a software tool, or both.

2.2 Requirements

2.2.1 Site Navigation

The web site should be organized such that different areas of the site are easy to find and access (with minimal clicks). Different site sections must display promptly in response to mouse clicks. It is important that the organization of the site must reflect the five steps of decision-making (see Section 1.2.1) that form the basis of the DSF conceptual model.

2.2.2 Content Presentation

Site content should be clearly written and factually accurate. Guidance must be appropriate to the overall conceptual model. Guidance on using the embedded software tools should address all the functionality of the tool in question in language that is understandable by the user without special scientific or technical knowledge.

2.2.3 Graphical Tool User Interface (UI)

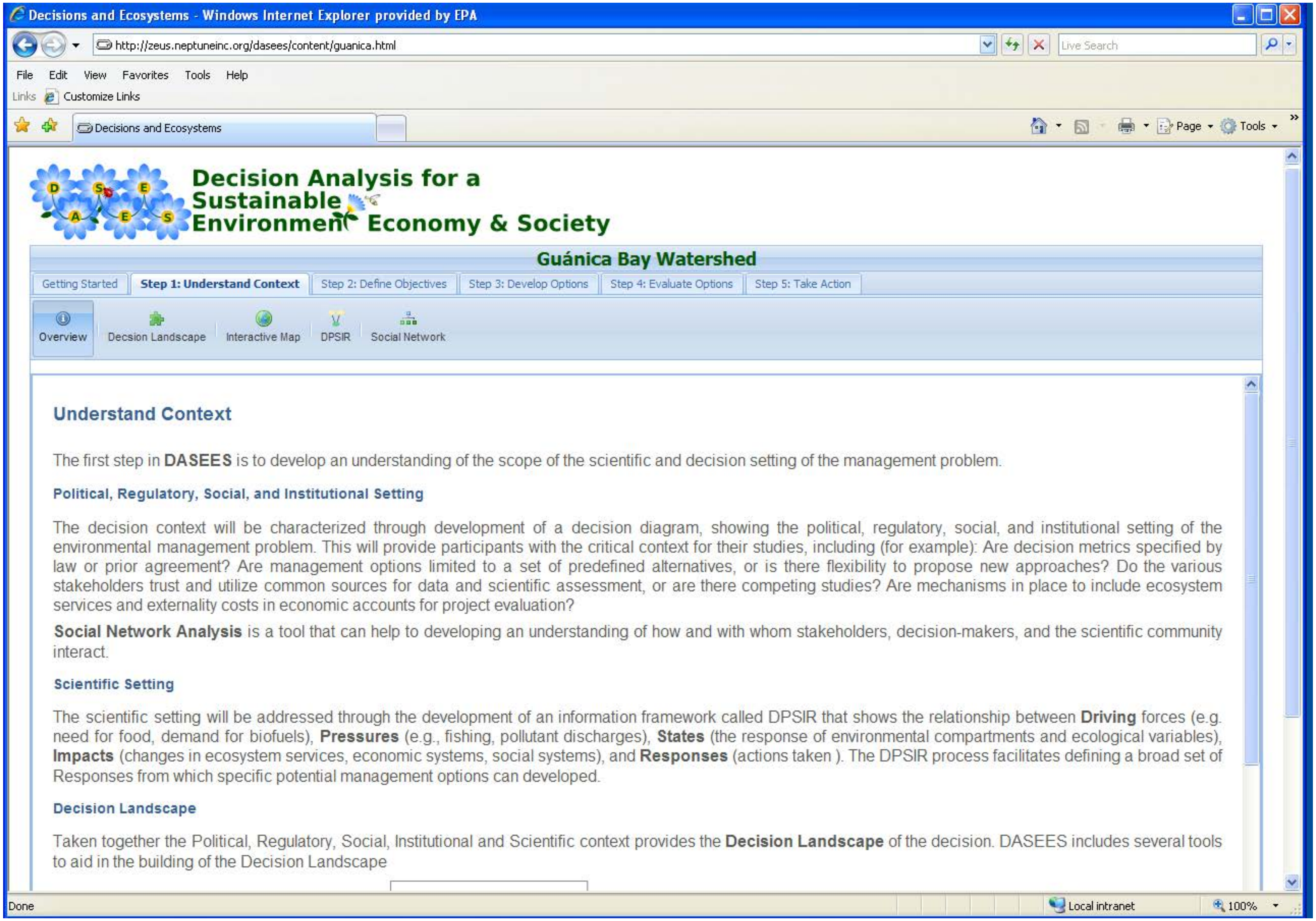
Software tools should have interfaces that are dynamic, responsive, and intuitive. Interacting with these tools should not lead to page reloads, require the user to go to a different page on the site or open a new browser window.

2.2.4 Data Management

The user should be able to input data relevant to their decision process and have those data stored in a persistent database. They should be able to modify or delete data after they have been entered. Data input interfaces should be responsive and intuitive.

2.2.5 Data Analysis

DASEES should be able to perform technical analysis of user-entered data. This will include performing statistical analysis of the data using Bayesian methodology and generating plots, charts, and graphs of the data. Images generated by analysis tools must be displayed promptly and without requiring the user to go to a different page on the site or to open a new browser window.



Decisions and Ecosystems - Windows Internet Explorer provided by EPA
http://zeus.neptuneinc.org/dasees/content/guanica.html
Live Search
File Edit View Favorites Tools Help
Links Customize Links
Decisions and Ecosystems
Page Tools
Decision Analysis for a Sustainable Environment Economy & Society
Guánica Bay Watershed
Getting Started
Step 1: Understand Context
Step 2: Define Objectives
Step 3: Develop Options
Step 4: Evaluate Options
Step 5: Take Action
Overview
Decsion Landscape
Interactive Map
DPSIR
Social Network
Done
Local intranet
100%

Understand Context

The first step in **DASEES** is to develop an understanding of the scope of the scientific and decision setting of the management problem.

Political, Regulatory, Social, and Institutional Setting

The decision context will be characterized through development of a decision diagram, showing the political, regulatory, social, and institutional setting of the environmental management problem. This will provide participants with the critical context for their studies, including (for example): Are decision metrics specified by law or prior agreement? Are management options limited to a set of predefined alternatives, or is there flexibility to propose new approaches? Do the various stakeholders trust and utilize common sources for data and scientific assessment, or are there competing studies? Are mechanisms in place to include ecosystem services and externality costs in economic accounts for project evaluation?

Social Network Analysis is a tool that can help to developing an understanding of how and with whom stakeholders, decision-makers, and the scientific community interact.

Scientific Setting

The scientific setting will be addressed through the development of an information framework called DPSIR that shows the relationship between **Driving** forces (e.g. need for food, demand for biofuels), **Pressures** (e.g., fishing, pollutant discharges), **States** (the response of environmental compartments and ecological variables), **Impacts** (changes in ecosystem services, economic systems, social systems), and **Responses** (actions taken). The DPSIR process facilitates defining a broad set of Responses from which specific potential management options can developed.

Decision Landscape

Taken together the Political, Regulatory, Social, Institutional and Scientific context provides the **Decision Landscape** of the decision. DASEES includes several tools to aid in the building of the Decision Landscape

Figure 3. DASEES Webpage Design

2.3 Hardware and Operating System Requirements

Since DASEES is a web-based application, user hardware and operating system requirements are minimal. DASEES will support any Web 2.0 compliant web browser that also supports Adobe FLASH technology. However, due to resource constraints, DASEES only will be tested comprehensively with Internet Explorer versions 7 and higher running on Windows and Firefox version 3.5 and eventually on Windows and Mac OS 10.6.

DASEES will be served from computers running the Linux operating system, with a minimum of 2 Gigabytes of RAM and 300 Gigabytes available hard disk space.

2.4 Secondary Data Requirements

A key component of the DASEES approach is the propagation of uncertainty at each step of the decision process. Data from a wide variety of different sources, as well as stakeholder values and preferences, will be combined as part of the decision analysis process. Under the Bayesian decision analysis paradigm (French et al., 2009) the quality of the information and data is represented by its uncertainty. Highly uncertain information and data are essentially weighted inversely to their uncertainty. Thus secondary data of low quality may be included with a high degree of uncertainty but would have little weight in the analysis. The amount of uncertainty in a particular area will help guide stakeholders and decision-makers in their decisions regarding how better to utilize scarce resources when collecting additional data.

3 System Design

3.1 Overview

Note: The remainder of this report is of a technical nature specific to web design and open source web development. For those not familiar with the terminology a glossary is included at the end of this report.

DASEES is a web application framework containing a collection of linked decision analysis tools to implement a comprehensive and coherent decision analysis framework for environmental decision making. The DASEES tools are designed to be used independently or within the DASEES 5-step decision analysis framework. For example, the Land User Scenario tool allows a user to add or edit land use polygons and the associated attributes, to create a new land use scenario. This tool can be used as a stand-alone GIS visualization tool or in conjunction with the DASEES framework to inform watershed modeling land use input requirements.

This system uses open source technology to mirror the capabilities of a system constructed with proprietary technologies such as S-PLUS, .Net, ArcGIS Server, and Flex. The resulting system is open source, can be installed easily and run on any desktop computer (such that internet access is not required to run the system) or server, is cross-browser, cross-platform compatible, and requires no browser plug-ins. This platform can incorporate a variety of GIS data types, including ESRI shape files, Google Earth Keyhole Markup Language (KML), GeoJSON, and flat files with geographical coordinates.

The web framework for DASEES tools leverages the Ext JS (JavaScript) Cross-Browser Rich Internet Application (RIA) Framework to provide a desktop-like look, feel, and responsiveness via its built-in support for Asynchronous JavaScript And XML (AJAX). Ext JS also has native support for representational state transfer (RESTful) data storage for managing create, read, update, delete (CRUD) interactions through PHP with the back-end database. The GeoExt project provides an extension of the Ext JS RIA that brings together OpenLayers and Ext JS to build desktop-style interactive mapping. Combining GeoExt with R, Geoserver, and PostgreSQL/PostGIS allows for a full-featured, web-based, open source GIS and spatial modeling system.

Due to recent advances, web-based visualization of information via vector-based/scriptable graphs, charts, and map and data interaction can be dynamically built and presented on a web page without requiring a plug-in. The HTML5 Canvas specification provides cross-browser support for JavaScript-based graphics. Canvas is supported by the Internet Explorer 9, Firefox, Chrome, and Safari web browsers. Backward capability for earlier versions of Internet Explorer is provided through the ExplorerCanvas JavaScript library. Although not a requirement, DASEES applications have been developed around the Google Earth plug-in.

Figure 4 depicts the overall client-server web application design for DASEES that will be discussed in detail in the following sections.

3.2 User Interface

The DASEES graphical user interface (UI) will be programmed in JavaScript (officially known as ECMAScript) using the ExtJS open source cross-browser JavaScript library. The ability of individual UI components to interact asynchronously with the server allows page content to be dynamically updated without reloading the page, providing a level of responsiveness more commonly associated with desktop applications running on the user's computer than with traditional web applications. Site navigation is implemented via a tab-based layout, which allows users to drill down to more specific layers of content while still being able to visualize the overall structure of the site.

The content portion of the web interface typically is created in the open source word processing program Open Office and exported to HTML, while the JavaScript code will reside in separate source files with a .js file extension. Presentation and styling is controlled using Cascading Style Sheets (CSS). CSS source code will also be stored in separate .css files. All three kinds of files will be served by the Apache web server in response to requests from the user's web browser; the browser then executes JavaScript. The server can display dynamically generated images of plots and graphs created by the R module or interactively display data and information in one of the many JavaScript based charting packages (e.g., Google Charts).

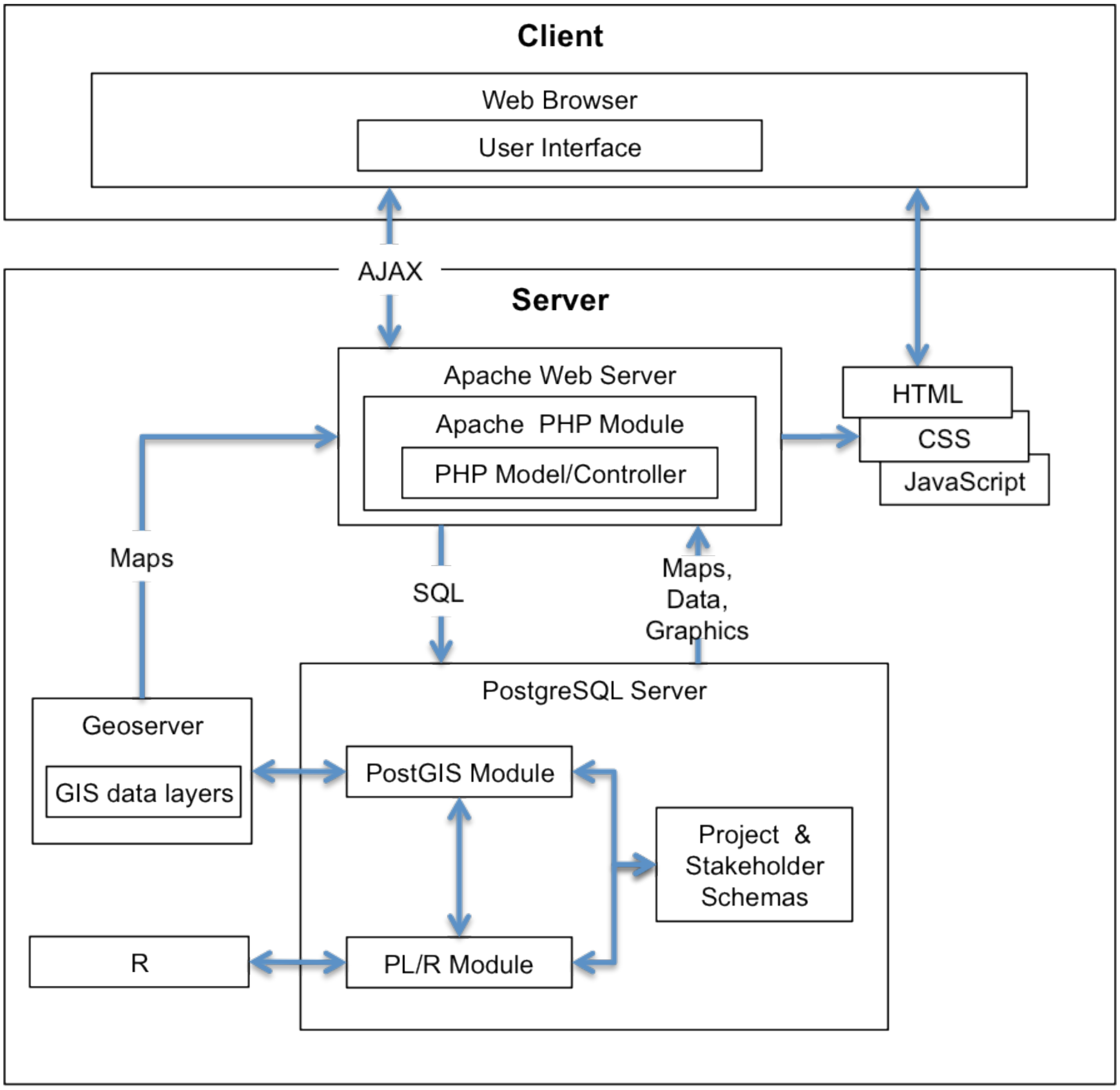


Figure 4. DASEES Web Application Framework

The interactive mapping interface will be developed in OpenLayers (www.openlayers.org), and GeoExt (www.geoext.org). Openlayers provides an API for incorporating and interacting with GIS data layers from several data sources and formats including Google Map base layers, Web Map Service (WMS) requests from a map server, ArcIMS requests, Google Earth Keyhole Markup Language (KML), GeoJSON, and PostGIS SQL requests. This creates a flexible environment for managing GIS data layers, by taking advantage of data products from external sources (e.g., Google, EPA), and allowing for data layers to be dynamically generated, analyzed, and updated. DASEES currently is using Geoserver, an open source map server application (www.geoserver.org), as its map server. However, map server applications that support standard specifications generally are interchangeable.

3.3 Server Scripting

PHP: Hypertext Preprocessor (PHP) is an open source server-side scripting language, which will run as a plug-in module to the open source Apache web server. The PHP module will implement the model and controller components (the view is implemented in the user interface) of a model/view/controller (MVC) architecture, which will allow users to interact directly with tables in the PostgreSQL database. Supported operations will include displaying table data and creating, deleting, and editing rows in the table. The PHP module also will allow the web interface to directly call stored procedures in the database. These stored procedures will be written in PL/R. PL/R is a PostgreSQL Procedural Language for R, a statistical computing, programming, and graphics language environment (www.r-project.org) that allows R functions to be stored and run in the PostgreSQL database using SQL.

3.4 Relational Data Managment System (RDMS)

Databases for the DASEES will be managed in PostgreSQL, a highly scalable, Structured Query Language (SQL) compliant open source object-relational database management system. Data will be organized using schemas. Schemas provide namespacing, which allows multiple tables with the same name to exist as long as they are in separate schemas. This provides great flexibility in database design. For example, multiple users each can have a set of tables that are identical in structure but contain user-specific data. Schemas also can be used on a per-project (rather than a per-user) basis. GIS and statistical technical analysis of the data will be implemented in stored procedures written in PL/R, a procedural language for PostgreSQL that provides an interface to the R statistical programming language. All geospatial data incorporated into DASEES will be Federal Geographic Data Committee (FGDC) compliant.

3.5 GIS Layers Management and Web Serving

GIS data layers will be developed and stored natively as ESRI shapefiles. This will allow static GIS data to be developed under a Windows operating system. ESRI shapefiles will be imported into Geoserver or PostGIS. Geoserver is used to serve maps that are static, while PostGIS is used to store spatial information that is being dynamically generated or edited by the user. The advantage of PostGIS is that open source spatial analysis tools available in R Packages can be called directly, interact with spatial data, and return results to the database through SQL requests from the AJAX/PHP/Apache engine. This allows for a responsive interactive web-based spatial analysis environment that can take advantage of the wide array of open source analysis tools available in R.

GIS and statistical analysis, computations, and algorithms will be accessed or programmed in R. R code will be accessed from PL/R functions written as stored procedures in the PostgreSQL database. The key workhorse packages for GIS analysis in R will be sp and rgdal. These packages provide the tools needed to provide full GIS functionality in a scriptable, open source, web interactive framework. Another potentially a key package for the GIS analysis in DASEES will be RSAGA. RSAGA provides an interface from R to the System for Automated Geoscientific Analyses, SAGA (www.saga-gis.org). SAGA is an open source spatial analysis tool designed to provide 1) an effective implementation of spatial algorithms, 2) an approachable user interface with many visualization options, and 3) run under Windows and Linux operating systems.

3.6 Probabilistic Modeling and Statistical Analysis

Bayesian probabilistic modeling and statistical analysis of data will be implemented in R using existing graphical modeling R packages such as gBase and gRain, Monte Carlo integration R packages such as MCMCpack, visualization R packages such as googleVis, and, when needed, custom DASEES R code. An influence diagram interface will provide the user the ability to build, specify and simulate Bayesian models connecting options and measures. Again, the foundation for the technical analysis is the PL/R functionality that connects the web interface, the underlying database, and the computations and visualizations in R.

3.7 Advantages of Design Using Open Standards

There are several advantages of designing DASEES using Open Source Software (OSS) standards. Use of OSS is advantageous in terms of software licensing and cost, and in terms of the philosophy that underlies the Open Source community. The Open Source philosophy is aimed at sharing information at all levels, gathering and responding to feedback for continuous improvement, and encouraging users to supply functionality and content. For DASEES, this consists of sharing content and all resources (including code), operating a continuous feedback option, and encouraging users to submit case studies that can be shared with the DASEES community of users.

The benefits of following the Open Source approach to the development of DASEES include:

- Potential users are not encumbered with software licensing issues.
- DASEES will allow users to engage at various levels of complexity depending on their interest. Different levels of complexity for each component might include, for each component: an overview, access to supporting information, details of mathematical methods (for example, environmental modeling, risk assessment, statistics, economic modeling, and decision analysis), computer code (for example, HTML, JavaScript, PHP, R), and case study examples.

- The holistic approach facilitates defensibility, traceability and transparency for each application.
- The approach promotes Quality Assurance QA through internal testing and through user-supplied feedback. The open nature of the JavaScript, PHP, and R code allows each aspect of DASEES to be reviewed thoroughly.
- As a web-based system, DASEES can be updated as new tools, technologies, and approaches become available without requiring users to install any additional software.

4 Software Development and Implementation

4.1 Development Process

4.1.1 Module Skeleton

DASEES developers will create an initial navigational, scripting, database, and technical analysis structure that reflects the system design as depicted in Figure 4. The user interface skeleton will be developed in HTML and JavaScript, the Model/Controller skeleton will be developed in PHP, the Database skeleton will be developed using SQL and PL/R, and the Technical Analysis skeleton will be developed in R. These skeleton components will provide containers for implementing specific functionality required by individual tools.

4.1.2 Module Interfaces

Once skeleton modules have been created, interfaces will be developed to allow communication among the modules. The User Interface will communicate with the Model/Controller via AJAX requests; the Model/Controller will communicate with the Database via direct SQL queries and calls to PL/R stored procedures; and the Database will communicate with the Technical Analysis module via R code embedded in PL/R stored procedures. These interfaces will be placeholders that will be replaced by task-specific communication mechanisms as individual tools are developed.

4.1.3 Tool Development

Once the skeleton infrastructure is implemented, tool development can begin. Each tool will have a specification for its user interface and functionality. This will involve coding in multiple modules. While some tools will not use all modules, no tool will be confined to a single module. When a new tool is integrated into the overall framework all existing tool test plans (see Section 5) will be run to ensure that the new code introduced to support the new tool does not compromise existing functionality.

4.2 Deployment

The DASEES system will undergo a three-phase deployment process: development, beta-testing, and deployment. During development phase, each of the new functions and components will be continuously tested as outlined in Section 5. At the end of the development phase, the new functions and components will be deployed on a test server. In the beta-testing phase, an internal review of the content and function of the new DASEES functions and components is conducted. After that review is complete and identified concerns have been addressed, a further review of those new functions and components is conducted by members of the DSF team. The DSF team reviewers provide the peer reviews needed for the EPA clearance process. The contractor (Neptune and Company, Inc.) then will address DSF team comments. The EPA will complete the clearance process. Once EPA approves the modified system in the beta-testing phase, the running system is deployed onto the deployment server and made available at www.dasees.org.

4.3 Change Control and Archiving

DASEES will be managed under Subversion (subversion.tigris.org). Subversion is an open source version control system that keeps track of changes to files and folders in a project repository. It will act as a central repository of the most up-to-date project files and will allow users, contributors, and developers to share them conveniently. All major releases of the DASEES system, source code, and documentation will be tagged and archived in Subversion. In addition, the entire Subversion system will be backed up on a daily basis and an off-site backup is performed weekly.

5 Quality Assurance (QA) and Review Activities for Validation, Verification, and Testing

5.1 Review Cycles

Implementing the DASEES decision analysis steps in a web-based user interface requires a complex system of information, databases, analysis tools, and decision analysis integration tools. It is essential that each DASEES component receive appropriate review prior to being deployed on the public DASEES website. These reviews will be performed for each of the DASEES components (guidance, databases, technical analysis tools, and user interface). Sections 5.2 and 5.3 provide details on the specific review for each DASEES component.

5.2 Testing DASEES Components

This section outlines the QA testing plan that is applied to each of the components of DASEES. Review questions to promote critical thinking will be completed by using a QA user protocol. The review questions are comprised of a series of yes/no questions for each of the four review categories. These review questions are outlined in the sections below. Technical QA review will be performed by members of the DSF team.

5.2.1 Technical Guidance

The quality objective for the technical guidance is to provide appropriate guidance using consistent and standard terminology. Affirmative answers to the following table of questions should ensure that quality objectives are met.

- Does the guidance use consistent and standard technical terminology?
- Does the guidance present appropriate interpretation of technical concepts?
- Are technical terms explained adequately?
- Are technical concepts explained adequately for the purposes of the software system?
- Is the guidance user friendly?
- Will the guidance be understood by the user?

5.2.2 Databases

The quality objective for the database searches is to produce accurate and anticipated results. The quality expectations of the databases will be assessed by answering each of the following questions:

- Are the database query results appropriate and accurate given the user input?
- Is data entered by the user accurately stored in the database?
- Are queries completed in a timely manner?

5.2.3 Technical Analysis

The quality objective for the technical computations is to produce accurate and anticipated results.

Technical computations will be performed in R. In general, the QA provided by R developers and the R user community provide a high level of accountability for the DASEES technical engine. In most cases, computer codes that need to be compiled include documentation with example datasets and results. Once a DASEES component has been programmed, these examples will be run and compared to the documented results. Each DASEES function will include an example dataset with known results. Comparison to known results will confirm that the functions are performing as expected. The quality expectations for the technical analysis will be assessed by answering each of the following questions:

- Do the technical analysis results compare favorably with the known results from the example datasets?
- Has the technical tool or method had sufficient QA to provide adequate defense of the data analysis results?

- Are assumptions and limitations described in such a way that the end user can make informed decisions regarding use of the method?
- Are examples of appropriate use given?

5.2.4 User Interface

The quality objective for the user interface is that it be intuitive, user-friendly and that it facilitates use of and interaction with technical analysis tools. The interface will be designed to intuitively elicit user responses and provide for easy navigation. User responses are collected through user interfaces and then are translated using JavaScript, PHP, and R to database search or technical analysis appropriate inputs.

The quality expectations of the user interface will be assessed by answering each of the following questions:

- Does the user interface use standard terminology and definitions throughout?
- Can the user easily navigate between different sections of the website?
- Are inputs validated (error-checked) and does the user interface provide feedback to the user on appropriate input for the tool if errors are found?
- Does the interface have guidance to aid the user?

5.3 DASEES Peer Review

Prior to the deployment of the DASEES website a Letter Peer Review will be conducted by EPA. EPA will select a peer group from the identified stakeholders, develop review questions, and mail these questions out to the peer group for review. The peer group will then review the DASEES website based on these review questions.

6 Documentation, Maintenance, and User Support

6.1 Documentation

DASEES electronic documentation provides information on:

- How to use DASEES
- The technical components and methods DASEES employs
- General guidance
- The Quality Assurance Project Plan (QAPP)

The documentation will be updated regularly to reflect functional changes in DASEES. The most recent EPA approved version of the documentation will be made available on the public (deployed) DASEES website. In addition, since DASEES is open source software the underlying software code will be available for download.

6.2 Maintenance and User Support

As a web-based application, DASEES has the advantage of centralized maintenance. If defects in the software are discovered, fixes can be applied directly on the public site without the need to distribute software patches to users. If a defect is identified, either by the DASEES team or by reviewers or users, the procedure described in the flowchart below (Fig. 5) will be followed to identify the problem, implement a fix, and eventually deploy the fix on the public site.

6.3 Security

DASEES is developed on Windows, Linux, and Macintosh machines located at Neptune's Los Alamos, New Mexico and Lakewood, Colorado offices. Both offices are secured by software firewalls, anti-virus software, and a combination of two to three Anti-Spyware programs for all Windows servers and desktops. Anti-Virus definitions are updated daily on all machines. Anti-Virus scans are run daily on servers and weekly on desktops. As the deployment site, the Los Alamos office has an added layer of security in the form of a hardware firewall. All servers and desktops at Los Alamos are located behind the hardware firewall.

The servers used for DASEES development, beta-testing and deployment and the server that hosts the Subversion source control system are Linux servers running the Fedora operating system. Linux was chosen as the operating system for deployment and testing because it offers superior performance to Windows and is more secure because the majority of viruses and malicious software is written specifically to target Windows. Thus, Linux is immune to these threats. Updates on Linux are automatically downloaded and installed nightly. The servers also implement a RAID-5 configuration to protect from hard drive failure and use Uninterrupted Power Supplies. All major releases of the DASEES system, source code, and documentation are tagged and archived in Subversion. In addition, the entire Subversion system is backed up on a daily basis and an off-site backup is performed weekly.

7 Reporting

The final deliverable for this project is an operation DSF. The operational DSF is now called DASEES and will be housed under www.dasees.org. Additionally, the DSF team members will prepare several peer reviewed journal articles based on DASEES, case study development, and interactions with stakeholders and decision-makers. DASEES will be Open Source Software and all code and documentation will be provided through a version control web site that will allow anonymous checkout of all the of DASEES' components.

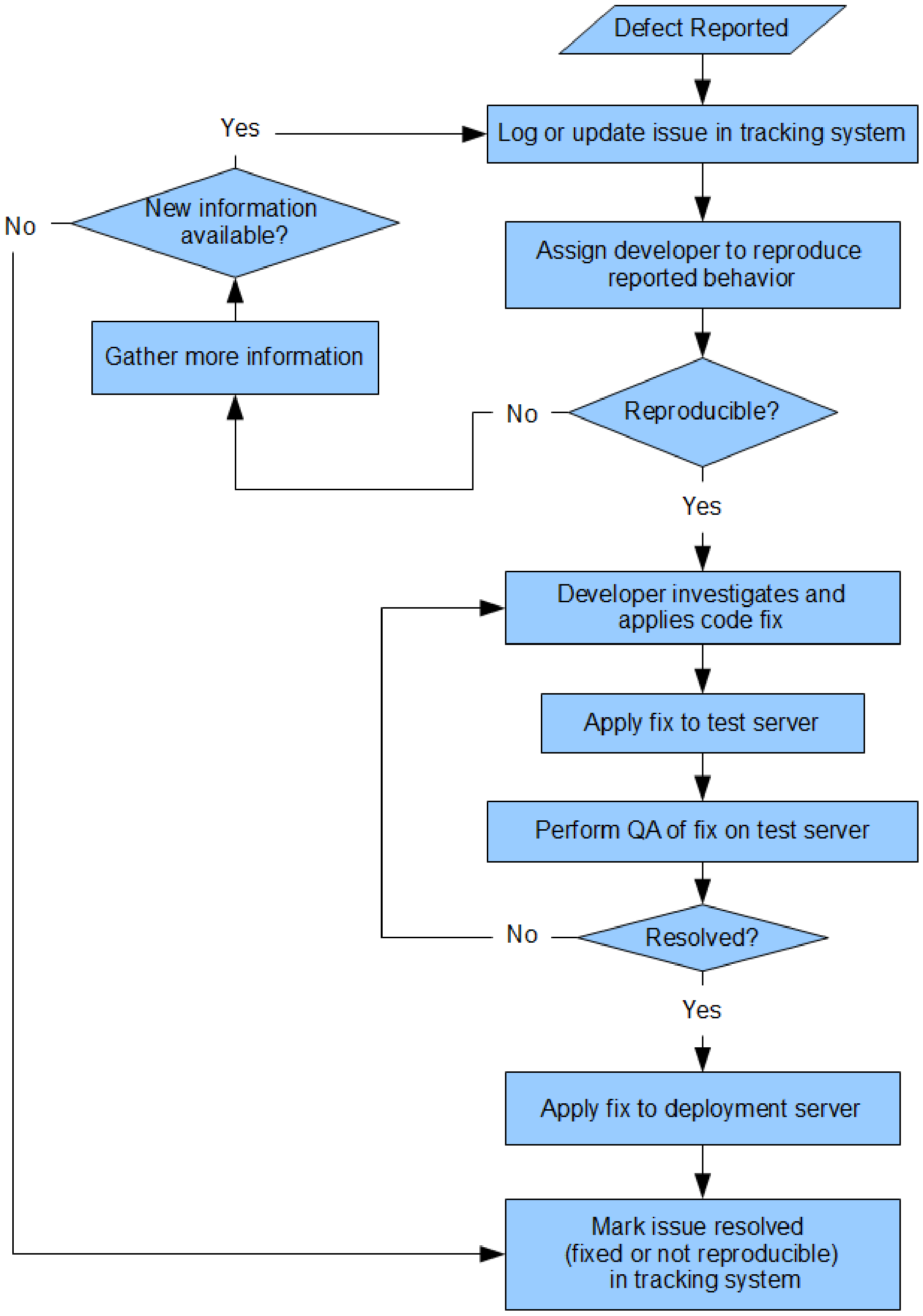

Defect Reported
Log or update issue in tracking system
Assign developer to reproduce reported behavior
Reproducible?
No
Yes
Gather more information
New information available?
Yes
No
Developer investigates and applies code fix
Apply fix to test server
Perform QA of fix on test server
Resolved?
No
Yes
Apply fix to deployment server
Mark issue resolved (fixed or not reproducible) in tracking system

Figure 5. Maintenance and User Support Workflow

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9 Glossary of Web Application Development Terminology

AJAX Asynchronous JavaScript And XML contains a consortium of client-side web application development methods to allow for asynchronous sending and receiving of data form a server.

Apache Apache HTTP Server is open source web server software usable by a wide variety of operating systems.

API Application programming interfaces are specified source code to interface between software components.

ArcGIS Server ESRI server for supplying web-based GIS mapping and spatial analysis services.

ArcIMS Arc Internet Map Server is an ESRI web map server.

Canvas An element of HTML5 allowing dynamic, scriptable renderings of two-dimensional shapes and bitmap images.

CRUD Create, read, update, delete are the four basic functions of persistent storage in relational database applications.

CSS Cascading Style Sheets are a simple method for adding style (fonts, color, etc.) to web documents.

ECMAScript ECMAScript is the name of the scripting language standardized in ECMA-262. It is used for client-side scripting for the web with JavaScript being a well-known version.

Ext JS A JavaScript Rich Internet Application (RIA) Framework has a library of tools supporting development of cross-browser interactive web applications using techniques such as AJAX.

Flex An Adobe software development kit for developing cross-platform web applications using Adobe Flash.

FGDC Federal Geographic Data Committee is an interagency entity promotes the national coordinated development, use, and sharing of geospatial data.

GeoExt A project that combines ExtJS with OpenLayers and provides a suite of customizable widgets and data support for making geospatial data applications.

GeoJSON An open source format for encoding geographic data structures. It is based on JSON (JavaScript Object Notation).

GeoServer Open source Java-based server for editing and sharing geospatial data. Designed for interoperability, it can be used to connect existing information to web-based maps in OpenLayers and GoogleMaps.

HTML Hypertext Markup Language uses elements which are the basic building blocks of webpage design.

HTML5 The fifth revision of the HTML standard. It is intended to improve HTML to support multimedia while maintaining human and machine-readable formats. HTML5 should include JavaScript.

JavaScript A recognized version of the ECMAScript language standard used mainly for client-side development of website user interfaces.

JSON JavaScript Object Notation is a text-based open standard using JavaScripting language for transmitting data over a network connection. It can serve as an alternative to XML.

KML Uses XML syntax to make visual and geographic annotation to web-based maps.

MVC Model-View-Controller is a software engineering architecture that permits the independent development of different aspects of the application logic.

.NET A Microsoft Windows-based software framework that facilitates web-based application development through software language interoperability.

OpenLayers An open source JavaScript library and lays the foundation for displaying maps in web browsers via application programming interfaces (API).

PHP Open source server side scripting language suitable for web application development and can be embedded in HTML.

PL/R PL/R is a PostgreSQL Procedural Language for R that allows R functions to be stored and run in the PostgreSQL database using SQL.

PostGIS Open source software supporting geographic objects in the PostgreSQL object-relational database structure.

PostgreSQL A highly scalable, Structured Query Language (SQL) compliant open source object-relational database management system.

R Open source version of S, a statistical computing, programming, and graphics language

RESTful REST is a software architecture style exemplified by the internet structure of origin servers, gateways, proxies, and clients. RESTful implies conformity with the existing REST architecture.

S A statistical programming language for data analysis and graphics.

SQL Structured Query Language is a programming language for managing data in a relational database management system.

S-PLUS Commercial version of the S programming language by Tibco Software.

XML Extensible Markup Language defines internet coding formats that are both human and machine-readable. Its open source specification follows the World Wide Web Consortium (W3C) international standards.

WMS Web Map Service is an internet standard for geo-referenced images generated via map server with GIS data.